
Economic Issues Concerning Electronic Publishing and Distribution of Scholarly Articles

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ABSTRACT

WHILE THERE HAVE BEEN LITERALLY HUNDREDS of articles and other publications dealing with electronic publishing, few go beyond expressions of opinion or speculation. Very few recent publications, even those having the term "economics" in their titles, provide any empirical evidence concerning these speculations. This article presents some economic issues, provides some quantitative evidence concerning the economics of scholarly journal publishing, and extends these data to examine the economics of electronic publishing. It is believed that publishers and librarians alike tend to apply traditional economic approaches to journal publishing in which economic competition is among journals. However, evidence shows that consumer choices are in fact among alternative ways of obtaining needed information and the attributes of the alternative sources of information rather than choices among journals. Readers of scholarly articles appear to apply a valid economic rationale to deciding from which source to obtain needed information. These economic choices appear to drive the current journal market demand and may do so for electronic alternatives in the future.

INTRODUCTION

This article deals with the economics of four types of electronic distribution of scholarly articles. The first type of electronic distribution is what Elder (1994) calls "full-text journals online." These are

full texts of journals made available online by commercial database vendors such as DIALOG, BRS, STN, and Lexis/Nexis. In a sense, this distribution is like electronic delivery of interlibrary loans (or articles obtained through document delivery services). Schauder (1994) calls this type "publishing via commercial database hosts." Elder states that, among the various vendors, several hundred titles are available, most of which are in business and law. A second type of electronic distribution is what Elder calls "image files on CD-ROM" and Schauder describes as "publishing via portable electronic media" which are journals found on CD-ROM. ADONIS and University Microfilms are the principal sources of such journals. Some of the articles are found in CD-ROM only, but most articles on CD-ROM are also available in print. Elder reports that *Ulrich's* (1992-93) lists 559 serials available on CD-ROM of which only 107 are journals or newsletters. A third type of electronic distribution is called "true electronic journals" by Elder and "publishing via the Internet and related academic networks" by Schauder. These are journals made available only by electronic distribution using the Internet or other networks (at minimal or net cost). Elder indicates that few journals are accessible in this manner. A fourth type of electronic publishing, discussed here because of extensive interest at the current time, deals with the idea that academically written scholarly articles be published by university presses and libraries. Patricia Battin (quoted by Franks, 1993) succinctly captured the widespread sentiments of the academic community by pointing out that:

The advent of electronic capabilities provides the university with the potential for becoming the primary publisher in the scholarly communication process. At the present time, we are in the untenable position of generating knowledge, giving it away to the commercial publisher, and then buying it back for our scholars at increasingly prohibitive prices. The electronic revolution provides the potential for developing university controlled publishing enterprises through scholarly networks supported either by individual institutions or consortia.

Some, such as Okerson (1992), have suggested that such arrangements can avoid many out-of-pocket costs by simply providing free access to these academically produced articles, presumably like interlibrary lending (at least until recently).

There are four basic economic topics that this article will address:

1. the nature and size of the scholarly journal system (at least in the United States),
2. scholarly journal system costs,
3. economics related to the demand for sources of scholarly articles, and

4. economics related to the supply/publishing of scholarly articles.

The next four sections deal with these topics. Following them is a section that discusses the relative importance of these economic issues and how they might affect the four electronic publishing alternatives mentioned earlier. Note that, while an abundance of quantitative economic data concerning scholarly journal publishing was published in the 1960s and 1970s, there is a paucity of such data in recent publications (aside from readership data). There are hundreds of articles on scholarly publishing and on electronic publishing (see, for example, an excellent review by Schauder, 1994, with just over 200 references and the 1992 *Serials Review* on economic models for networked information); few of the recent references provide more than opinion or speculation.

THE NATURE AND SIZE OF THE SCHOLARLY JOURNAL SYSTEM

Scholarly journals clearly dominate in the amount of information published and read in science, engineering, and medicine and, to a lesser degree, in other scholarly fields. In science (including engineering), the number of journals and the number of scholarly articles has grown dramatically since the genesis of such publishing. In fact, this type of recorded knowledge has doubled in quantity about every seventeen years, a trend which persists today—e.g., in the United States, the number of articles published has increased from 208,000 in 1960 to 382,000 in 1977 to 601,000 in 1990 (see Griffiths et al., 1991; King et al., 1981). However, these numbers tend to reflect the growth in the number of scientists and engineers. Evidence over a twenty-five year period shows that the number of scientific scholarly articles published per scientist or engineer has increased and then decreased slightly (0.110 articles per person in 1965; 0.155 in 1977; 0.114 in 1985; to 0.104 in 1990). The majority of scientific articles are written by scientists at universities and government laboratories. There are many reasons why scientists write articles, including requirements (implicit or explicit) by funding agencies that they do so, the often reported “publish or perish” syndrome, and so on. We believe that documenting research is an integral and enhancing aspect of creativity, and that many authors recognize this. In addition to those who write for the pleasure of it, we also believe that many write for the altruistic purpose of wanting to share their research results and creative ideas with others.

There has long been a misconception of the extent to which articles are read and used, at least in scientific fields. Two lines of inquiry, started in the 1960s, led to the belief by many that journal articles are infrequently read and not particularly useful. The first of these was a series of

studies by Allen (see for example, 1988, 1966) and others (see for example, Rosenbloom & Wolek, 1967; Tushman, 1979; Shuchman, 1981) in which researchers (primarily engineers) were asked to indicate sources of information they used to help address a specific research project. They all found that engineers tend to use interpersonal communication extensively, and they rely on internal technical reports more than on the formal published literature.¹ Later, Allen (1988) pointed out that the literature is the primary source used for two scientific research projects (Rosenbloom and Wolek [1967] reported similar results). Thus, journal articles are particularly useful in scientific research.

In fact, all forms of communication fill special niches, depending on the purpose for the use of the information, time when needed, ease of access, desired depth and accuracy, required amount, cost, availability, and so on. Regardless of the frequency of use of a source of information (or the order in which sources are used), the usefulness and value of information when it is used can be considerable. For example, information obtained from library-provided articles has greater usefulness and value than articles obtained elsewhere, even though less reading is from library collections than from other sources (Griffiths & King, 1993).

