The economics of electronic journals

Andrew Odlyzko, AT&T Labs - Research, New Jersey, USA

NOTE: This is not the paper that will most closely correspond to Dr Odlyzko's lecture in Canterbury, and that, *The slow evolution of electronic publishing,* will soon be available on his Web page, which is:
http://www.research.att.com/~amo

Abstract

Can electronic publications be operated at much lower costs than print journals, and still provide all the services that scholars require? That is the key question that is still in dispute. Available evidence shows that free or at least much less expensive journals are possible on the Net. It is probable that such journals will dominate in the area of basic scholarly publishing. However, the transition is likely to be complicated, since the publishing business is full of inertia and perverse economic incentives.

1. Introduction

It is now practically universally accepted that scholarly journals will have to be available in digital formats. What is not settled is whether they can be much less expensive than print journals. Most traditional print publishers still claim, just as they have claimed for years, that switching to an electronic format can save at most 30% of the costs, namely the expenses of printing and mailing. Prices of electronic versions of established print journals are little, if any, lower than those of the basic paper versions. What publishers talk about most in connection with electronic publishing are the extra costs they bear, not savings [BoyceD]. On the other hand, there is also rapid growth of electronic-only journals run by scholars themselves, and available for free on the Internet.

Will the free electronic journals dominate? Most publishers claim that they will not survive (see, for example, [Babbitt]) and will be replaced by electronic subscription journals. Even some editors of the free journals agree with that assessment. My opinion is that it is too early to tell whether subscriptions will be required. It is possible that we will have a mix of free and subscription journals. However, I am convinced that even the subscription journals will be much less expensive than the current print journals. The two main reasons are that modern technology makes it possible to provide the required services much more cheaply, and that in scholarly publishing, authors have no incentive to cooperate with the publishers in maintaining a high overhead system.

Section 2 summarizes the economics of the current print journal

system. Section 3 looks at the electronic-only journals that have sprung up over the last few years and are available for free on the Net. Section 4 discusses the strange economic incentives that exist in scholarly publishing. Finally, Section 5 presents some tentative conclusions and projections.

This paper draws heavily on my two previous papers on scholarly publishing, [Odlyzko1, Odlyzko2], and the references given there. For other references on electronic journals, see also [Bailey, PeekN].

2. Costs of print journals

Just how expensive is the current print journal system? While careful studies of the scholarly journal system had been conducted in the 1970s [KingMR, Machlup], they were obsolete by the 1990s. Therefore, in writing the "Tragic loss ..." essay [Odlyzko1], I made some estimates based on a sample of journals, all in mathematics and computer science. They were primary research journals, purchased mainly by libraries. The main identifiable costs associated with a typical article were the following:

(1) revenue of publisher: $4,000

(2) library costs other than purchase of journals and books: $8,000

(3) editorial and refereeing costs: $4,000

(4) costs of preparing a paper: $20,000

Of these costs, the publishers' revenue of $4,000 per article (i.e., the total revenue from sales of a journal, divided by the number of articles published in that journal) is the one that attracts the most attention in discussions of the library or journal publishing "crises." It is also the one that is easiest to measure and most reliable. However, it is also among the smallest, and this is a key factor in the economics of scholarly publishing. The direct costs of a journal article are dwarfed by various indirect costs and subsidies.

The cost estimates above are only rough approximations, especially those for the indirect costs of preparing a paper. There is no accounting mechanism in place to associate the costs in items (3) and (4) with budgets of academic departments. However, those costs are there, and they are large, whether they are half or twice the estimates presented here.

