The Economics of Open-Access Journals

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May 2006

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, 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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Acknowledgments: We thank Mark Armstrong, Sumit Joshi, Simon Loertscher, David Malueg, Lars Stole, and seminar participants at American University, Dartmouth College, George Washington University, MIT, New York University, Ruhr-Universität Bochum, Santa Clara University, Tulane University, the University of Chicago, the University of Göttingen, the Cologne Summit on Open Access Publishing, the Emory University Symposium on Open Access and Digital Preservation, and the International Industrial Organization Conference (Chicago) for helpful comments. We are grateful for funding provided by a grant from the Open Society Institute and the NET Institute. Some of this research was undertaken while Snyder was an Olin Visiting Professor at the Stigler Center for Study of Economy and State at the University of Chicago Graduate School of Business, and he thanks the Center for generous support.

1. Introduction

The typical scholarly journal earns most of its revenue from subscriber fees—fees charged to libraries and individual subscribers. Focus for the moment on library subscription fees since they constitute most of journal revenue, especially for journals published by commercial (for-profit) firms. Library subscription fees vary widely across journals and can be quite high. In economics, for example, yearly library subscription fees 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).[1] Across science and technology journals more generally, the average yearly library subscription fee, measured by the Blackwell Periodical Price Index, was £671 ($1,200) in 2000 (Wellcome Trust 2003).

Recent developments in the market for journals have led to dissatisfaction among some scholars and librarians with this business model involving such high subscriber fees.[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

[1] Dewatripont *et al.* (2006) find that commercial journals' prices are three times higher than non-profits' accounting for other factors in their updated, comprehensive study.

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

of a new business model, the open-access model. An open-access journal's articles are available over the Internet free of charge to all readers. Revenue to cover publication costs (and generate a profit for commercial publishers) comes from fees charged to submitting authors. In March 2006, the Directory of Open Access Journals (www.doaj.org) listed over 2,000 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. The 60 BioMed Central journals charge author fees ranging from $1,410 to $1,690 per accepted paper. The entry of open-access journals in business and economics, documented in Table 1, has been slower than in the hard sciences. Author fees are generally lower as well: with one exception, none of the business and economics journals in the table charge author fees at present, operating instead on donated labor and computer facilities.[3]

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.[4] Since journals are a channel for dissemination of knowledge in the economy, frictions in this channel may have much broader implications for the economy as a whole. Another reason

[3]The exception is the *South African Journal of Information Management*, which charges authors 75 Rand ($11) per published page.

[4]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. Within venues, open-access articles generated over three times the citations of print articles. Antelman (2004) and Harnad and Brody (2004) find that the citation rates for published articles that were also freely available in some form (draft, preprint, or postprint) on an open-access website are significantly higher than the rates for published articles that were not also freely available on the internet in some form. None of these studies fully accounts for the possible bias in the selection of open-access articles. Walker (2004) provides evidence on the revealed preference of authors for open access in his discussion of a hybrid entomology journal—hybrid in the sense that it publishes articles in its subscription journal but for a fee will also place the article on its open-access website. At a price of $124 for an eight page article, two thirds of authors currently pay for open access.

for analyzing the journals market for an academic audience is that it is one of the few markets that academics participate in as producers and consumers and exercise some control over as journal founders and editors.

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, it is not obvious that a non-profit journal with the objective of introducing open access 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 (Jeon and Menicucci 2003, McCabe 2004) 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 consider authors as well as readers in a two-sided-market model. Each side of the market benefits from externalities provided by the other: an author benefit from additional readers because this increases his impact and citations; a reader benefits from additional articles because articles contain content which is valuable to readers. Since authors are unable to compensate readers for these externalities and vice versa, how total fees are divided between authors and readers will matter in equilibrium because fees cannot simply be passed through.

Our paper is part of a growing theoretical literature on two-sided markets as applied to such markets as telecommunications and payment-card systems.[5] Perhaps the closest work to ours is contemporaneous research by Armstrong (forthcoming) and Rochet and Tirole (forthcoming). These papers provide general analyses of platform competition for a variety of different cases, but each has a section on the hybrid case of singlehoming on one side of the market and multihoming on the other side. This is the relevant case for academic journals and the one which we analyze, for with academic journals, authors can submit a single article only to one journal (singlehoming) while readers can subscribe to multiple journals simultaneously (multihoming). On a formal level, our work differs from Armstrong's in that our specification of costs is more general and our platforms (journals) are homogeneous rather than being differentiated on a Hotelling line.[6] The case of homogeneous platforms is important to analyze since it provides the extreme counterpoint to monopoly on the continuum of market structures. While our monopoly case is nested in Rochet and Tirole's general model, they do not study competing platforms as we do. On a conceptual level, the questions we address are different. The main results of relevance in Armstrong relate to the efficiency of equilibrium as the platforms become less differentiated and to the comparative static effect of moving from per-connection to lump-sum pricing. The main results of relevance in Rochet and Tirole relate to the derivation of Lerner indexes. Rochet and Tirole do offer general principles for when one side of the market will be charged zero prices, but they do not focus on providing a formal analysis as we do here.

Aside from the complication of two-sided markets, in other dimensions the model is quite simple. This is a deliberate modeling strategy. We are interested in determining the range

[5]The literature on two-sided markets includes Ambrus and Argenziano (2005); Armstrong (forthcoming); Baye and Morgan (2001); Caillaud and Jullien (2001, 2003); Evans (2003); Hermalin and Katz (2004); Jeon, Laffont, and Tirole (2004); Laffont *et al.* (2001); Rochet and Tirole (2002, 2003, forthcoming); Schmalensee (2002); and Wright (2004a, 2004b).