Another line of research concerning scientific communication was pursued by Garvey and Griffith for the American Psychological Association (see for example, Garvey, 1979). During the 1960s and early 1970s, Garvey and colleagues also reported a small amount of reading of individual journal articles. Their research was performed by sending copies of tables of contents to a random sample of scientists and engineers and asking if they had read the articles. From the large samples of scientists and engineers, a median of about fifteen readings per article title distributed was observed and reported. In some instances (e.g., Griffith & Mullins, 1992), they reported that the median amount of reading per psychology article is about 200 when extrapolated from a 7 percent sample to the entire population. Both the 15 median readings and the 200 median readings have been quoted often. To some, these results have suggested that journals are not an effective means of communicating. From a statistical standpoint, however, the averages are somewhat higher than the medians since the observations involved highly skewed distributions of readings. Furthermore, the tables of contents were sent fairly soon after publication so that the amount of reading of articles beyond that time was neither included nor projected. The Garvey and Griffith data were reviewed and the results extrapolated to the entire population and over time (King et al., 1976). The time dimension was taken into account using an aging distribution. This produced an average amount of reading per article nearly five times greater than, for example, the

reported 200 readings per psychology article. Later, from a 1977 national survey of scientists and engineers, it was estimated that the average reading per psychology article is 858 readings (King et al., 1981). Garvey's method was later replicated partially to understand it better and to confirm the statistical validity of the two methods and resulting estimates (King et al., 1978). The Garvey and Griffith data continue to be misreported to this day (see, for example, Williams, 1975, in Schauder, 1994). Garvey and colleagues also presented strong evidence of the relative roles of various forms of scientific communication and when newly created knowledge shows up in various forms, again demonstrating that the various forms fill specific niches depending on their attributes and user requirements.

There is some indication that the average amount of reading per person (and time spent reading) has recently decreased somewhat as has the average number of articles published. The current amount of reading is estimated to be forty-seven scholarly article readings per year for professionals located in nonacademic environments²(eighty-two readings for R&D professionals) and 178 readings for faculty and academic researchers.³ We believe that writing and reading may have decreased slightly over the years as a result of competition for professionals' available communication time. In particular, there is some indication that an increase in number of informal meetings one must attend, electronic mail, doing one's own word processing, and so on, are all detracting from time spent reading and writing journal articles (and other formal publications). On the other hand, there is overwhelming evidence of the continued usefulness and value of scholarly journal articles in both academic and nonacademic environments (see Schauder, 1994; Schaffner, 1994, for a summary of journal use and usefulness; and King, 1994, for a summary of the work of Allen, Garvey, and Griffith, and Pinelli et al.).

As shown in Table 1, scholarly articles are read most frequently by nonacademic professionals to apply to their work activities, although nearly one-third of the readings are for keeping up with the literature and 8 percent for communications purposes (Griffiths & King, 1993). Faculty also use journal articles primarily for their teaching (21 percent) or research (33 percent).

One indicator of the value of scholarly articles is the time professionals are willing to spend reading them—51 hours per year per professional in nonacademic organizations (86 hours by R&D professionals) and 205 hours in universities. Others, such as Pinelli et al. (1989), have observed similar results. Professionals and faculty would not expend this scarce resource (their time) on reading if the information read was not of considerable value to them. Professionals must read or they will simply be left behind. Since recorded knowledge doubles

Table 2.
Sources of Scholarly Articles that are Read

| <i>Source of Articles</i> | <i>Proportion of Readings (%)</i> | |
|-------------------------------|------------------------------------------|----------------------------------------------|
| | <i>Academic Institutions³</i> | <i>Nonacademic Organizations²</i> |
| Personal subscriptions | 51 | 45 |
| Organization libraries | 35 | 32 |
| Shared department collections | 8 | 5 |
| Other | 6 | 18 |

about every seventeen years, scientists graduating from college will have been exposed to only one-sixth of the new knowledge that will be created during their careers and which they must master to be successful.

We have observed that performance and achievement are correlated to the extent of reading by professionals and academicians (Griffiths & King, 1993). The amount of work-related reading is found to be correlated to five indicators of productivity; reading is shown to lead to higher quality of work; reading results in substantial savings; those whose achievements have been recognized through awards and high level assignments read more than nonachievers; and, in one company, twenty-five persons designated as the "fast-trackers" read substantially more than their cohorts and others. Similar results were also observed in the 1960s (Lufkin & Miller, 1966). While a distinction is not made in these results for types of documents read, it is known that most reading and time spent reading involves scholarly journal articles.⁴

SCHOLARLY JOURNAL SYSTEM COSTS

In order to examine the economic implications of electronic distribution of scholarly articles, one must determine all of the current functions associated with communication through journals and establish whether and how the functions might be performed by electronic means and the likely cost implications. To our knowledge, this has not been done recently. A list of functions and their costs were reported by King et al. (1981) for traditional scientific journal publications and by King and Roderer (1978) for electronic alternatives. These functions are listed below along with some current costs (Griffiths & King, 1993), and the 1977 costs are extrapolated by inflation factors.

- *Authorship.* Average scientists' time preparing articles was 82 hours per article in 1977. The extrapolated 1977 cost (including salaries of authors and support staff, postage, etc. of writing and reworking articles, resubmission, etc.) is \$5,470 per article. Author page charge fees are \$490 per article.
- *Reviewing/refereeing.* In 1977, reviewers averaged 6 hours per manuscript for those rejected and 6.25 hours for those accepted. The extrapolated 1977 cost (largely donated) of reviewing articles is \$480 per article. This includes review and critical annotation.
- *Subject editing (donated).* The extrapolated 1977 subject editing cost is \$95 per article.
- *Editing.* The extrapolated 1977 cost of review by editorial staff, submission to reviewers, decision to accept or reject, and copy editing is \$67,900 per journal; \$790 per article published; \$10.80 per subscription; \$0.09 per article distributed.
- *Composition and graphics preparation.* The extrapolated 1977 costs are \$102,500 per journal; \$1,190 per article; \$16.10 per subscription; \$0.16 per article distributed.
- *Subscription runoff.* The extrapolated 1977 cost of reproduction of the master image, assembly into journal issue, and distribution to subscribers is \$16.00 per subscription and \$0.16 per article distributed.
- *Separates runoff.* Preprint and reprint extrapolated 1977 costs are \$11.80 per article copy (138 copies per article average).
- *Miscellaneous publishing activities.* Such activities include journal promotion, advertising, etc. The extrapolated 1977 costs are \$16,600 per journal; \$190 per article; or \$0.03 per article distributed.
- *Library acquisitions.* The extrapolated 1977 cost for new acquisitions (placement of order, follow-up on order, cataloging of new titles) is \$224 per new journal. The cost for annual maintenance (receipt of journal issues and preparation for access and use) is \$72.35 per journal. Annual storage cost is \$14.04 per journal and weeding cost is \$2.11 per journal. In 1993, the cost is estimated to be \$68 per journal (not including new title acquisitions).
- *Library use.* The extrapolated 1977 cost to libraries for use of journals in the library is \$4.70 per use. Currently this cost is estimated to be \$5.92 per reading (\$1.61 per reading in current periodicals room). These costs include photocopying, reshelving, and indirect costs allocated.
- *Interlibrary lending and borrowing.* The extrapolated 1977 cost is \$27.14 to the borrowing library and \$19.70 to the lending library. The current estimated cost is \$18.07 per item borrowed (\$19.12 per item via document delivery service) and \$20.25 per item loaned. These costs include allocated indirect costs.