The estimate of $4,000 in publishers' revenue per article made in [Odlyzko1] has until recently been just about the only one available in the literature. It is supported by the recent study of Tenopir and King [TenopirK], which also estimates that the total costs of

preparing the first copy of an article are around $4,000. The estimate in [Odlyzko1] was based primarily on data in [AMSS], and so is about five years out of date. If I were redoing my study, I would adjust for the rapid inflation in journal prices in the intervening period, which would inflate the costs. On the other hand, in discussing general scholarly publishing, I would probably deflate my estimate to account for the shorter articles that are prevalent in most areas. (The various figures for size of the literature and so on derived in [Odlyzko1] were based on samples almost exclusively from mathematics and theoretical computer science, which were estimated to have articles of about 20 pages each. This is consistent with the data for these areas in [TenopirK]. However, the average length of an article over all areas is about 12 pages.) Thus, on balance, the final estimate for the entire scholarly literature would probably still be $3,000-4,000 as the publisher revenue from each article.

The $4,000 revenue figure was the median of an extremely dispersed sample. Among the journals used in [Odlyzko1] to derive that estimate, the cost per article ranged from under $1,000 for some journals to over $8,000 for others. This disparity in costs brings out another of the most important features of scholarly publishing, namely lack of price competition. Could any airline survive with $8,000 fares if a competitor offered $1,000 fares?

Wide variations in prices for seemingly similar goods are common even in competitive markets, but they are usually associated with substantial differences in quality. For example, one can sometimes purchase round-trip trans-Atlantic tickets for under $400, provided one travels in the off-season in coach, purchases them when the special sales are announced, travels on certain days, and so on. On the other hand, a first-class unrestricted ticket bought at the gate for the same plane can cost 10 times as much. However, it is easy to tell what the difference in price buys in this case. It is much harder to do so in scholarly publishing. There is some positive correlation between quality of presentation (proofreading, typography, and so on) and price, but it is not strong. In the area that matters the most to scholars, that of quality of material published, it is hard to discern any correlation. In mathematics, the three most prestigious journals are published by a commercial publisher, by a university, and by a professional society, respectively, at widely different costs. In economics, the most prestigious journals are published by a professional society, and are among the least expensive ones in that field.

Many publishers argue that costs cannot be reduced much, even with electronic publishing, since most of the cost is the first-copy cost of preparing the manuscripts for publication. This argument is refuted by the widely differing costs among publishers. The great disparity in costs among journals is a sign of an industry that has

not had to worry about efficiency. Even in the print medium, costs can be reduced. That they have not been is due to the strange economics of scholarly publishing, which will be discussed in Section 3. However, even the least expensive print publishers still operate at a cost of around $1,000 per article. Electronic publishing offers the possibility of going far below even that figure.

3. Costs of "free" electronic journals

How low can the costs of electronic publishing be? One extreme example is provided by Paul Ginsparg's preprint server [Ginsparg]. It currently processes about 20,000 papers per year. These 20,000 papers would cost $40-80M to publish in conventional print journals (and most of them do get published in such journals, creating costs of $40-80M to society). To operate the Ginsparg server in its present state would take perhaps half the time of a systems administrator, plus depreciation and maintenance on the hardware (an ordinary workstation with what is by today's standards a modest disk system). This might come (with overheads) to a maximum of $100K per year, or about $5 per paper.

In presentations by publishers, one often hears allusions to big NSF grants and various hidden costs in Ginsparg's operation. Ginsparg does have a grant from NSF for $1M, spread over three years, but it is for software development, not for the operation of his server. However, let us take an extreme position, and let us suppose that he has an annual subsidy of $1M. Let us suppose that he spends all his time on the server (which he manifestly does not, as anyone who checks his publications record will realize), and let us toss in a figure of $300K for his pay (including the largest overhead one can imagine that even a high-overhead place like Los Alamos might have). Let us also assume that a new workstation had to be bought each year for the project, say at $20K, and let us multiply that by 5 to cover the costs of mirror sites. Let us in addition toss in $100K per year for several T1 lines just for this project. Even with all these outrageous overestimates, we can barely come to the vicinity of $1.5M per year, or $75 per paper. That is dramatically less than the $2,000-4,000 per paper that print journals require. (I am using a figure of $2,000 for each paper here as well as that of $4,000 from [Odlyzko1] since APS, the publisher of the lion's share of the papers in Ginsparg's server, collects revenues of about $2,000 per paper.) As Andy Grove of Intel points out [Grove], any time anything important changes in a business by a factor of 10, it is necessary to rethink the whole enterprise. Ginsparg's server lowers costs by about two orders of magnitude, not just one.

