Do Electronic Site Licenses for Academic Journals Benefit the Scientific Community?

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When academic journals were distributed only as paper editions, the obvious way for scholars to share a journal was to borrow a copy from the shelves of their university library. With the arrival of electronic access, the logistics of journal-sharing has changed. Physical proximity, which once made libraries the natural venue for shared access, is no longer important. Despite this change, university libraries continue to act as publishers' revenue collectors and gatekeepers, by purchasing *site licenses* that entitle their faculty and students to access journals electronically. Since there is no compelling *logistic* reason for university libraries to do so, we ask whether university-wide site licenses perform a *fiscal* function that benefits the academic community. We find a surprising answer. If a journal is priced to maximize the publisher's profits, scholars on average are likely to be worse off when universities purchase site licenses than they would be if access were by individual subscriptions only. But site-licenses are not *always* disadvantageous. Journals issued by professional societies and university presses are typically priced so as to maximize subscriptions while recovering average costs. When such journals are sustained by institutional site licenses, the net benefits to the scientific community are larger than if these journals are sold only by individual subscriptions.

The difference between the library subscription prices charged by charged by for-profit and non-profit publishers for print journals is quite remarkable. Surveys of journal pricing in several academic disciplines show that the average *price per page* charged by commercial journals to libraries are typically six times as high as those charged by professional societies and university

	Cost per page ($ US)		**Cost per citation ($ US)**	
	For-profit	Non-profit	For-profit	Non-profit
Ecology	1.01	0.19	0.73	0.05
Economics	0.83	0.17	2.33	0.15
Atmosph. Sci.	0.95	0.15	0.88	0.07
Mathematics	0.70	0.27	1.32	0.28
Neuroscience	0.89	0.10	0.23	0.04
Physics	0.63	0.19	0.38	0.05

Table 1: Journal prices per page and per citation.

presses. These prices do not reflect quality differences as measured by citation rate; differences in price charged *per citation* differ by an even greater margin.[1]

The emergence of electronic site licenses is so recent that consistent patterns of pricing behavior may not yet been established. It is common, however, for commercial publishers to include electronic site licenses with print for a surcharge of 10-25% and to offer electronic subscriptions without print for about the same price as print alone. The pricing strategies of non-profit journals for electronic subscriptions vary quite widely. For example, *Science*, which has traditionally relied on individual subscriptions, charged $1,500 to $5,500 for an electronic site license in 2001 — many times the institutional print price of $370. In the same year, *Proceedings of the National Academy of Sciences USA*, which has not relied heavily on individual subscription revenue, offered electronic access for free to institutions that purchased the $970 print subscription.

To those accustomed to thinking about markets for ordinary commodities like shoes or houses, the economics of information goods, such as journal

[1] Citation data are from the Institute for Scientific Information's *Journal Citation Reports*. Journal lists, pricing, and page data for atmospheric sciences, economics, mathematics, neurosciences, and physics are from refs. [3, 4, 6, 7].

access or computer software is very curious. If you sell a house to one buyer, you can not sell the same house to others. To sell to more buyers, you must bear the costs of producing additional houses. The owner of copyrighted information does not suffer from this constraint, but is able to sell the same bit of information to many different buyers with a negligible cost of extending access to each additional buyer. The seller of information can also choose to sell collective access to groups of individuals in firms or universities by means of site licenses. This marketing device has no direct parallel in markets for ordinary commodities, and the implications of such sales are not widely understood.

In this paper, we apply elementary economics and statistical concepts to explore the way that we can expect profit-maximizing publishers and nonprofit societies to manage the sale of site licenses for academic journals, and the impact of these policies on the welfare of the scientific community.

A simple market

A simple example illustrates many of the basic features of the market for electronic journal access. A scientific journal is of interest to three types of scientists, A, B, C. There are 100 scientists of each type and the buyer values[2] of the three types for this journal are respectively, \$300, \$200, and \$100. The cost of editing the journal and putting it online is \$32,000. Once the journal is produced, there is no additional cost to adding another subscriber.