- *Printed indexes.* The extrapolated 1977 cost of printed indexes is \$0.44 per article used.
- *Automated bibliographic searching.* The extrapolated 1977 cost of automated searching is \$95.50 per online search or about \$14.30 per article read. 1993 costs are estimated to be \$160.17 per search or \$23.90 per article read (including allocation of indirect costs).
- *User acquisition costs.* The 1993 cost to order, process, and retain a personal subscription is \$9.80 per journal and cost to use (browsing, look-up, etc.) is \$3.50 per article read. The cost to use a library article is \$11.20. This includes about \$8.40 in professionals' time (salary, etc.) to visit and browse journals (based on an average of three readings per visit). Also included is an average of \$2.80 photocopying cost per article read (based on 57 percent of readings resulting in photocopies being made). For all reading, this comes to \$400 per year per person or \$3.96 per reading (in nonacademic organizations).
- *Reading articles.* In 1977, scientists averaged forty-five minutes per article read or seventy-two hours per year at an extrapolated cost of \$2,340 per year per person or \$24.30 per article read. In 1993, this cost is estimated to be \$2,970 per year per scientist (R&D) or \$36.20 per reading (in nonacademic organizations), based on fifty minutes per article read.

In 1977, the total scientific and technical scholarly journal expenditure (not extrapolated) in the United States was estimated to be \$4.7 billion or about \$19.25 per article read. At that time, all the distribution channels leading to a reading were described and estimates developed in terms of the number of transmissions and costs. Quantities and costs for electronic alternatives were also estimated.

ECONOMICS RELATED TO DEMAND FOR SOURCES OF SCHOLARLY ARTICLES

The number of scholarly journal subscriptions varies with price. Classic pricing studies in the past that show this were conducted by Berg (1973) and Braunstein (1977). Recent evidence of this is described by Noll and Steinmueller (1992). They show graphs in which circulation is plotted against subscription price for 1,400 journals. They conclude that "the most important source of subscription price variation among scholarly journals is variation in their circulation" (p. 37). However, there are many factors that determine whether or not an individual or a library subscribes to a journal.

In both academic and nonacademic institutions, most readings result from browsing personal subscriptions, library-routed issues, or current periodicals found in library or department collections. Such

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browsing generally keeps readers current with the literature, although sometimes the information has immediate use for research, teaching, or other activities. Browsing sometimes leads to use at a later time when a specific information need arises (13 percent of readings of articles over one month old are from articles that were previously read). Other means for identifying read articles include colleagues (19 percent), citations in another article (6 percent), citations in a printed index (3 percent), and automated bibliographic searches (5 percent).

Read articles are physically obtained from a number of sources including personal subscriptions,⁵ library copies, interlibrary borrowing or document delivery services, colleagues or authors, and so on. In Table 2, the proportion of readings of articles obtained from various sources is displayed.

The choices made by professionals from among sources of information appear to depend, to a large degree, on the following factors:

- price of personal subscriptions,
- membership in a professional society,
- discretionary funds available (organizations, grant, personal) for professionals to buy journals,
- number of times a journal is read,
- distance to library,
- age of article that is read, and
- purpose of reading.

Some evidence concerning the dependence of these factors is discussed later.

In the late 1970s, an economist from Charles River Associates, Inc. (1978) conducted an economic analysis of factors that explain

the probability that a professional will subscribe to a particular scientific journal. The five most important factors are listed in their order of importance (i.e., contributions to the probability of purchase):

1. availability of the journal in a library frequently used by the professional and convenience of the location of the library to the professional;
2. the subscription price;
3. the proportion of articles read for current awareness;
4. whether the journal is an association journal; and
5. the amount of professionals' expenditures on journals and other information services.

Obviously, the most desirable source is a personal subscription. However, readers are often forced to choose between subscribing and relying on journals that are available through their library. For current reading, the choice appears to be dictated by the trade-off between the personal subscription price (and relative ease of access and use) and the price paid in terms of one's time and effort to go to a library to read. Most older articles, say over two years, are obtained from a library—even when readers subscribed to the journal at the time the article was first published.

The price of a journal subscription clearly influences whether or not persons subscribe to scholarly journals and, as widely reported, journal prices are increasing at a much faster rate than inflation (see Figure 1 for evidence involving the increasing price of scientific journals and Table 3 in which data suggest that commercially published journals are worse in this regard than nonprofit publications).

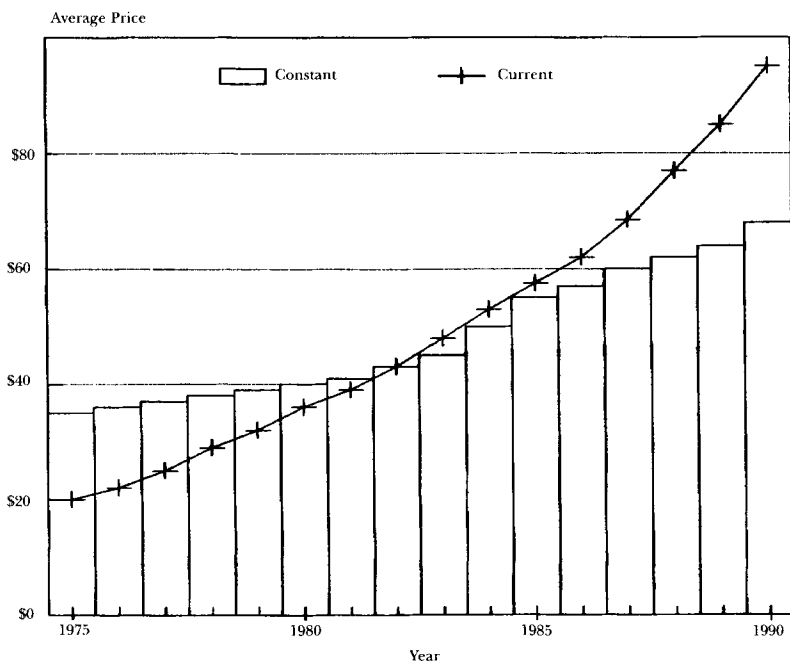
TABLE 3.
PRICE INCREASES BY TYPE OF PUBLISHER

| <i>In Scientific Journal</i> | <i>Price in Constant Dollars (1982)</i> | | | |
|------------------------------|-----------------------------------------|----------------|--------------------|--------------|
| <i>Year</i> | <i>Commercial</i> | <i>Society</i> | <i>Educational</i> | <i>Other</i> |
| 1985 | \$58.01 | \$49.13 | \$14.82 | \$21.83 |
| 1990 | \$91.35 | \$53.99 | \$13.59 | \$20.21 |
| Percent of Change | 57% | 10% | -800% | -700% |