A skeptic might point out that there are other "hidden subsidies" that have not been counted yet, such as those for the use of the Internet by the users of Ginsparg's server. Those costs are there, although

the bulk of them is not for the Internet, which is comparatively inexpensive, but for the workstations, local area networks, and users' time coping with buggy operating systems. However, those costs would be there no matter how scholarly papers are published. Publishers depend on the postal system to function, yet are not charged the entire cost of that system. Similarly, electronic publishing is a tiny part of the load on the computing and communications infrastructure, and so should not be allocated much of the total cost.

Ginsparg's server is an extreme example of minimizing costs. It also minimizes service. There is no filtering of submissions, nor any editing, the things that distinguish a journal from a preprint archive. Some argue that no filtering is necessary, and that preprints are sufficient to allow the community to function. However, such views are rare, and most scholars agree that journals do perform an important role. Even though some argue that print plays an essential role in the functioning of the journal system (see the arguments in [Rowland] and [Harnad] for opposing views on this issue), it appears that electronic journals can function just as well as print ones. The question in this paper is whether financial costs can be reduced by switching to electronic publishing.

There are hundreds of electronic journals that are operated by their editors and are available for free on the Net. They do provide all the filtering that their print counterparts do. However, although their ranks appear to double every year [ARL], they are all new and small. The question is whether a system of free journals is durable, and whether it can be scaled to cover most of scholarly publishing.

Two factors make free electronic journals possible. One is advances in technology, which make it possible for scholars to handle tasks such as typesetting and distribution that used to require trained experts and a large infrastructure. The other factor is a peculiarity of the scholarly journal system that has already been pointed out above. The monetary cost of the time that scholars put into the journal business as editors and referees is about as large as the total revenue that publishers derive from sales of the journals. Scholarly journal publishing could not exist in its present form if scholars were compensated financially for their work. Technology is making their tasks progressively easier.

Most scholars are already typesetting their own papers. Many were forced to do so by cutbacks in secretarial support. However, even among those, there are few who would go back to the old system of depending on technical typists if they had a choice. Technology is making it easier to do many tasks oneself than to explain to others how to do them.

Editors and referees are increasingly processing electronic

submissions, even for journals that appear exclusively in print. Moreover, the general consensus is that this makes their life much easier. Therefore, if the additional load of publishing an electronic journal were small enough, one might expect scholars to do everything themselves. That is what many editors of the free electronic journals think is feasible. As the volume of papers increases, one can add more editors to spread the load, as the Electr. J. Comb. [EJC] has done recently (and as print journals have done in the past). The counterargument (cf. [Babbitt, BoyceD]) is that there will always be too many repetitive and tedious tasks to do, and that even those scholars who enjoy doing them now, while they are a novelty, will get tired of them in the long run. If so, it will be necessary to charge for access to electronic journals to pay for the expert help needed to run them. Some editors of the currently-free electronic journals share this view. However, none of the estimates of what would be required to produce acceptable quality come anywhere near the $4,000 per article that current print publishers collect. In [Odlyzko1] I estimated that $300-1,000 per article should suffice, and many others, such as Stevan Harnad, have come up with similar figures. In the years since [Odlyzko1] was written, much more experience in operations of free electronic-only journals has been acquired. I have corresponded and had discussions with editors of many journals, both traditional print-only, and free electronic-only. The range of estimates of what it would cost to run a journal without requiring authors, editors, and referees to do noticeably more than they are doing now is illustrated by the following two examples (both from editors of print-only journals):

(a) The Editor-in-Chief or a large journal, which publishes around 200 papers per year (and processes several times that many submissions) and brings in revenues of about $1M per year to the publisher thinks he could run an electronic journal of equivalent quality with a subsidy of about $50K per year to pay for an assistant to handle correspondence and minor technical issues. He feels that author-supplied copies are usually adequate, and that the work of technical editors at the publisher does not contribute much to the scientific quality of the journal. If he is right, then $250 per paper is sufficient.