[6]A technical contribution of our paper is to be one of the first to generalize Bertrand competition in the presence of heterogeneous consumers to the two-sided-market context. Caillaud and Jullien (2001, 2003) analyze Bertrand competition for homogeneous consumers. Contemporaneous research by Ambrus and Argenziano (2005) analyzes Bertrand competition for heterogeneous agents under Ambrus' (forthcoming) coalitional-rationalizability refinement. They demonstrate the possibility of profitable asymmetric equilibria. We mainly focus on symmetric equilibria, in which, as we prove, both journals always to earn zero profit; but we also characterize asymmetric equilibria (see Proposition 6).

of possibilities that emerge from an elemental model. As we will see, even without further complications, our elemental model is successful in producing the whole gamut of possibility results. Among other simplifications, 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 in sequence the monopoly case, the social optimum, and the case of competing journals. We derive a number of general propositions in these sections, but the presence of demand discontinuities in even simple numerical examples prevents us from concentrating exclusively on 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 that are of central interest in this paper. 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, copy editing, 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.[7] 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_k^R is a random variable with cumulative distribution function F^R. Normalize the mass of readers to unity.

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

[7] 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.

quality.[8] 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.

We assume, consistent with industry practice, that authors cannot make direct payments to readers and vice versa, so that the benefits authors provide readers and vice versa are externalities. This makes academic journals a classic example of what the economic literature refers to as a two-sided market. See Rochet and Tirole (forthcoming) for a discussion and review of the literature. In a two-sided market, how total fees are divided across the two sides of the market will matter in equilibrium because their inability to make direct payments to each other eliminates their ability to pass the fees through.

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

[8] A natural question arising in this simple model regards why journals exist in the first place. Why do authors not circumvent the intermediary and circulate their articles directly to readers? First, bundling articles in a journal economizes on the fixed cost, c^R, of serving readers. If $c^R > 0$, it would be prohibitively expensive for the infinitesimal authors to circulate their articles directly to the infinitesimal readers. Second, even if $c^R = 0$, it would be straightforward to extend the model to allow journals a role in winnowing the wheat of scholarly articles from the vast chaff of irrelevant information.

make explicit cash transfers to authors or readers.[9]

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 anomalous 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 strate-

[9]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.

gies 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). 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 "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 Pareto optimum for them within the feasible payoff space of the subgame.[10]

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

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

[10] Our refinement is weaker than strong Nash equilibrium (Aumann 1959), which would require the outcome on any proper subgame played by the infinitesimal players to be immune to deviations by any coalition of them, rather than just the grand coalition of them as in our refinement. As Bernheim, Peleg, and Whinston (1987) note, strong Nash equilibria often fail to exist, and this problem indeed arises in our setting. See Ambrus (forthcoming) for formal analysis of an equilibrium refinement related to the one adopted here, coalitional rationalizability.

Similarly, the structural equation for readers' demand is

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

For brevity, we will nest equations (5) and (6) as follows (and use a similar convention for the notation throughout the remainder of the paper):

$$n^x = 1 - F^x(p^x/n^y) \tag{7}$$

where $x \in \{A, R\}$ refers to one side of the market and $y \in \{A, R\}$, $y \neq x$, refers to the other. Solving the system of equations in (7) simultaneously yields reduced-form solutions for demand

$$\hat{n}^x(p^x, p^y) = \sup\big\{n | G^x(n, p^x, p^y) = 0\big\} \tag{8}$$

where

$$G^x(n, p^x, p^y) = 1 - F^x\left(\frac{p^x}{1 - F^y(p^y/n)}\right) - n \tag{9}$$

for $x, y \in \{A, R\}$, $x \neq y$.

The reduced-form demands have straightforward comparative static properties. For example, 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 equation $G^x(n, p^x, p^y) = 0$ embedded in the definition of $\hat{n}^x(p^x, p^y)$ in (8) may have multiple solutions for n, and these solutions may vary discontinuously with p^x and p^y. 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 feedback 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 proofs of Proposition 1 and all subsequent propositions are provided in the Appendix.

Proposition 1. *Monopoly demand $\hat{n}^x(p^x, p^y)$ is weakly decreasing in prices p^x and p^y for all $x, y \in \{A, R\}$, $x \neq y$.*

The monopoly journal maximizes profit given by expression (1), substituting $\hat{n}^x(p^x, p^y)$ for demands for both $x = A$ and $x = R$. Call this profit $\Pi^m(p^A, p^R)$. As mentioned above, demands $\hat{n}^x(p^x, p^y)$ 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. Suppress the arguments of the demand functions for brevity. Let MC^x be the effective marginal cost of adding a customer on side $x \in \{A, R\}$ of the market. From (2), $MC^x = c^x + c\hat{n}^y$. The first-order conditions for the optimum are

$$\hat{n}^x + (p^x - MC^x)\frac{\partial \hat{n}^x}{\partial p^x} + (p^y - MC^y)\frac{\partial \hat{n}^y}{\partial p^x} = 0 \tag{10}$$

for all $x, y \in \{A, R\}$, $x \neq y$. The first-order conditions in (10) 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 $x, y \in \{A, R\}$. It follows that

$$L^x = \frac{1}{|\epsilon^{xx}|}\left[1 + L^y \epsilon^{yx}\left(\frac{p^y \hat{n}^y}{p^x \hat{n}^x}\right)\right] \tag{11}$$

Proposition 1 implies $\epsilon^{yx} \leq 0$ for all $x, y \in \{A, R\}$. 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.[11]

Equation (11) indicates that a monopoly journal may charge prices strictly above marginal cost for both authors and readers. This will be the case if both sides of the market are symmetric or nearly so. Charging a strictly positive markup allows the monopolist to extract surplus from both sides of the market. For the monopolist to charge zero or negative markups, the two sides of the market must be sufficiently asymmetric: i.e., the revenue from one side of the market must be sufficiently greater than from the other (note the revenue-ratio term in equation (11)). The monopolist would then subsidize the low-revenue side of the market in order to extract more surplus from the high-revenue side.