[2] An individual's *buyer value* for an item is the largest amount of money that she would be willing to pay to have it rather than not have it. This is sometimes called the *reservation price* or *willingness-to-pay*.

A profit-maximizing publisher

Suppose that the journal's publisher is a profit-maximizer who must charge the same price to all buyers. At price \$300, only type A's buy the journal and 100 subscriptions are sold. At price \$200, the A's and B's buy, and 200 subscriptions are sold. At price \$100, the publisher sells 300 subscriptions. Profit is maximized by selling 200 subscriptions at \$200 each. Revenue is then \$40,000, and since production costs are \$32,000, profit is \$8,000.

A buyer's *consumer's surplus* is defined as the difference between her buyer value and the price that she actually pays. At a price of \$200, type A scientists each get a consumer's surplus of \$100. Type B's get zero consumer's surplus, since the price is as high as their buyer values. Type C's get zero consumer's surplus, since they pay nothing and get nothing. Scientists therefore gain a total consumers' surplus of $\$100 \times 100 = \$10,000$.

Now imagine that these scientists are employed at 100 universities, each of which employs one scientist of each type. The publisher chooses not to sell individual subscriptions but any university can buy a site license that provides free access to all of its employees. Acting in the best interests of its scientists, a university library will buy a site license so long as the site license price does not exceed the sum of its resident scientists' buyer values. Since each university has one scientist of each type, the sum of buyer values at each university is \$600. The publisher can set a price of \$600 and sell one site license to each university. The 100 sales yield a revenue of \$60,000 and a profit of $\$60,000 - \$32,000 = \$28,000$.

With university site licenses, all three types of scientists have access to the journal, while with individual subscriptions, only types A and B have access. Since there is no real cost to extending access to everyone, site

licenses offer superior efficiency. But these efficiency benefits are all absorbed as extra profits for the publisher, and paradoxically, total consumer surplus of the scientific community is *reduced* by the use of site licenses. In our example, the site license price of $600 is equal to the sum of all scientists' buyer values at each university. Thus the scientific community is *worse off* than it would be is subscriptions were sold only to individuals and no better off than it would be if the journal did not exist.

A non-profit publisher

What happens if this journal is produced by a professional society that seeks the largest possible circulation consistent with recovering its total costs from subscription revenue? There is no single price at which the society could recover its costs *and* sell to all 300 scientists. The type C's will buy only if the price is $100 or less, at which price total revenue would be only $30,000, while total costs are $32,000. But the society could recover its total costs by setting a price of $160 and selling 200 subscriptions (to types A and B). At this price, scientists of types A and B have consumer's surpluses of $140 and $40 respectively. The scientists' total consumers' surplus is $18,000.

In this case the scientists will get greater total consumer surplus if universities buy site licenses. The society can cover its costs by selling a site license to each of the 100 universities at a price of $320. Since the sum of buyer values at each university exceeds $320, all 100 libraries will subscribe. Scientists at each university get a consumers' surplus of $\$600 - \$320 = \$280$ and the sum of consumers' surpluses is $28,000. Thus for non-profit journals, the scientific community benefits when universities purchase electronic site licenses rather than leaving individuals to purchase their own subscriptions.

More realistic markets

Our example assumes that all universities employ the same number of scientists of each type and so all universities place the same value on a site license. In this case, a publisher can set a price equal to total willingness to pay at any university and thereby expropriate *all* of the benefits resulting from the journal's existence.