(b) An editor of a much smaller journal thinks that extensive editing of manuscripts is required. In his paper, he does all the editing himself, and the resulting files are then sent directly to the printer, without any technical staff at the publisher being involved. He estimates that he spends between 30 minutes and an hour per page, and thinks that having somebody with his professional training and technical skills do the work results in substantially better result. If we assume a loaded salary of $100K per year (since such work could often be done by graduate students and junior postdocs looking for some extra earnings in their spare time), we have an estimate of

$25-50 per page, or $250-1,000 per article, as the cost of running an electronic journal of comparable quality.

All the estimates fit in the range $300-$1,000 per article that was projected in [Odlyzko1], and do not come close to the $4,000 per article charged by traditional publishers. Why is there such a disparity in views on costs? It is not caused by a simple ignorance of what it takes to run a viable journal on the part of advocates of free or low-priced publications, since many of them are running successful operations. The disparity arises out of different views of what is necessary. It has always been much easier to enlarge a design or add new features than to slim down. This has been noted in ship design [Pugh], cars, and airplanes, as well as in computers, where the mainframe builders were brought to the brink of ruin (and beyond in most cases) before they learned from the PC industry. Established publishers are increasingly providing electronic versions of their journals, but usually only in addition to the print version. It is no surprise therefore that their costs are not decreasing. The approach of the free electronic journal pioneers has been different, namely to provide only what can be done with the resources available. They are helped by what are variously called the 80-20 or 70-30 rules (the last 20% of what is provided costs 80% of the total, etc.). By throwing out a few features, it is possible to lower costs dramatically.

An example of large differences in costs is provided by projects that make archival information available digitally. Astrophysicists are in the process of digitizing about a million pages of journal articles (without doing optical character recognition, OCR, on the output) and are making them available for free on the Web. The scanning project (paid for by a grant from NASA) is carried out in the U.S., yet still costs only $0.18 per page in spite of the high wages. On the other hand, the costs of the JSTOR project, which was cited in [Odlyzko2] as paying about $0.20 per page for scanning, are more complicated. JSTOR pays a contractor around $0.40 per page for a combination of scanning, OCR, and human verification of the OCR output, with the work done in a less-developed country that has low wage costs. However, JSTOR's total costs are much higher, about $1-2 per page, since they rely on trained professionals in the U.S. to ensure they have complete runs of journals, that articles are properly classified, and so on. Since JSTOR aims to provide libraries with functionality similar to that of bound volumes, it is natural for it to strive for high quality. This raises costs, unfortunately.

It is important to realize how easy it is to raise costs. Even though lack of price competition in scholarly publishing has created unusually high profits [Hayes], most of the price that is paid for journals covers skilled labor. The difference in costs between the astrophysics and JSTOR projects is dramatic, but it does not come from

any extravagance. Even at $2 per page, the average scholarly article would cost around $25 to process. At a loaded salary of $100K per year for a trained professional, that $25 corresponds to only half an hour of that person's time. Clearly one can boost the costs by doing more, and JSTOR must be very frugal in the use of skilled labor.

Is the higher quality of the JSTOR project worth the extra cost? It is probably essential for JSTOR to succeed in its mission, which is to eliminate the huge print collections of back issues of journals. Personally I feel that JSTOR is a great project, the only one I am aware of in scholarly publishing that benefits all three parties, scholars, libraries, and publishers. Whether it will succeed is another question. It does cost more than just basic scanning, and it does require access restrictions. One can argue that the best course of action would be simply to scan the literature right away, while there are still low-wage countries that will do the work inexpensively. The costs of the manual work of cutting open volumes and feeding sheets into scanners is not likely to become much smaller. At $0.20 per page, the entire scholarly literature could probably be scanned for less than $200M. (By comparison, the world is paying several billion dollars per year just for one year of current journals, and the Harvard libraries alone cost around $60M per year to operate.) Once the material was scanned, it would be available in the future for OCR and addition of other enhancements.