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 $\hat{n}^x(p^x, p^y)$ are differentiable and the social planner's problem has an interior optimum. The Lagrangian associated with this constrained optimization problem is

$$\int_{p^A/\hat{n}^R}^{\infty} \hat{n}^R b \, dF^A(b) + \int_{p^R/\hat{n}^A}^{\infty} \hat{n}^A b \, dF^R(b) - TC(\hat{n}^A, \hat{n}^R) + \lambda \Pi^m(p^A, p^R), \tag{12}$$

where $\lambda \in \mathbb{R}^+$ is the Lagrange multiplier on the break-even constraint, and where we have continued to suppress the arguments of the demand functions for brevity. Let $V^x(p^x, p^y)$ be the benefit from adding a customer on side $x \in \{A, R\}$ of the market averaged across the population

[11] 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.

of consumers on the other side of the market, $y \in \{A, R\}$, $y \neq x$:

$$V^x(p^x, p^y) = \int\limits_{p^y/\hat{n}^x}^{\infty} b\, dF^y(b). \tag{13}$$

Then the first-order conditions associated with Lagrangian (12) are

$$\lambda \hat{n}^x + \big[(1+\lambda)(p^x - MC^x) + V^x\big] \frac{\partial \hat{n}^x}{\partial p^x} + \big[(1+\lambda)(p^y - MC^y) + V^y\big] \frac{\partial \hat{n}^y}{\partial p^x} = 0 \tag{14}$$

for $x, y \in \{A, R\}$, $x \neq y$. Equation (14) can be rearranged into a Lerner index formula:

$$L^x = \frac{1}{|\epsilon^{xx}|} \left\{ \frac{\lambda}{1+\lambda} + \epsilon^{yx} \left[L^y + \frac{V^y}{(1+\lambda)p^y} \right] \left(\frac{p^y \hat{n}^y}{p^x \hat{n}^x} \right) \right\} - \frac{V^x}{(1+\lambda)p^x}. \tag{15}$$

Equation (15) nests both the first best (by letting $\lambda \to 0$) and the monopoly problem (by letting $\lambda \to \infty$). Equation (15) 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 exerted 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. Because, as can be demonstrated from equation (2), the total cost function exhibits nondecreasing ray average cost, markups in equation (15) can be negative. Indeed, if the zero-profit constraint binds, at least one of the second-best markups L^A or L^R from (15) will be nonpositive.

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 infinitesimal players (authors and readers) coordinate on a Pareto optimum on any proper subgame. We will also focus for the moment on symmetric equilibria. By symmetry we mean equal journal prices. The next proposition 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 grand coalition of infinitesimal players can benefit by coordinating on one of the two. Requiring infinitesimal players to coordinate on a Pareto optimum on any proper subgame leads submitters and subscribers all to 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.*

Proposition 2 has an interesting implication for the supposed asymmetry between authors and readers. It has been argued that journals compete more aggressively for authors than readers.[12] The argument is that journals' exclusive rights over the articles they publish limit readers' ability to substitute among journals and thus make readers' demand relatively inelastic. On the other hand, since readers may subscribe to multiple journals, authors may be able to substitute among a number of alternatives to reach the same audience, thus making authors' demand relatively elastic. In terms of the literature on two-sided markets, the fact that authors singlehome but readers multihome leads to a possible asymmetry between them. A natural question is whether this asymmetry remains in the limit as journals become less differentiated. Proposition 2 suggests the answer to this question is negative: any asymmetry disappears in the limiting case of price competition between homogeneous journals because readers as well as authors singlehome in equilibrium. The lack of asymmetry between authors and readers is borne out more formally in Proposition 4 below.

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

[12] This argument is made informally in Bergstrom and Bergstrom (2004) and McCabe and Snyder (2004). Rochet and Tirole (forthcoming) provide a subtle counterargument.

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*

$$\Pi^m(p^{A*}, p^{R*}) = 0 \tag{16}$$

if monopoly demands $\hat{n}^x(p^x, p^y)$, $x, y \in \{A, R\}$, $x \neq y$, 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.

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 (16). Unlike the standard Bertrand game, therefore, here we potentially have a continuum of equilibria.

To determine which subset of this continuum are equilibria, some notation is in order. Let Z be the set of prices providing a stand-alone journal with zero profit:

$$Z = \left\{(p^A, p^R) \in \mathbb{R}^2_+ \,\middle|\, \Pi^m(p^A, p^R) = 0\right\}.$$

Define the "greater than" sign for vectors as follows: $(x'_i)_{i=1}^n > (x''_i)_{i=1}^n$ implies $x'_i \geq x''_i$ for all $i = 1, \ldots, n$ with at least one inequality strict. Let $\underset{\sim}{Z}$ be the following subset of Z:

$$\underset{\sim}{Z} = \left\{ (p^A, p^R) \in Z \;\middle|\; \begin{array}{l} \text{there exists no } (p^{A'}, p^{R'}) \in Z \text{ such that} \\ \left(\hat{n}^A(p^{A'}, p^{R'}), \hat{n}^R(p^{R'}, p^{A'})\right) > \left(\hat{n}^A(p^A, p^R), \hat{n}^R(p^R, p^A)\right) \end{array} \right\},$$

i.e., $\underset{\sim}{Z}$ is the subset of Z whose elements are associated with quantities that are not less than (in the vector sense) the quantities associated with some other element of Z. We have the following proposition.

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

The next proposition shows the second best will typically be an equilibrium in our model with competing journals.

Proposition 5. *Suppose the journal's zero-profit constraint binds in the second-best social optimum. There exists an equilibrium of the duopoly journal game satisfying the refinement we consider in which both journals charge the prices observed in the second best.*

Thus far, we have restricted attention to equilibria in which the journals choose the same prices, i.e., symmetric equilibria. There also may exist many asymmetric equilibria as the next proposition shows.

Proposition 6. *Consider two elements* $(p^{A'}, p^{R'}), (p^{A''}, p^{R''}) \in \underline{Z}$ *such that* $\Pi^m(p^{A'}, p^{R'}) = \Pi^m(p^{A''}, p^{R''})$*. There exists an equilibrium of the duopoly journal game satisfying the refinement we consider in which one journal charges* $(p^{A'}, p^{R'})$ *and the other* $(p^{A''}, p^{R''})$*. This equilibrium is asymmetric if* $(p^{A'}, p^{R'}) \neq (p^{A''}, p^{R''})$*.*

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, so that the assumptions behind our Lerner index formulae (11) and (15) may not hold. 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. The analysis of numerical examples does not impair the generality of the results in our context as much as it might in some others because one of our chief interests is in deriving possibility results. For instance, on the question of whether or not a profit-maximizing monopolist would choose open access, demonstrating a case in which it does and a case in which it does not is sufficient to prove a formal proposition on the existence of both possibilities.