To explore the outcome when universities are less uniformly constituted, we study models in which there are several universities and each university has n scientists[3] whose buyer values are drawn from a specified distribution function F. If journal access is sold by individual subscriptions at price p, then only those scientists with buyer values of at least p will subscribe and the seller's revenue will be proportional to $p\,(1 - F(p))$. If access is sold by university site licenses at a price np, then assuming that libraries purchase a journal when the sum of buyer values exceeds the price, a university will purchase the journal only if the *mean buyer value* of its faculty exceeds the *per capita* price p of a site license. In this case, the seller's revenue will be proportional to $p\,(1 - F_n(p))$ where F_n is the distribution of the sample mean for a group of size n. A profit-maximizing publisher will choose a per capita price p that maximizes its total revenue. For a specified distribution and any given size of university groups, we can calculate the profit-maximizing price, the publishers' expected profits, the scientists' expected per capita

[3] In the real world, variation in the size of universities produces variation in willingness to pay. If the prices of site licenses do not depend on university size, the largest universities retain some consumers' surplus, while very small universities will not subscribe. In principle, publishers could improve their profits by price discriminating by university size. Publishers have typically not done so when selling print editions, but recently several major publishers have begun to do so for electronic site licenses.

consumers' surplus, and expected deadweight loss.[4]

Thus we can explore the effect of group size on profits, consumers' surplus and deadweight loss. As group size increases, the variance of mean buyer values across groups decreases. For sufficiently large groups of equal size, this variance becomes arbitrarily small and a profit-maximizing seller can sell site licenses to almost all groups at a per capita price that is arbitrarily close to the population mean buyer value. Therefore for large group size, a profit-maximizing publisher captures almost the entire value of net benefits and the academic community is left with almost no consumers' surplus.[5]

The results for small groups are less straightforward. We have studied three distributions for which the distribution of sample means for small samples is manageable: the normal distribution, the uniform distribution, and the exponential distribution. Here we discuss the case of the exponential distribution. Results for the normal and uniform distribution are qualitatively similar, with some interesting differences that space prevents us from discussing here.[6]

Suppose that buyer values are distributed according to the exponential

[4]Deadweight loss is a measure of the inefficiency caused by excluding some scientists from access to the journal and is equal to the expected total of buyer values of those scientists willing to pay less than p for a subscription.

[5]Economists (Adams and Yellen [1], Schmalensee [5]) introduced a similar idea to explain the profitability to a monopolist of marketing a bundle of several products rather than selling them individually. Bakos *et al* [2] note that because group formation reduces variance of demand, sharing of software or video cassettes among acquaintances may increase rather than decrease the seller's profits.

[6]Our code is available at http://octavia.zoology.washington.edu/publishing/suppl.html, along with a similar analysis for the normal and uniform distributions. Calculations were performed numerically using *Mathematica*. David Park provided additional routines used in producing the graphs.

distribution function,[7] $F(x) = 1 - e^{-x}$. With this distribution, the mean buyer value is 1. We assume that the total cost of producing the journal is 0.2 times the total number of scientists.

The graphs in the left column of Figure 1 show the demand curve for individual subscriptions. For each price, the corresponding quantity is the fraction of all scientists who would subscribe at this price. The graph in the upper left shows the outcome when the publisher is a profit-maximizer and that in the lower left shows the outcome when the seller prices at average cost. Simple calculus shows that a profit-maximizing seller would set the price $p = 1$ and sell subscriptions to the fraction $1/e$ of all scientists. A non-profit publisher could recover its costs by charging 0.26 per subscription and selling subscriptions to a fraction 0.77 of all scientists. The shaded areas in the graphs show total costs, profits, consumers' surplus and deadweight loss for each case.

The graphs in the right column of Figure 1 show the demand curve for site licenses when scientists are randomly clustered into "universities" with 100 members. Here the demand curve gives the fraction of universities that would subscribe at each per capita price. The profit-maximizing price is 0.84 and at this price, 95% of all universities would subscribe. At a price of $20 per capita for site licenses, virtually all universities will subscribe and thus a non-profit publisher will almost certainly recover its costs.