In 1965, the average number of personal subscriptions was 5.0 subscriptions per scientist and the average increased to 5.7 in 1977 (King et al., 1981). Since that time, the average number of personal

subscriptions appears to have decreased sharply to about 3.4 at the present time (Griffiths et al., 1991). The proportion of readings from library-provided articles has increased substantially during that time period—from 18 percent in 1977 to 27 percent in 1984 and 35 percent currently.

Some data collected in companies and federal agencies demonstrate the economic trade-offs of purchasing a personal subscription versus going to the library to read a journal. Professionals average about \$11.20 per article reading to use library copies of journals. Thus, it costs about \$11.20 to read one article from a typical journal, \$56 to read five articles from the journal, \$280 to read twenty-five articles, and \$896 to read eighty (or most) articles from a typical journal. The question is how this compares with the cost of reading from a personal subscription at these levels of reading. The latter cost includes three cost elements: the price of the subscription; the cost to order, receive, and retain it; and the cost to browse or access an article in



Note: GNP Implicit Price Deflator was used to obtain 1982 constant dollars

Source: *The Bowker Annual of Library and Book Trade Information*, pp. 8-35. New York: R.R. Bowker, 1962-1990

In: Griffiths, J.-M., & King, D. W. (1993) *Special Libraries: Increasing the Information Edge*. Washington, DC: Special Libraries Association.

Figure 1. Average price of U.S. periodicals, all fields: 1975-1990.

order to read it (not including the reading time). For example, assume that a journal personal subscription price is \$80. The ordering, receiving, and retention cost is estimated to be about \$9.80 per journal and the cost to read (browsing, look-up, etc.) is about \$3.50 per article read. Thus, the total cost of reading one article from this journal is \$93.30 (compared with \$11.20 using the library copy). The total cost of reading five articles is \$107.30; twenty-five articles is \$177.30; and eighty articles is \$369.80 compared with \$56, \$280, and \$896 respectively for reading five, twenty-five, and eighty articles obtained from the library. Referring to Figure 2, it is clearly less expensive to read articles from a journal in the library if there are fewer than twelve (11.7) readings from the journal, and less expensive to subscribe to the journal above that number of readings. At the extremes, say one reading and eighty readings, the average cost per reading is dramatically different. At one reading from the journal, it would cost \$82.10 less to read the article in the library than to subscribe to

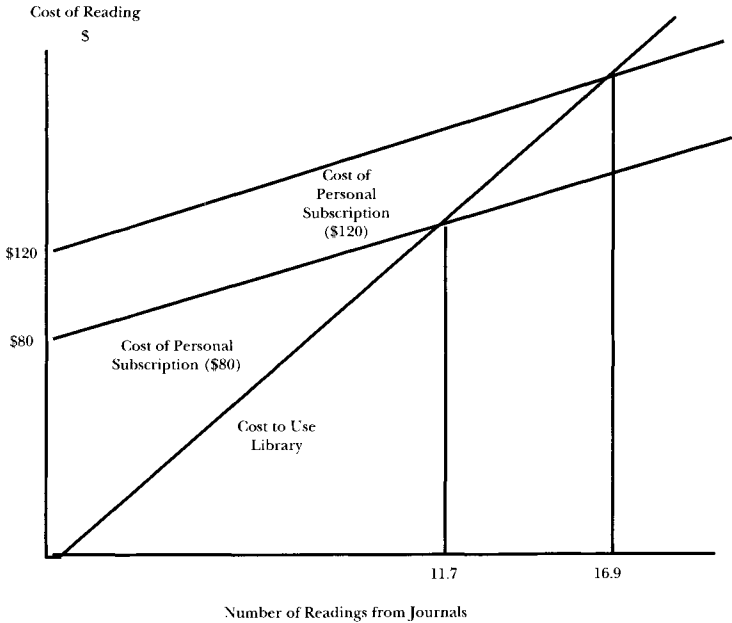


Figure 2. Journal price and demand relationship (output versus usage).

TABLE 4.
DISTRIBUTION OF AMOUNT OF READING IN JOURNALS

| <i>An Individual's Reading per Journal</i> | <i>Proportion of Readers (%)</i> | <i>Cumulative Proportion of Readers (%)</i> |
|------------------------------------------------|--------------------------------------|-----------------------------------------------------|
| 1-5 articles read | 43.6 | 43.6 |
| 6-10 articles read | 34.4 | 78 |
| 11-15 articles read | 8.21 | 86.21 |
| 16-20 articles read | 5.5 | 91.71 |
| 21-25 articles read | 3.37 | 95.08 |
| 26-30 articles read | 1.97 | 97.05 |
| 31-40 articles read | 1.23 | 98.28 |
| 41-50 articles read | 0.82 | 99.1 |
| >50 articles read | 0.9 | 100 |

the journal. At eighty readings from the journal, it would cost \$6.58 less per reading or a total of \$526.20 less to read the articles from a personal subscription. Under the same assumptions, the breakeven point increases as the personal subscription price increases as follows (based on solving for x —the number of readings—in the simple equation $\$89.80 + \$3.50x = \$11.20x$): 16.9 break even at \$120; 39 readings at \$200; 66 readings at \$500; and 131 readings at \$1,000.