Start by assuming the distributions of author and reader benefits, F^A and F^B, are symmetric, both being uniform distributions on $[0, 1]$. (We will consider the case of asymmetric distributions of benefits below.) Table 2 presents results from three different cost configurations for this 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 each of Examples 1–3 that the monopoly journal charges a price 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 the equilibrium maximizing the number of readers puts all the fees on the author side. 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 to authors and vice versa. The equilibrium maximizing the number of readers involves open access 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.

Several additional notes about the results are in order. Note that most of the subscription fees are seen to fall in Table 2 when the reader cost is reduced from $c^R = 0.1$ in Example 1 to $c^R = 0$ in Example 2 and 3. Subscription fees fall because the effective marginal cost of adding a reader, MC^R, falls with a reduction in c^R, and the lower cost is reflected in lower prices. For instance, in the monopoly case in Example 1, $MC^R = 0.1$ compared to $MC^R = 0.054$ in the monopoly case in Example 2.[13]

It comes as no surprise that the fees in the first best are less than marginal costs. The journal can be subsidized in the first best and does not need to cover costs. It is more surprising that fees in the second best can also be less than marginal costs. In the second best in Example 2, one can calculate $MC^A = 0.197$ and $MC^R = 0.082$, so both submission fee (0.172) and the subscription fee (0.022) are less than the corresponding author and reader effective marginal costs. Recall from our discussion following equation (15) that the markup over marginal cost in the second best need not be positive because the cost function exhibits increasing ray average costs, and so price can be less than marginal cost and still have revenue cover total costs.

Next, we will consider numerical examples for the case of asymmetric author and reader benefits. Table 3 provides a set of examples in which author benefits exceed reader benefits. Specifically, authors' benefits are uniformly distributed on $[0, 2]$ and so are double what they are in Table 2. Readers have uniformly distributed benefits on $[0, 1]$ per author/article as in Table 2. The cost configurations are the same as in Table 2.

Relative to the case of symmetric author and reader benefits in Table 2, in Table 3 the monopoly journal raises the price charged the high-demand side of the market (authors) and lowers the price charged to the low-demand side of the market (readers). Indeed, in Example 6 the monopoly journal uses an open-access regime. Though reducing subscription fees lowers the revenue extracted from readers, readers exert such a large positive externality on authors that this

[13] It might be thought that the increase in c would offset the reduction in c^R in moving from Example 1 to Example 2 to keep MC^R constant. This is not true for two reasons. First, c^R appears directly in $MC^R = c^R + c\hat{n}^A$, whereas c is multiplied by $\hat{n}^A \leq 1$. Second, a simultaneous increase in c and equal decrease in c^R will cause $\hat{n}^A$ to fall. This is because the increase in c has a direct effect on n^A, through its effect on p^A, whereas a decrease in c^R only indirectly affects n^A through its effect on p^R and thus n^R.

decline in revenue is more than offset by the increase in submission fees the monopoly journal can charge when more readers are expected to subscribe. This result bears out what we saw in the Lerner index formula in (11). Equation (11) shows that the markup should be adjusted up for the side of the market generating more revenue (c.f. $p^y \hat{n}^y / p^x \hat{n}^x$ in the second factor, which note is multiplied by the negative elasticity ϵ^{yx}).

In all three examples in Table 3, the competitive equilibrium maximizing the number of readers involves open access. This equilibrium coincides with the second best in all three examples. Thus, the second best involves open access in all three examples, as does the first best. There are a range of competitive equilibria that do not involve open access, as indicated by the fact that the equilibrium maximizing the number of authors does not involve open access in all three examples.

In Table 4 we take the mirror-image case in which readers have a larger benefit than authors. Readers' benefits are uniformly distributed on $[0, 2]$ and so are double what they are in Table 2. Authors have uniformly distributed benefits on $[0, 1]$ as in Table 2. The notable result from the table is that, while open access emerges in the competitive equilibrium maximizing the number of readers in all three examples, open access is not second-best efficient in any of them. The first best involves open access, but the journal earns strictly negative profit, so such an outcome would not be feasible without subsidies.

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.

The first question regards whether profit-maximizing journals would voluntarily choose open access. The theoretical results from Section 3, in particular the Lerner index formula (11), suggest that profit-maximizing monopoly journals will not voluntarily choose open access unless the elasticities line up in just the right way (presumably a rare case) or unless authors' benefits are much more important than readers'. In the numerical examples of Section 6, we saw open access never emerged with a profit-maximizing monopoly journal if authors' and readers' benefits were symmetric (Examples 1–3) or readers' benefits were higher than authors' (Examples 7–9). The monopolist charged readers substantial markups in an effort to extract revenue from all possible sources. The monopoly journal only pursued open access in Example 6, in which marginal reader costs were zero and authors' benefits were substantially higher than readers'.

Compared to the case of a profit-maximizing monopoly journal, open access emerged more often as an equilibrium with competitive journals (in essence perfectly competitive in our model). Referring to the numerical examples in Section 6, open access emerged in the equilibrium maximizing the number of readers in all of the examples.[14] Open access did not emerge in any of the competitive equilibria maximizing the number of authors.

In sum, if journals are profit-maximizing, we would predict open access would be more likely to be observed the lower is journals' market power, the greater are author benefits relative to reader benefits, and the lower are the marginal cost of serving readers.