The single-peaked curves in Figure 2 show the relationship between the per-capita price and the publisher's per-capita profit when buyer values are exponentially distributed. Different colors correspond to different group

[7] We leave the choice of currency units unspecified. The reader may want to think of x as measured in hundreds of dollars. The exponential distribution is convenient because sample means of independent draws from this distribution have gamma distributions.

Figure 1: Demand curves, profits, costs, consumers' surplus, and deadweight loss for individual subscriptions and site-licenses.

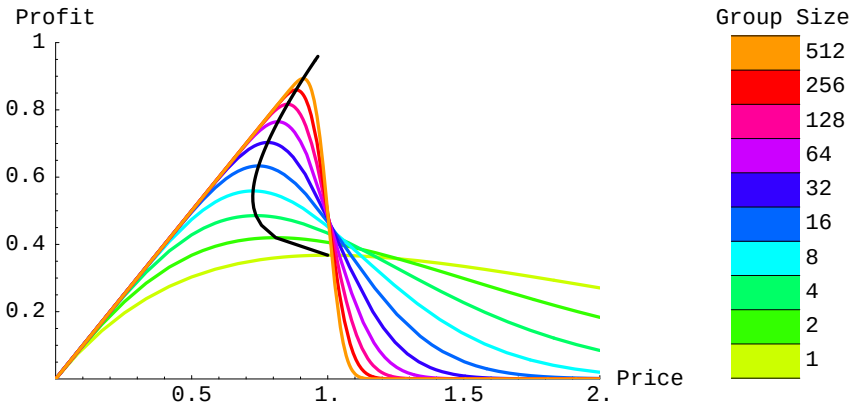

Figure 2: Per-capita profit as a function of price, for various site-license group sizes. The black arc traces the profit-maximizing price.

sizes. For each group size, the profit-maximizing price is the value at which the price–profit curve peaks. The black curve connects the locus of these profit-maximal price–profit combinations. Moving along the black curve from the peak of the yellow curve (individual sales) to the orange curve (groups of 512), the profits of the seller rise monotonically, while the per-capita price decreases with group size for group sizes up to 7 and increases with group size beyond that. Indeed, numerical analysis (not shown) reveals that every increase in group size leads to an increase in the profits enjoyed by a commercial seller, a decrease in consumers' surplus[8], and a decrease in deadweight loss. Although the sale of site licenses to larger groups increases efficiency, in the sense of increasing the sum of profits and consumers' surplus, the gains in efficiency are more than absorbed by the sellers, so that the scientists are actually worse off as group size increases.

Discussion

Our models suggest that university libraries, acting in their collective interest[9] should agree to purchase a journal site license only if the subscription price is close to the publisher's average cost. Commercial publishers seeking to maximum their profits would then be faced with a choice between selling

[8]Consumers' surplus decreases even as per capita price decreases because the gain in surplus from reduced prices is offset by the chance that individuals with high buyer values will belong to groups with low average buyer values and thus be excluded from access.

[9]If universities act independently, the situation is more problematic. Publishers have an incentive to set higher prices for individual subscriptions than they would if site licenses were not sold, so as not to spoil the market for site licenses. At these individual prices, scientists at a single university may benefit if their own library purchases site licenses that are priced far above average cost.

site licenses at prices close to average cost or of selling subscriptions only to individuals. Although the former arrangement is more efficient than the latter, either of these two outcomes would result in greater net benefits for the scientific community than a policy of purchasing electronic site licenses at prices set by profit-maximizing publishers.

For non-profit journals, individual and collective incentives operate in the same direction. The scientific community benefits and individual universities benefit if libraries purchase site licenses and make access freely available to their faculty and students.

Our analysis indicates that the scientific community would benefit if overpriced journals were displaced by journals committed to price approximately at average cost. This suggests that non-profit professional societies and university presses would benefit the academic community by expanding their existing journals or starting new ones. Individual scholars could advance this process by refusing to do unpaid referee work for overpriced journals and by favoring reasonably priced journals with their submissions.

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