The main conclusion to be drawn from the discussion in this section is that the monetary costs of scholarly publishing can indeed be lowered, even in print. Whether they will be is another question, one closely bound up with the strange economics of the publishing industry.

4. The perverse incentives in scholarly publishing

Competition drives the economy, but it often works in strange ways. A study done a few years ago (before managed care became a serious factor) compared hospital costs in mid-sized U. S. cities that had either one or two hospitals. An obvious guess might be that competition between hospitals would lead to lower costs in cities that had two hospitals. However, the results were just the opposite, with the two-hospital cities having substantially higher prices. This did not mean that basic economic laws did not apply. Competition was operating, but at a different level. Since it was doctors who in practice determined what hospital a patient went to, hospitals were competing for doctors by purchasing more equipment, putting in specialty wards, and the like, which was increasing their costs (but not making any noticeable difference in the health of the population they served). The patients (or, more precisely, their insurers and employers) were paying the extra price.

Scholarly publishing as a business has many similarities to the

medical system, except that if anything, it is even more involved. Journals do not compete on price, since that is not what determines their success. There are four principal groups of players. The first one consists of scholars as producers of the information that makes journals valuable. The second consists of scholars as users of that information. However, as users, they gain access to journals primarily through the third group, the libraries. Libraries purchase journals from the fourth group, the publishers, usually in response to requests from scholars. These requests are based overwhelmingly on the perceived quality of the journals, and price seldom plays a role (although that is changing under the pressure to control growth of library costs). The budgets for libraries almost always come from different sources than the budgets for academic departments, so that scholars as users do not have to make an explicit tradeoff between graduate assistantships and libraries, for example.

Scholars as writers of papers determine what journals their work will appear in, and thus how much it will cost society to publish their work. However, scholars have no incentive to care about those costs. What matters the most to them is the prestige of the journals they publish in. Often the economic incentives are to publish in high-cost outlets. It has often been argued that page charges are a rational way to allocate costs of publishing, since they make the author (or the author's institution or research grant) cover some of the costs of the publication, which, after all, is motivated by a desire to further the author's career. However, page charges are less and less frequent. As an extreme example, in the late 1970s, Nuclear Physics B, published by Elsevier, took over as the "journal of choice" in particle physics and field theory from Physical Review D, even though the latter was much less expensive. This happened because Phys. Rev. D had page charges, and physicists decided they would rather use their grant money for travel, postdocs, and the like. Note that the physicists in this story behaved in a perfectly rational way. They did not have to use their grants to pay for the increase in library costs associated with the shift from an inexpensive journal to a much pricier one. Furthermore, even if they had to pay for that cost, they would have come out ahead; the increase in the costs of just their own library associated with an individual deci- sion to publish in Nucl. Phys. B instead of the less expensive Phys. Rev. D (could such a small change have been quantified) would have been much smaller than the savings on page charges. Most of the extra cost would have been absorbed by other institutions.

To make this argument more explicit, consider two journals, H (high priced) and L (low priced). Suppose that each one has 1,000 library subscriptions and no individual ones. L is a lean operation, and it costs them $3,000 to publish each article. They collect $1,000 from authors through page charges, and the other $2,000 from subscribers, so that each library in effect pays $2 for each article that appears

in L. On the other hand, H collects $7,000 in revenue per article, all from subscriptions, which comes to $7 per article for each library. (It does not matter much whether the extra cost of H is due to profits, higher quality, or inefficiency.)

>From the standpoint of society as a whole, or of any individual library, it would be desirable to steer all authors towards publishing in L, as that would save a total of $4,000 for each article. However, look at this situation from the standpoint of the author. If she publishes in L, she loses $1,000 that could be spent on graduate students, conferences, etc. If she publishes in H, she gets to keep that money. She does not get charged for the extra cost to any library, at least not right away. Eventually the overhead rates on her contract might go up to pay for the higher library spending at her institution. However, this effect is delayed and is very weak. Even if we had accounting mechanisms that would provide instantaneous feedback (which we do not, with journal prices set over a year in advance and totally insensitive to minor changes caused by individual authors deciding where to publish), our hypothetical author would surely only get charged for the extra $5 that she causes her library to spend ($7 for publication in H as opposed to $2 in L), and not for the costs to all the other 999 libraries. She would still save $995 ($1000 - $5) of her grant money. Is it any wonder if she chooses to publish in H?