The next question regards whether non-profit journals with the objective of introducing open access can be viable in competition with profit-maximizing journals. Our numerical examples demonstrated that the answer is yes. In all of the examples, there was a stable equilibrium in which both firms chose open access. As Proposition 6 suggests, there may exist asymmetric equilibria in which an open-access journal competes alongside another journal that charges a different configuration of prices, involving possibly positive reader prices. To be more concrete, consider any of Examples 1–3 and in particular any of the three equilibrium loci in Figure 2. Any outcome in which the open-access journal charges prices given by point R and the other

[14] This is not a general result but stems from the fact that the support of the distribution of reader benefits includes 0 in all of the examples. Examples can be constructed in which the support of the distribution of reader benefits is bounded away from 0 in which open access does not emerge in any competitive equilibrium. Suppose author benefits are uniformly distributed on $[0, 1]$ but readers' benefit per article equals 1 for all readers. It can be shown that the competitive equilibrium maximizing the number of readers involves free submission and a subscription fee of 0.100. (Note there are a continuum of zero-profit outcomes maximizing the number of readers; the competitive equilibrium satisfying our refinement among them maximizes reader surplus.)

(non-open-access) journal charges prices given by some other point on the locus of equilibria will be an equilibrium.

Our results that profit-maximizing journals with market power are less likely to choose open access than those without market power should not be construed to imply that market power *prevents* open access from being viable. It should be emphasized that the aforementioned result is for profit-maximizing journals only. Increasing a journal's market power increases the rents it could use to achieve objectives other than profit maximization if it so chose. In particular, if a non-profit journal were dedicated to open access, increasing its market power would facilitate achieving this goal.

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 (Examples 1 and 2) or if readers' benefits are large relative to authors' (Examples 7–9), then the second best involves positive reader fees. However, if authors and readers have symmetric benefits and readers are costless to serve (Example 3) or authors' benefits are substantially larger than readers' (Examples 4–6), open access is efficient. Are the conditions under which open access is second-best efficient of practical relevance? We would argue yes, for two reasons. First, the case of symmetric author and reader benefits seems to be a reasonable benchmark.[15] Second, the case in which readers are costless to serve corresponds to the case of online journals, precisely the environment in which open access has been advocated (open access was not a policy issue in the print-journal era). In sum, our results indicate that open access tends to be efficient in an environment in which journals are distributed over the Internet and in which readers' benefits do

[15] One could point to cases in which science is considerably advanced by the publication of seminal articles swamping any author benefit. Another effect going in the same direction is that, since the number of readers is invariably higher than the number of authors (rather than in equal proportion as the model implicitly assumes), reader benefits should be scaled up in proportion to the relative populations of readers and authors. On the other hand, there are likely a large number of articles that help the career prospects of the author more than they advance the field. Furthermore, there are inherent "business stealing" effects which add to the private benefit of publication but not the social benefit. Intuitively, the marginal social benefit of an article may not be great if another author would have published a similar article in the near future.

not swamp authors'.

We have in a sense been conservative in our assessment of both the social benefit and competitive potential of open access by ignoring an important technological advantage of open access to this point. The model assumed that the costs c^A, c^R, and c were exogenous, independent of the journal's pricing scheme. In particular, if c^R was assumed to be positive, it was assumed to be positive whether or not the journal was open access. One of the benefits of open access is that by posting articles on the Internet and allowing readers to access them freely, there is no need to administer reader accounts. This benefit could be modeled by supposing there is a discontinuous fall in the cost of administering a reader account from $c^R > 0$ for a journal that charges a subscription fee, no matter how small, to $c^R = 0$ for an open-access journal. Making this assumption on how costs change with the pricing scheme would lead open access to be socially optimal and for a wider set of parameters and to emerge as a competitive equilibrium for a wider set of parameters. For instance, the second best in Example 1 would switch from one involving positive submission and subscription fees (0.100 each) to an open-access regime with a submission fee of 0.100 and zero subscription fee (to see this, note the open-access cost structure would be identical to that in Example 3). Social welfare would rise from 0.699 to 0.855.

8. Conclusion

There is currently an active debate between advocates of the traditional business model for scholarly journals and a new business model involving open access. Both sides have at times claimed that their preferred model is competitively more viable, and at times claimed that their preferred model is socially more efficient, than the alternative. In this paper, we provide the first attempt to bring formal economic theory to bear in the debate. We argued that a two-sided-market model is required to address questions regarding the economics of open-access journals properly. We constructed and analyzed what might be considered the most elemental version of such a model.

On a superficial level, our analysis suggests there is merit to both sides of the debate. Consider the "possibility results" derived from our numerical examples. We showed it is possible for open access to emerge in equilibrium with profit maximizing journals. This was true for various journal market structures ranging from monopoly to Bertrand competition. We showed it is possible for open access to be socially efficient. On the other hand, all of the numerical examples had non-open-access equilibria. Indeed, we provided additional examples (see footnote 14) in which open access did not emerge in any competitive equilibrium. We also provided a range of cases in which the second-best social optimum (second best in the sense journals are constrained to earn non-negative profit without external subsidy) did not involve open access.

On a deeper level, our interest is in characterizing the conditions under which open access is competitively viable and/or socially efficient. Consider the comparative-statics results from our general analysis of the model assuming well-behaved interior optima, corroborated by our analysis of numerical examples which allowed for demand discontinuities and corner solutions. We found a profit-maximizing journal would be more likely to adopt open access in equilibrium (a) the lower the journal's market power, (b) the lower the marginal cost of serving a reader, and (c) the higher the distribution of author benefits. These comparative statics results are intuitive. The more market power the journal has, the freer it is to extract rent from both sides of the market, readers as well as authors, through high markups. Equilibrium prices at least partially reflect marginal costs for the usual reasons, so the subscription price tends to be low only if marginal reader costs are low. High author benefits are associated with low subscription prices because low subscription prices increase the quantity of readers, in turn increasing the demand of the high-value authors. For sufficiently high author relative to reader benefits, and sufficiently low marginal reader costs, there are cases in which even a monopoly journal would adopt open access, as we mentioned in the previous paragraph. Competing journals would adopt open access for a broader set of author/reader benefits and marginal reader costs.

Our second set of comparative statics results related to the conditions under which a non-profit journal that decided to adopt open access could be competitively viable. Obviously, it would be competitively viable in all the cases from the previous paragraph in which a profit-maximizing journal was found to adopt open access in equilibrium. It would also be more likely to be competitively viable the greater its market power. The journal can use the rents accruing from its market power to facilitate achieving its objectives, whether maximizing readership through open access or some other objective. Thus, while an increase in market power reduces the likelihood a *profit-maximizing* journal would choose open access in equilibrium, an increase in market power increases the likelihood a *non-profit* journal would find open access feasible.