Clearly under these assumptions, price increases can result in a dramatic shift from reading personal subscriptions to relying on alternative sources for the information, including a library. Some evidence of how this phenomenon might affect the demand for personal subscriptions is given in the next section, but first some caveats concerning the data that are discussed above:

- The trade-offs discussed earlier only include costs to the individual. The reason for this is that the choices made by individuals tend to consider only their time and costs. However, from the university, company, or agency's perspective, the library costs should also be considered.
- Clearly other factors (e.g., availability of the journal in the library, its availability in a shared office collection, journal routing, etc.) will affect the model.
- Also, the parameters of the model are variable, and therefore any departures from the assumed values will affect the economic trade-offs.
- Very little reading of articles over two years old comes from personal subscription issues, presumably because they are discarded.

TABLE 5.
SOURCES OF FREQUENTLY READ JOURNALS TO WHICH SCIENTISTS DO NOT SUBSCRIBE
AND REASONS FOR NOT SUBSCRIBING

| | <i>Proportion of Scientists (90)</i> |
|--------------------------------------------------------------|--------------------------------------|
| Sources of Frequently Read Journals not Subscribed To | |
| Borrow or obtain from colleague | 21 |
| Library copy | 76 |
| Other | 3 |
| Reasons for not Personally Subscribing to Journal* | |
| Readily available from colleague | 10 |
| Price of journal | 66 |
| Readily available from library | 61 |
| Other | 3 |

Source: King Research, Inc., 1984 National Statistical Indicators survey (n = 985) in Griffiths & King (1993).

*Proportions do not add to 100 percent, since respondents could have more than one reason.

The reason for presenting a simplistic example is to demonstrate what may well be taking place, and considerable evidence supports this assertion. One weakness of the model is that professionals do not think of their time in terms of dollars, which were used in the example given earlier, although evidence suggests that their economic behavior roughly follows the pattern discussed. Some further indication of this economically rational behavior is given in the next section.

ECONOMICS RELATED TO SUPPLY/ PUBLISHING OF SCHOLARLY ARTICLES

In this section, the economic evidence discussed earlier is extended to the publishers' perspective. Under the assumptions discussed, the breakeven point between using a library and purchasing a personal subscription increases dramatically as the subscription price increases. Knowing the distribution of readership of a journal can help determine how price increases affect demand. Several studies have provided some useful evidence in this regard.⁶ Across readings, the distribution of current readings per journal is derived⁷ and presented in Table 4.

TABLE 6.
HYPOTHETICAL EFFECT OF PRICE CHANGES ON PUBLISHERS' REVENUES AND PROFITS

| <i>Individual Reading per Journal</i> | <i>Breakeven Journal Price (\$)</i> | <i>Number of Subscribers</i> | <i>Journal Cost (\$)</i> | <i>Journal Revenue (\$)</i> | <i>Profit or Loss (\$)</i> |
|---------------------------------------|-------------------------------------|------------------------------|--------------------------|-----------------------------|----------------------------|
| 1 to 5 | \$46 | 5,640 | \$190,240 | \$259,440 | \$69,200 |
| 6 to 10 | \$85 | 2,200 | \$135,200 | \$187,000 | \$51,800 |
| 11 to 15 | \$123 | 1,380 | \$122,080 | \$169,740 | \$47,660 |
| 16 to 20 | \$162 | 830 | \$113,280 | \$134,460 | \$21,180 |
| 21 to 25 | \$200 | 490 | \$107,840 | \$98,000 | (\$9,840) |
| 26 to 30 | \$239 | 300 | \$104,800 | \$71,700 | (\$33,100) |
| 31 to 40 | \$316 | 170 | \$102,720 | \$53,720 | (\$49,000) |
| 41 to 50 | \$392 | 90 | \$101,440 | \$35,280 | (\$66,160) |

What this distribution says is that about 43.6 percent of professionals who read a journal (at least once), read five or fewer articles from the journal, 78.0 percent of the readers read ten or fewer articles, and so on. This means that if there are 10,000 persons who might read at least one article over the life of a year's publication of a journal, about 7,800 persons will read fewer than eleven articles from that journal.

The average number of journals in which at least one article is read by a professional is 12.4 journals. The current estimated number of personal subscriptions is 3.4 subscriptions per person (with an average 5.6 of the 12.4 read journals found in libraries, 0.6 in shared department collections, and 2.8 from other sources). From the distribution discussed, the number of journals (of the 12.4 that are read) in which more than ten articles are read is estimated to be 2.7 journals (not much below the 3.4 average number of personal subscriptions). In fact, some journals obtained through personal subscriptions are infrequently read (and some above ten readings are from library copies and other sources). For example, 11.6 percent of journals which have five or fewer readings are personal subscriptions and about 2.5 percent of journals having over fifty readings are from libraries and shared office collections. This phenomenon mentioned earlier is to be expected because of varying distances to the library and prices of personal subscriptions.

A 1984 survey of scientists provided some reasons for not subscribing to frequently read journals (see Table 5). The principal alternative source is a library copy (76 percent of scientists), and the reasons given for using alternative sources include the price of the journal (66 percent of scientists) and that the journal is readily available from the library (61 percent).

Distance to the library will have some impact on the trade-off since the time of professionals is relatively expensive. Most of the cost of reading library copies is attributable to this time. Thus, if a person is far from the library, the library reading cost goes up and the breakeven point decreases thereby requiring more personal subscriptions. Some indication that distance to the library does, in fact, affect subscription decisions is as follows (Griffiths & King, 1993):

- Professionals close to libraries take fewer personal journal subscriptions than those farther away (2.8 subscriptions for those less than 10 minutes away versus 4.0 subscriptions for those ten minutes or more away).
- Professionals close to libraries and shared department collections read more from these sources than from personal subscriptions. Specifically, if professionals are:
 - less than five minutes away, 55 percent of their readings are from library and shared department collection copies;
 - between five and ten minutes away, 38 percent of their readings are from library and shared department collection copies; and
 - more than 10 minutes away, 25 percent of their readings are from library and shared department collection copies.

While the economic model mentioned earlier does not fully explain choices as to sources of journals used, it is a good indicator of what appears to be happening.

To demonstrate the effect of the distribution of readership on journal publishing, an example is given later in this discussion. This example assumes that there is a total of 10,000 readers of this journal's articles and that individuals will subscribe to journals only if their amount of reading is above the breakeven point. It further assumes that the proportion of publishers' fixed predistribution costs allocated to personal subscriptions is \$100,000, and reproduction and distribution costs are about \$16 per subscription. Under these assumptions, the breakeven prices, number of personal subscriptions, journal cost, revenue, and profit or loss would be as given in Table 6.