A secondary consideration for authors is to ensure that their papers are widely available. However, this factor has never played a major role, and with the availability of preprints through email or home pages it is becoming insignificant. Authors are not told what the circulation of a journal is (although for established publications, they probably have a rough idea of how easy it is to access them). Further, it is not clear that this information would make any difference, at least in most areas. Authors can alert the audience they really care about (typically a few dozen experts) through preprints, and the journal publication is for the resume more than to contact readers.

In 1993-4, there was a big flap about the pricing of International Mathematics Research Notices (IMRN), a new research announcement journal spun off from the Duke Mathematical Journal. The institutional subscriptions cost $600 per year, and there were not many papers in it. The Director of Publishing Operations for Duke University Press then responded in the Newsletter on Serials Pricing Issues [NSPI], by saying that his press was doing the best it could to hold down prices. It's just that their costs for IMRN were going to be $60,000 per year, and they expected to have 100 (sic!) subscriptions, so they felt they had to charge $600 per subscription. Now one possibility is that the Duke University Press miscalculated, and that it might have been easier for them to sell 400 subscriptions

at $150 than 100 at $600, since IMRN did establish a good reputation as an insert to Duke Math. J. However, if their decision was right, then there seem to be two possibilities: (i) scholars will decide that it does not make sense to publish in a journal that is available in only 100 libraries around the world, or (ii) scholars will continue submitting their papers to the most prestigious journals they can find (such as IMRN), no matter how small their circulation, since prestige is what counts in tenure and promotion decisions, and since everybody that they want to read their papers will be able to get them electronically from preprint servers in any case. In neither case are journals such as IMRN likely to survive in their present form.

The perverse incentives in scholarly publishing that are illustrated in the examples above have led to the current expensive system. They are also leading to its collapse. The central problem is that scholars have no incentive to maintain it. In book publishing, royalties align the authors' interests with those of publishers, as both wish to maximize revenues. (This is most applicable in the trade press, or in textbooks. In scholarly monograph publishing, the decreasing sales combined with the typical royalty rate of at most 15% are reducing the financial payoff to authors, and appears to be leading to changes, with monographs becoming available electronically for free.) For the bulk of scholarly publishing, though, the market is too small to make provide a significant financial payoff to the authors.

5. The future

Although scholars have no incentive to maintain the current journal system, they currently also have no incentive to dismantle it. Even the physicists who rely on the Ginsparg preprint server continue to publish most of their papers in established print journals. The reason is that it costs them nothing to submit papers to such journals, and also costs them nothing to have their library buy the journals. The data from the Association of Reesarch Libraries [ARL] show that the average cost of the library system at leading research universities is about $12,000 per faculty member. (It is far higher at some, with Princeton spending about $30,000 per year per faculty member.) This figure, however, is not visible to the scholars, and they have no control over it. They are not given a choice between spending for the library and for other purposes.

Until the academic library system is modified, with the costs and tradeoffs made clear to scholars and administrators, it is unlikely there will be any drastic changes. We are likely to see slow evolution (cf. [Odlyzko3]), with continuing spread of preprints (in spite of attempts of journals in certain areas, such as medicine, to play King Canute roles, and attempt to stem this natural growth). Electronic journals will become almost universal but most of them will

be versions of established print journals, and will be equally expensive. Free or inexpensive electronic journals will grow, but probably not too rapidly. However, this situation is not likely to be persist for long. I have been predicting [Odlyzko1, Odlyzko2] that change will come when administrators realize just how expensive the library system is, and that scholars can obtain most of the information they need from other sources, primarily preprints. Over the decade from 1982 to 1992, library expenditures have grown by over a third even after adjusting for general inflation [ARL]. However, they have fallen by about 10% as a share of total university spending. Apparently the pressure from scholars to maintain library collection has not been great enough, and other priorities have been winning. At some point in the near future more drastic cuts are likely.