Our last set of comparative statics results related to the conditions under which open access is socially efficient (in the sense of being part of a second-best social optimum). The set of cases in which open access is socially efficient is smaller than the set of cases in which open access emerged in a competitive equilibrium. Open access tended to be inefficient when readers' benefits were large relative to authors' or when the marginal cost of serving readers was high. The intuition again is clear. It is inefficient to have free reader access if readers are costly to serve at the margin or if the positive externality authors exert on readers is so high that author demand should be subsidized by positive reader fees.

In the model with competing journals, our decision to have them be symmetric competitors rather than an entrant competing against an incumbent was deliberate. While it is true that most scholarly journals are not open access, and so expansion of open access will require entry, we wanted to separate pricing issues from entry issues. We recognize that there may be significant barriers to entry in the journal market, among other reasons because a journal's reputation may be based on its stock of publications and may only evolve slowly over time. Such barriers to entry are not specific to open-access journals, however; they apply to any new journal whether it use an open-access or traditional pricing scheme. Rather than positing some exogenous quality difference between journals, we were interested in a model in which any quality differences between journals emerged endogenously, in our model through the number of articles published.

In future work, it would be useful to analyze how evolving reputations create potential barriers to entry. Although number of articles functioned somewhat as a proxy for journal quality in our model, it would also be useful to add an explicit consideration of quality certification. In McCabe and Snyder (2005), we sketch the beginnings of such an analysis. In that model, articles are exogenously good or bad; editors are variously talented at uncovering bad articles that are as costly to read but unlike good ones provide no useful information. The analysis becomes sufficiently complicated that we are forced to study only the monopoly case and are forced to assume that author benefits are homogeneous, effectively turning the two-sided-market model into a one-sided model. Analyzing quality considerations in a full-blown two-sided-market model awaits further research.

Appendix

Proof of Proposition 1: It is evident that $G^x(n, p^x, p^y)$ in expression (9) is weakly decreasing in p^x. Thus, by Lemma 1 of Milgrom and Roberts (1994),

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

for all $\delta \geq 0$. Therefore $\hat{n}^x(p^x, p^y) \geq \hat{n}^x(p^x + \delta, p^y)$. That is, $\hat{n}^x(p^x, p^y)$ is weakly decreasing in p^x. The proof that $\hat{n}^x(p^x, p^y)$ is weakly decreasing in p^y is 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 $\hat{n}^x(p^x, p^y)$, $x \in \{A, R\}$, $x \neq y$, 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. □

Proof of Proposition 4: Suppose both journals charge $(p^A, p^R) \in \underline{Z}$; all participating customers (authors and readers) coordinate on one or the other journal if both charge (p^A, p^R); and, if one journal deviates to another price vector $(p^{A'}, p^{R'})$, all participating customers coordinate on the non-deviating journal unless all participating customers' coordinating on the deviating journal Pareto dominates coordinating on the non-deviating journal for customers.

We will show these strategies form a subgame-perfect, rational-expectations equilibrium satisfying our refinement. We need to show there exists no strictly profitable deviation $(p^{A'}, p^{R'})$ for a journal. Given customers' strategies, the deviation will generate zero demand, and thus not be strictly profitable, unless all participating customers coordinate on it. But if all participating customers coordinate on the deviation, it will be unprofitable if $(p^{A'}, p^{R'}) \notin Z$. So suppose $(p^{A'}, p^{R'}) \in Z$. Since $(p^A, p^R) \in \underline{Z}$, by definition of $\underline{Z}$, at least one of the following three conditions must hold regarding the relationship between (p^A, p^R) and $(p^{A'}, p^{R'})$:

$$\begin{aligned}
\left(\hat{n}^A(p^A, p^R), \hat{n}^R(p^R, p^A)\right) &= \left(\hat{n}^A(p^{A'}, p^{R'}), \hat{n}^R(p^{R'}, p^{A'})\right) && (17)\\
\hat{n}^A(p^A, p^R) &> \hat{n}^A(p^{A'}, p^{R'}) && (18)\\
\hat{n}^R(p^R, p^A) &> \hat{n}^R(p^{R'}, p^{A'}). && (19)
\end{aligned}$$

If (17) holds, the participating customers obtain the same surplus whether coordinating on the deviating or non-deviating journal. If (18) holds, if all participating customers coordinate on the non-deviating journal, there exists an author whose private value b_i^A is slightly greater than the marginal authors', and thus obtains strictly positive surplus. This author does not submit if all participating customers coordinate on the deviating journal, and obtains zero surplus then. Similarly, if (19) holds, there exists a reader who obtains positive surplus if all participating customers coordinate on the non-deviating journal but zero surplus if they coordinate on the deviating journal. In sum, if one of (17), (18), or (19) holds, all participating customers' coordinating on the deviating journal does not Pareto dominate their coordinating on the non-deviating journal. According to the strategies from the first paragraph of this proof, participating customers thus do not coordinate on the deviating journal, implying it obtains no customers, implying it earns zero profit from deviating, implying its deviation is not strictly profitable. □

Proof of Proposition 5: Let (p^{A*}, p^{R*}) be the price vector implementing the second best. Suppose the journal's zero profit constraint binds in this second best. There cannot exist $(p^{A'}, p^{R'}) \in Z$ such that

$$\left(\hat{n}^A(p^{A'}, p^{R'}), \hat{n}^R(p^{R'}, p^{A'})\right) = \left(\hat{n}^A(p^{A*}, p^{R*}), \hat{n}^R(p^{R*}, p^{A*})\right)$$

or else $(p^{A'}, p^{R'})$ would provide participating customers with more surplus, and would generate more social (customers plus journal) surplus, than (p^{A*}, p^{R*}), contradicting the fact that (p^{A*}, p^{R*}) implements the second best. Hence $(p^{A*}, p^{R*}) \in \underline{Z}$. By Proposition 4, (p^{A*}, p^{R*}) there exists an equilibrium satisfying our refinements in which both journals charge (p^{A*}, p^{R*}). □