It is clear, under the assumptions given, that increasing prices result in reduced profit, and charging too much (e.g., over \$200) would

lead to substantial losses to publishers. At 5,000 readers, there would not be a profit at any price level from personal subscriptions. The combination of this kind of price sensitivity and not understanding user choices may have led some publishers astray in their pricing policies. While noncommercial publishers are unconcerned with profits, their revenue must at least cover costs and, therefore, they must be concerned as well. Professional societies "bundle" a number of services in their membership fees and thus have been able to keep subscription costs relatively low (see Table 3).

LIBRARY ARTICLE BORROWING VERSUS PURCHASING JOURNALS

The choice between "borrowing" through interlibrary loan (or document delivery service) versus purchasing a journal is very much

TABLE 7.
BREAKEVEN POINT OF PURCHASING JOURNAL VERSUS DOCUMENT DELIVERY SERVICE, BY JOURNAL SUBSCRIPTION PRICE

| <i>Subscription Price</i> (\$) | <i>Breakeven Point (Readings)</i> |
|-----------------------------------|-----------------------------------|
| \$50 | 6.8 |
| \$100 | 9.6 |
| \$120 | 10.8 |
| \$150 | 12.5 |
| \$250 | 18.2 |
| \$500 | 32.6 |
| \$1,000 | 61.2 |

Source: Griffiths and King, 1993.

TABLE 8.
GROWTH IN ARTICLE COPIES OBTAINED BY LIBRARIES, 1980 TO 1993

| | <i>Article Copies (Millions)</i> | | |
|----------------------------|----------------------------------|-------------|-------------|
| | <i>1980</i> | <i>1988</i> | <i>1993</i> |
| Interlibrary loan | 7 | 8.9 | 12.2 |
| Document delivery services | 1.9 | 3.4 | 6.8 |
| Bibliographic utilities | 0.3 | 1.7 | 5.6 |
| Total | 9.2 | 14 | 24.6 |

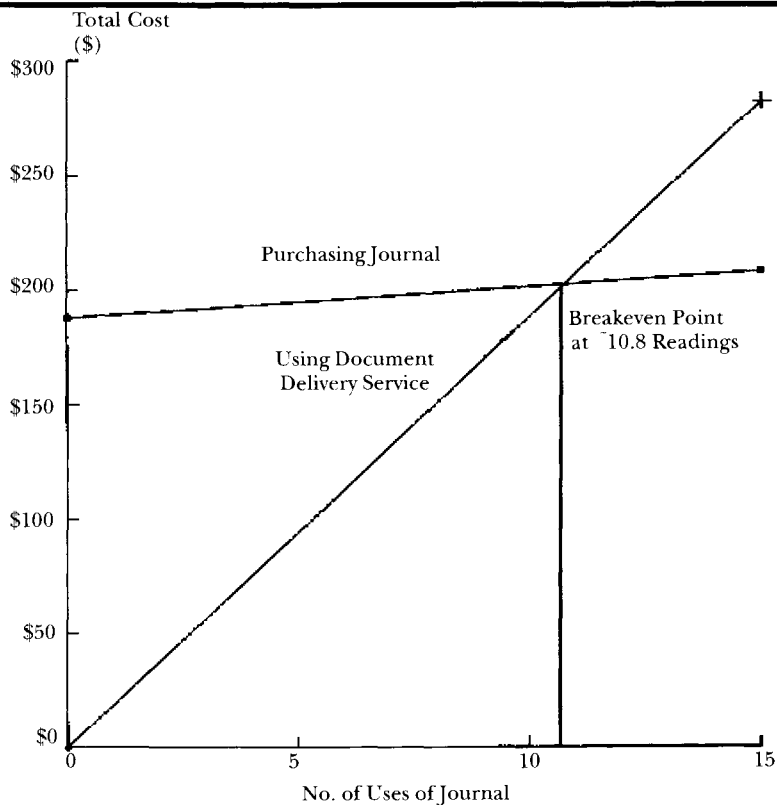


Figure 3. Comparison of the total cost of purchasing a \$120 journal versus using a document delivery service.

like that of an individual's choice. If there are few collective readings from a library journal, the library should probably obtain article copies from interlibrary loan (or document delivery), and if there are many readings, the library should subscribe to the journal. Again, there is a breakeven point somewhere between amount of reading extremes depending on the price of the journal, number of times the journal is read, and ILL or document delivery attributes such as cost (including charges), ability to locate copies, speed of delivery, and photocopy quality (e.g., with photographs, etc.). In special libraries, library subscriptions average about 118 readings per journal per year, and journals in shared department collections average 38 readings (recognizing that these latter journals are generally maintained for less than two years).

Library subscription prices are often higher than personal subscriptions and library costs of processing are much higher. The fixed

cost to a library of a \$120 journal is about \$188 because of an estimated \$68 cost for collection development, acquisition, ordering, claiming, storage, and so on. The library variable cost per article read in the library is about \$1.34 per article read which includes photocopying and reshelving. Interlibrary borrowing comes to about \$18.10 per item borrowed, including staff time, equipment, facilities, and overhead (or allocated indirect costs). The trade-off between these two choices is depicted in Figure 3. The breakeven point is 10.8 readings using the earlier discussed assumptions. As shown in Table 7, the breakeven point increases substantially as the subscription price increases.

Yet, because the collective amount of reading of library journals is so much greater than for personal subscriptions, the library demand is substantially less sensitive to changes in journal prices. For example, if a publisher more than doubles the price from \$120 to \$250, the breakeven point nearly doubles (from 10.8 to 18.2), but the change in price is likely to affect the decision to subscribe for only about 10 or 11 percent of the journals based on reading distribution observed in two academic libraries (Chen, 1972; Kent et al., 1978). Thus, the price increase would merely decrease demand by about 11 or 12 percent, and revenue (profit) would increase dramatically if all libraries have similar distributions of readings from their journals.

Of course the large price increases over the years have yielded fewer library journal subscriptions and, consequently, there has been a remarkable growth in number of article copies obtained by libraries from 9.2 million in 1980 to 24.6 million in 1993. Part of this growth is attributable to the borrowing versus purchasing trade-offs, where price increases lead to a trend toward borrowing. On the other hand, the amount of use of library copies has increased as a result of a shift from personal subscriptions to library use, thereby dampening the effects of price increases. However, federal and statewide support of multitype library networking, improved verification capabilities, faster fulfillment and delivery, the growth of document delivery services, and article availability through bibliographic utilities (e.g., CARL, OCLC, DIALOG, etc.) have also contributed to this growth. For example, as shown in Table 8, greater relative growth has taken place through document delivery and bibliographic utilities than interlibrary loan.