References

[AMSS] Survey of American research journals, Notices Amer. Math. Soc. 40 (1993), 1339-1344.

[ARL] Association of Research Libraries, http://arl.cni.org.

[Babbitt] D. G. Babbitt, Mathematical journals: Past, present and future - a personal view, Notices Amer. Math. Soc., Jan. 1997. Available at http://www.ams.org.

[Bailey] C. W. Bailey, Jr., Scholarly electronic publishing bibliography, available at http://info.lib.uh.edu/sepb/sepb.html.

[BoyceD] P. B. Boyce and H. Dalterio, Electronic publishing of scientific journals, Physics Today, Jan. 1996, pp. 42-47. Available at http://www.aas.org/~pboyce/epubs/.

[Brody] H. Brody, Wired science, Tech. Rev., 99, no. 7 (Oct. 1996), 42-51.

[Conway] P. Conway, Conversion of microfilm to digital imagery: A demonstration project, Yale Univ. Library report, 1996.

[EJC] The Electronic Journal of Combinatorics, http://www.combinatorics.org/.

[EMIS] European Mathematical Information Service, http://www.emis.de/.

[Ginsparg] P. Ginsparg, Winners and losers in the global research village, available at URL http://xxx.lanl.gov/blurb/pg96unesco.html.

[Grove] A. Grove, "Only the Paranoid Survive," Bantam Doubleday Dell, 1996.

[Harnad] S. Harnad, The paper house of cards (and why it's taking so long to collapse), Ariadne, issue # 8, March 1997. Web version at http://www.ukoln.ac.uk/ariadne/.

[Hayes] J. R. Hayes, The Internet's first victim?, Forbes, Dec. 18, 1995, pp. 200-201.

[KingMR] D. W. King, D. D. McDonald, and N. K. Roderer, "Scientific Journals in the United State. Their production, Use and Economics," Hutchinson Ross, 1981.

[Machlup] F. Machlup, K. Leeson, and Associates, "Information Through the Printed Word: The Dissemination of Scholarly, Scientific, and Intellectual Knowledge," vol. 2: Journals, Praeger, 1978.

[NSPI] Newsletter on Serials Pricing Issues, published electronically at Univ. of North Carolina, available at URL http://sunsite.unc.edu/reference/prices/prices.html.

[Odlyzko1] A. M. Odlyzko, Tragic loss or good riddance? The impending demise of traditional scholarly journals, Intern. J. Human-Computer Studies (formerly Intern. J. Man-Machine Studies) 42 (1995), 71-122. Also in the electronic J. Univ. Comp. Sci., pilot issue, 1994 (http://hyperg.iicm.tu-graz.ac.at). Available at author's home page, http://www.research.att.com/~amo.

[Odlyzko2] A. M. Odlyzko, On the road to electronic publishing, Euromath Bulletin, vol. 2, no. 1 (June 1996), 49-60. Available at author's home page, http://www.research.att.com/~amo.

[Odlyzko3] A. M. Odlyzko, The slow evolution of electronic publishing, in preparation.

[PeekN] R. P. Peek and G. B. Newby, eds., "Scholarly Publishing: The Electronic Frontier," MIT Press, 1996.

[Pugh] P. Pugh, "The Cost of Seapower: The Influence of Money on Naval Affairs from 1815 to the Present Day," Conway, 1986.

[Rowland] F. Rowland, Print journals: Fit for the future?, Ariadne, issue # 7, Jan. 1997. Web version at http://www.ukoln.ac.uk/ariadne/.

[TULIP] "TULIP Final Report," Elsevier, 1996. Electronic version available at http://www.elsevier.nl/locate/tulip/.

[TenopirK] C. Tenopir and D. W. King, Trends in scientific scholarly journal publishing in the U. S., manuscript, 1996.