Proof of Proposition 6: This proposition can be proved using arguments paralleling the proof of Proposition 4. □

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

Economics journals	Business journals
Available by March 2004	
Brazilian Elec. J. Ec.	*Acadamy Marketing Sci. Rev.*
Ec. Bulletin	*B Quest*
Elec. J. Evolutionary Modeling	*Elec. J. Bus. Ethics and Org. Stud.*
Industrial Geographer	*J. Empirical Generalisations in Marketing Sci.*
Rev. Network Ec.	*Public Administration and Management*
	M@n@gement
	South African J. of Info. Management
Added by March 2006	
African Population Stud.	*Cato J.*
Australian Rev. Public Affairs	*Elec. J. Bus. Research Methods*
Demographic Research	*Elec. J. Info. Systems Evaluation*
European J. Comparative Ec.	*Elec. J. Knowledge Management*
Int. Rev. Ec. Education	*J. Elec. Commerce Research*
J. Applied Ec.	*J. Research for Consumers*
Monthly Labor Review	
Sustainability: Sci., Practice, and Policy	
Theoretical Ec.	

Source: March 28, 2004 and March 19, 2006 downloads of titles identified as business or economics journals from Directory of Open Access Journals (DOAJ, available on the web site www.doaj.org). A downloaded title's web site was consulted to determine whether it was affirmatively mentioned that the journal is refereed and whether the majority of articles are published in English. Notes: One journal in the March 2004 download and 18 in March 2006 download were published in a language other than English. The date of DOAJ listing does not necessarily correspond to the start of the journal. *Finnish Ec. Papers* was an open-access journal in March 2004 but now charges a subscription fee.

Table 2: Numerical Examples with Symmetric Author and Reader Benefits

		Competitive Equilibria		Social Optimum	
	Monopoly	Maximizing Authors	Maximizing Readers	Second Best	First Best
Example 1 (Equal author and reader costs): $c^A = 0.1$, $c^R = 0.1$, $c = 0.0$					
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

Note: Author and reader benefits are uniformly distributed on $[0, 1]$.

Table 3: Numerical Examples with Large Author Relative to Reader Benefits

		Competitive Equilibria		Social Optimum	
	Monopoly	Maximizing Authors	Maximizing Readers	Second Best	First Best
Example 4 (Equal author and reader costs): $c^A = 0.1$, $c^R = 0.1$, $c = 0.0$					
Submission Fee	0.909	0.000	0.212	0.212	0.000
Subscription Fee	0.048	0.230	0.000	0.000	0.000
Number Authors	0.497	1.000	0.894	0.894	1.000
Number Readers	0.903	0.770	1.000	1.000	1.000
Industry Profit	0.355	0.000	0.000	0.000	−0.200
Consumer Surplus	0.425	1.067	1.246	1.246	1.500
Social Welfare	0.780	1.067	1.246	1.246	1.300
Example 5 (Print journals case): $c^A = 0.1$, $c^R = 0.0$, $c = 0.1$					
Submission Fee	1.100	0.000	0.200	0.200	0.000
Subscription Fee	0.000	0.230	0.000	0.000	0.000
Number Authors	0.450	1.000	0.900	0.900	1.000
Number Readers	1.000	0.777	1.000	1.000	1.000
Industry Profit	0.405	0.000	0.000	0.000	−0.200
Consumer Surplus	0.428	1.067	1.260	1.260	1.500
Social Welfare	0.833	1.067	1.260	1.260	1.300
Example 6 (Online journals case): $c^A = 0.1$, $c^R = 0.0$, $c = 0.0$					
Submission Fee	1.050	0.000	0.100	0.100	0.000
Subscription Fee	0.000	0.113	0.000	0.000	0.000
Number Authors	0.475	1.000	0.950	0.950	1.000
Number Readers	1.000	0.887	1.000	1.000	1.000
Industry Profit	0.451	0.000	0.000	0.000	−0.100
Consumer Surplus	0.463	1.281	1.377	1.377	1.500
Social Welfare	0.914	1.281	1.377	1.377	1.400

Notes: Readers' benefits are uniformly distributed on $[0, 1]$. Authors' benefits are uniformly distributed on $[0, 2]$.

Table 4: Numerical Examples with Large Reader Relative to Author Benefits

		Competitive Equilibria		Social Optimum	
	Monopoly	Maximizing Authors	Maximizing Readers	Second Best	First Best
Example 7 (Equal author and reader costs): $c^A = 0.1$, $c^R = 0.1$, $c = 0.0$					
Submission Fee	0.048	0.000	0.230	0.000	0.000
Subscription Fee	0.909	0.212	0.000	0.212	0.000
Number Authors	0.903	1.000	0.770	1.000	1.000
Number Readers	0.497	0.894	1.000	0.894	1.000
Industry Profit	0.355	0.000	0.000	0.000	-0.200
Consumer Surplus	0.425	1.246	1.067	1.246	1.500
Social Welfare	0.780	1.246	1.067	1.246	1.300
Example 8 (Print journals case): $c^A = 0.1$, $c^R = 0.0$, $c = 0.1$					
Submission Fee	0.084	0.000	0.200	0.000	0.000
Subscription Fee	0.811	0.212	0.000	0.212	0.000
Number Authors	0.837	1.000	0.800	1.000	1.000
Number Readers	0.516	0.894	1.000	0.894	1.000
Industry Profit	0.362	0.000	0.000	0.000	-0.200
Consumer Surplus	0.403	1.246	1.120	1.246	1.500
Social Welfare	0.765	1.246	1.120	1.246	1.300
Example 9 (Online journals case): $c^A = 0.1$, $c^R = 0.0$, $c = 0.0$					
Submission Fee	0.067	0.000	0.100	0.000	0.000
Subscription Fee	0.820	0.106	0.000	0.106	0.000
Number Authors	0.875	1.000	0.900	1.000	1.000
Number Readers	0.531	0.947	1.000	0.947	1.000
Industry Profit	0.406	0.000	0.000	0.000	-0.100
Consumer Surplus	0.450	1.371	1.305	1.371	1.500
Social Welfare	0.857	1.371	1.305	1.371	1.400

Notes: Authors' benefits are uniformly distributed on $[0, 1]$. Readers' benefits are uniformly distributed on $[0, 2]$.