ECONOMICS OF ELECTRONIC DISTRIBUTION OF SCHOLARLY JOURNAL ARTICLES

True Electronic Journals

There are currently a few journals processed and distributed exclusively electronically (Elder, 1994). Some, including electronic distribution of preprints, appear to be very successful (see, for example, Stix's [1994] and Leslie's [1994] descriptions of Ginsparg's physics and

mathematics database and Harnad's *Psycology*). It is assumed that any scholarly system in the near future will continue the basic functions now performed (i.e., authorship, peer review, refereeing, editing, electronic composition, etc.). Some have argued against continued peer review; however, arguments for its continuance are persuasive, at least to us (see Daniel, 1993). Technology can enhance and speed all of the predistribution functions, but this is true of paper-based distribution as well. Thus, unless electronic processes limit quality and format of text, thereby reducing display (and subsequent print-out) quality, the predistribution processing costs are likely to remain about \$2,000 per article⁸ or about \$3.10 per reading (at 640 average readings per article). This cost (\$3.10 per reading) would be the absolute minimum a publisher or other entity would have to charge (royalty) to recover costs for an article read 640 times. Other publisher and reader costs would be electronic input to a database, storage and access costs; electronic transmission costs; request processing/invoicing; user costs for browsing or identifying, locating, requesting/display, print-out (if desired); and so on. Once these costs are established, one should compare subscription costs and electronic distribution costs (see Figure 2 where electronic distribution substitutes for "cost to use library"). Lesk (1992) suggests that incremental (i.e., distribution) cost is nearly zero (and without loss of quality), and the issue becomes one of who will pay the average cost. He also points out that there are no valid economic analogies to electronic publishing among many possibilities. A major question is who retains the electronic store of articles. Some favorable economies of scale would likely result if a large facility is used. It seems unlikely that with all costs included, the unit costs would be below \$5.00 and could be as much as \$15.00. This suggests that some readers should still obtain traditional personal subscriptions if enough articles are read.

It appears that the unit cost of accessing articles electronically would have to be well below about \$4.00 per article read for this form to replace all personal subscriptions to journals (some argue that this is the case). Returning to choices made by individuals (see Figure 2) as an example, one could replace access from library copies by access electronically at, say, a cost of \$8.00 per reading. Thus, the breakeven point would be about twenty readings. Referring back to Table 6, this would reduce the number of subscriptions from 2,200 to 830 subscriptions. About 67 percent of the 640 readings per article would be from journals read twenty or fewer times (i.e., 429 readings). For eighty articles in a traditional journal, the increased amount of revenue would be \$154,400 at a charge of \$4.50 per use (in addition to \$134,460), and increased costs would be \$34,300 (since \$3.50 of the costs mentioned earlier are to cover an allocation of fixed

predistribution costs and about \$1.00 is assumed to cover electronic distribution). Thus, the net revenue potential for electronic article distribution is substantial. Under the assumptions discussed, this appears to be a win-win situation in that readers pay less to obtain their information, and publishers have an opportunity for increased return on their investment. The disadvantage to publishers is that the new revenue takes place at the time of reading and not ahead of time when journal subscription revenue is received, thus reducing their positive cash flow somewhat.

Since \$8.00 per reading for electronically provided articles is less than \$11.20 per reading from journals provided in libraries, it would appear that library journals would not be used. Again, one can make a strong argument for the niche still to be occupied by library access to journals. In academic libraries, neither the students nor the libraries may want to pay \$4.50 (cost to the publisher) for each article read electronically when the cost per reading of many journals found in academic libraries is far less than this amount. As mentioned previously, the distance to the library contributes substantially to the \$11.20 library reading cost. Furthermore, for some, the average readings per visit will be many more than three. Thus, for many in an organization who are close to the library, reading costs will be less than the \$8.00 cost per reading assumed for electronically provided articles. Finally, a substantial proportion of library readings are of older articles which may not be available electronically.

The example above is based on 640 readings per article. If there are one-half that number, the predistribution costs would increase from \$3.10 to \$6.20, but subscription price would likely increase as well. The net effect might be that journals or articles with low readership may be more amenable to total electronic distribution. Certainly, there are many high quality and useful articles that have a limited audience or readership which are now "covered" in journals by highly read articles in the journal. They must be considered for electronic distribution as well.

The demand for electronic distribution will depend on attributes of the information and the distribution of readings. Getz (1992) gives some examples of attributes (which he calls "values") of electronic publications and feels they must exceed performance of print. These attributes include readability, durability, portability, manipulability, storage costs, and the ability to index them.

Full-Text Journals Online

Electronic access to full text from commercial database vendors is somewhat like true electronic journals, except that predistribution costs are likely to be incurred only by traditional publishers, and they

would use vendors as a complement to traditional paper-based distribution. Royalties received from such electronic distribution are advantageous to publishers. This form of distribution may well displace the "other" sources of current reading (Table 2) and traditional interlibrary "lending" of scholarly articles. The latter depends in part on the edge of electronic holdings since a significant portion of articles obtained through ILL are older ones. Unit costs for this electronic means of distribution are likely to be less than for current interlibrary loan but higher than for true electronic journals because vendor costs must be added to current publisher costs. There is also likely to be a valuable niche for this form of electronic distribution as a partial replacement for readings now obtained from libraries (see Figure 2), when unit cost is less than the cost to use a library (e.g., when users are far away from the library), and as an alternative to personal subscriptions when the subscription price is high and/or the amount of reading in the journal is relatively low. In some instances, librarians may serve as intermediaries for this means of article distribution.

Image Files on CD-ROM

This form of electronic distribution is seriously being tested in a number of academic libraries (e.g., the TULIP experiment). It is assumed that not only will libraries acquire full text in CD-ROM but also will provide remote access to users by networked CD-ROM (LAN). To examine the economics of this electronic alternative, one can use Figure 2 as an example, where the cost of library use is likely to be significantly less (particularly when users are far away), thereby increasing the breakeven point and reducing the number of personal subscriptions. The costs of library use should be viewed from the perspective of the entire organization (i.e., user and library) since publishers will likely ultimately require royalty payments or site license for locally networked distribution, and there will be a shift in costs from users to the library. The library costs would include distribution costs and fixed costs of price, acquisition, retention, and so on (allocated by amount of use in the library versus remote access). Depending on the fixed costs already discussed, there will still be some need to obtain articles from infrequently read journals and/or articles. These may be obtained from true electronic journals or full-text journals online depending on their accessibility and cost. The economic trade-offs would be similar to those shown in Figure 3. Academic libraries are likely to remain the principal source for both paper and CD-ROM forms of scholarly journals because of student requirements and extensive faculty use. In companies and agencies, distribution from networked library CD-ROM copies is likely to replace journal routing.