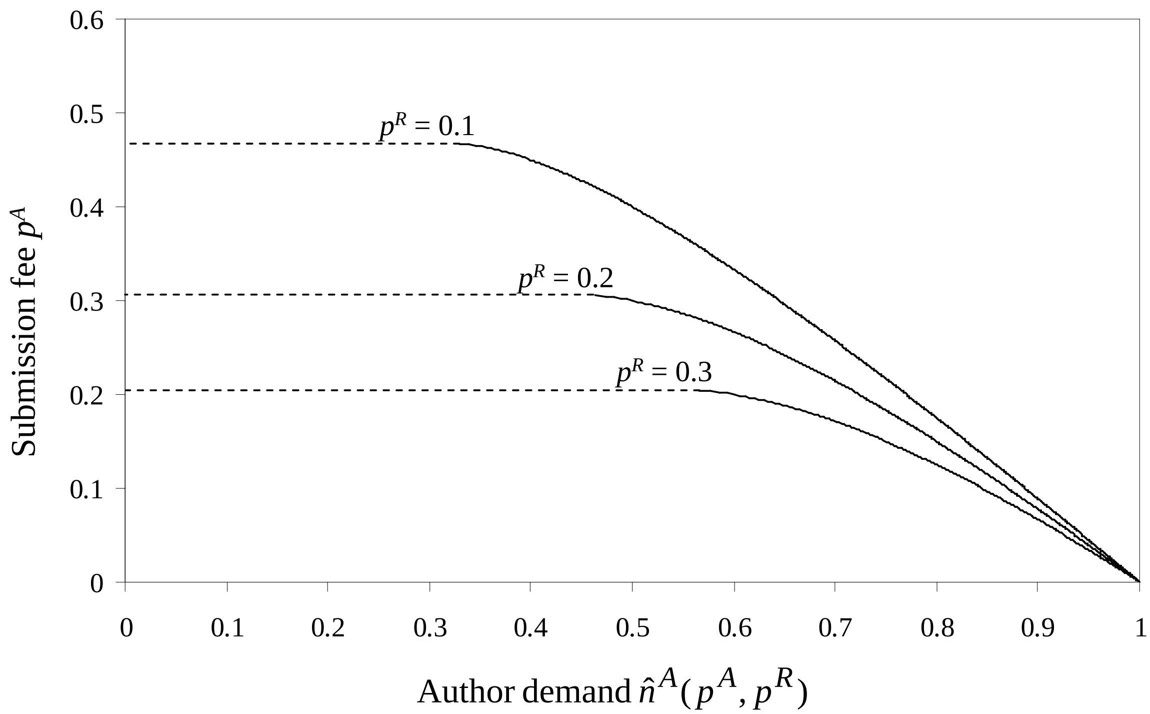

Figure 1: Discontinuities exhibited by reduced-form author demand in numerical example with uniformly-distributed benefits.

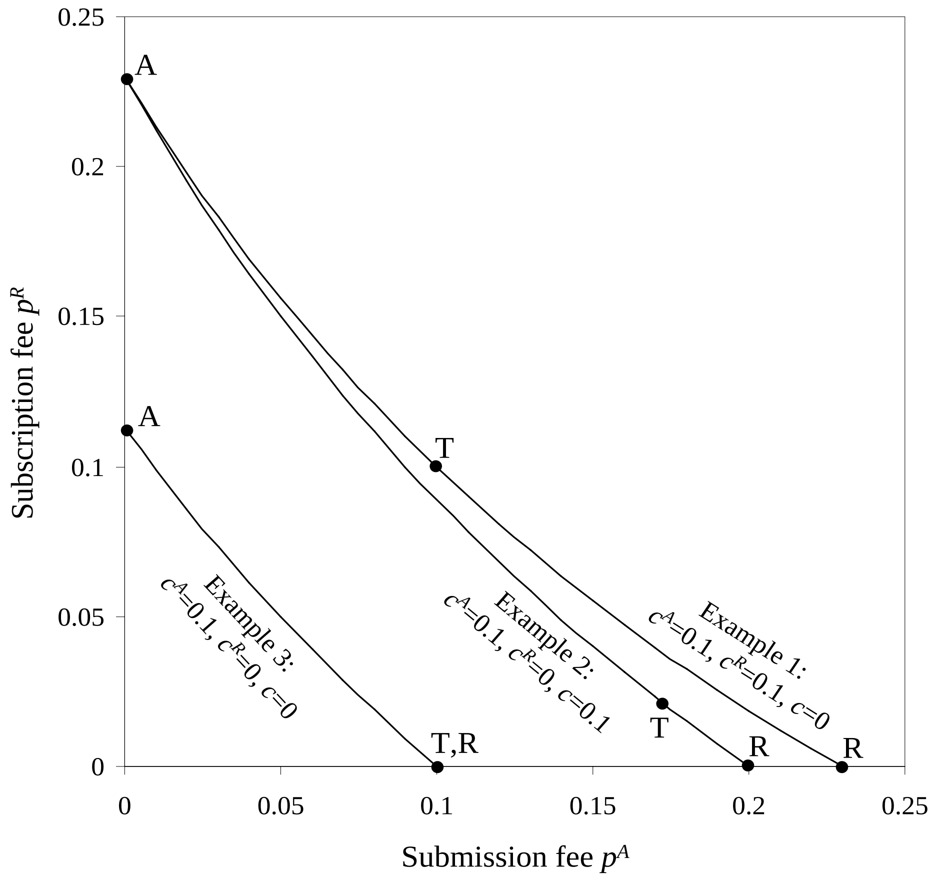

Figure 2: Continuum of competitive equilibria in three numerical examples with uniformly-distributed benefits. In each example, A is the equilibrium maximizing authors' demand, R is the equilibrium maximizing readers' demand, and T is the equilibrium maximizing consumer (i.e., author plus reader) surplus.