Electronic Publishing and Distribution Through Academic Entities

Bryant (1994) provides a discussion of how the university press and academic libraries may collaborate to form a basis for future electronic publishing and distribution of academically created knowledge found in articles. The initiative for this alternative seems to be driven by the dramatic increase in journal prices, particularly prices of commercially published journals. The idea is that most scholarly articles are written, refereed, and read by academicians and thus the major costs of the scholarly article system are already borne by this community. With new technologies widely available, perhaps the "middleman" can be eliminated and costs significantly reduced.

While the concept is a compelling one, two economic considerations should enter into any serious thought regarding this electronic alternative. First, the total and unit costs of all of the current functions must be carefully determined. Some functions are likely to have distinguishable economies of scale in which the average or unit costs decrease as the number of units increase (up to a "critical mass" at which the unit costs approach an asymptote). Editing, arrangement for refereeing/review, composition, and means for identifying, locating, and accessing articles are all possibilities in which economies of scale should be determined and taken into account. Since authorship, review/refereeing, and some subject editing are currently "donated" costs, it has been suggested that editing costs also be donated by academicians. With most costs donated, it is assumed that the information can be distributed "free" or at a very minimal charge (ignoring the fact that the bookkeeping cost of charging any charge is in itself not minimal). Because of economies of scale,⁹ our concern is that this model could result in maximizing overall "system" costs (although some costs are hidden costs) rather than reducing costs.

Our second concern involves scholarly articles in science, engineering, business, and so on because most reading of these articles is in companies and government agencies and laboratories. The usefulness and value of this information is enormous in these settings (Griffiths & King, 1993). Thus, some provision should be made by academic publishers to distribute articles electronically (or in paper form) to this nonacademic community. This brings into question the suggestion of ignoring some donated costs and of not recovering costs (sometimes through exchange among universities). If university administrators object to footing the bill for nonacademic use of scholarly articles, some means of charging or royalty payments may be required. On the other hand, the electronic images could be turned over or licensed to a vendor or publisher for distribution. It is believed

that this issue of exchange among academic institutions may be much less a problem in some fields such as history, philosophy, and so on, since this literature appears to be largely read by academicians. For this reason, the latter fields might be better suited to this electronic alternative. However, Altbach (1989) says that: "In my view, at least for the social sciences and humanities, the traditional forms of communication are alive and well—and unlikely to be replaced by any kind of innovations in the near future" (p. 72). This is because of a general lack of interest on the part of the journal system participants.

CONCLUSION

We have described the nature and economics of the scholarly journal system, particularly in science and technology. Some simple economic examples are extended to four potential types of electronic distribution of scholarly articles. However, it seems clear that further systemic and economic examination is required before we in the information community can predict which of the electronic alternatives will surface in a prominent manner and the niches they will fill. Further economic analysis should be done of individual journal and article reading distributions and of detailed costs of all relevant functions. This was done in libraries in the 1970s for the reading of library journals (Chen, 1972; Kent et al., 1978), and similar reading distributions are needed for all sources of article reading. Future economic analysis should also take into account a distinction between small and large journals (i.e., those journals and articles having a small readership and those having a large readership).

Based on this sparse economic evidence, we speculate that electronic article distribution could result in the following scenarios over the next five to ten years:

- academic libraries will reduce the size of their scholarly journal collections but not substantially so;
- libraries in companies, agencies, etc., will also reduce the size of their scholarly journal collections to a greater degree than academic libraries;
- scholarly journals on CD-ROM will have a niche in both types of libraries but will not replace some current paper journals;
- all four types of electronic publishing are likely to survive, with each establishing a role depending on the amount of use and attributes of delivery;
- some large organizations and their libraries will begin to negotiate licensing arrangements with large publishers (i.e., those with a large number of titles) so that libraries can distribute articles electronically to their constituents (e.g., within a company, etc.) without copyright infringement;

- personal subscriptions to commercially published journals will continue to drop dramatically unless prices are decreased drastically;
- personal subscriptions through professional memberships will drop but not substantially;
- reduced personal subscriptions will result in more use of library collections and electronic publications;
- most distribution through interlibrary loan will be replaced by electronic distribution (exceptions being for older rare journal articles which will be processed by document delivery services at a high cost);
- most external electronic distribution will be by one or more online vendors, depending on licensing arrangements by publishers;
- universities are likely to play a role in electronic publishing of their faculty and student outputs, however, particularly for science and engineering, they may not be the sole distribution channel; and
- electronic publishing will require new emphasis on navigational and search tools and support.

Grycz (1992) summarizes several models in reviewing papers presented in *A Special Issue on Economic Models for Networked Information*. These "models" are: benchmark print-based model; acquisition-on-demand model; national site license model; discipline-specific literature base model; augmented print model; distributed information model; and corporation for scholarly publishing model. These models describe "generic" ways in which electronic publishing might be done. None of the models is quantitative or mathematical in nature.

Lynch (1992) also prepared a reaction to the *Special Issue* papers in which he concluded that three options emerge from calls to action among the papers. In the first option, he indicates that an agreement with the existing rights holder is needed to allow the current print-based rights holders to make the transformation to networked information. He goes on to emphasize that the tradition is print based and, for the foreseeable future, networked information will merely be printed information stored and distributed using electronic technology. Virtually all of it will be published both electronically and in print. The same conclusion was reached by King et al. in 1981, but improved technologies and resulting economies since then are likely to push much more toward the electronic alternative. Unfortunately, few economic data exist to allow us to really know. Lynch goes on to suggest that "we need to develop an indigenous electronic scholarly publishing and communication system" involving electronic journals, databases, knowledge bases, bulletin boards, listservs and "other new flora and fauna" in the network ecology. Finally, he recommends developing "better tools for managing, navigating, filtering, and

mining both old and new resources." To that might be added the need to better understand the systemic and economic dynamics of current scholarly communication and the effects of relevant electronic alternatives.

NOTES

- ¹ Probably the most comprehensive set of studies conducted with engineers is by Pinelli, Kennedy, and Barclay and colleagues (see King [1994] for a summary of this impressive work).
- ² Data are from a compilation of twenty-three proprietary studies of companies and government agencies and four national surveys involving over 10,000 survey responses from scientists, engineers, lawyers, and other professionals (Griffiths & King, 1993).
- ³ Data are from a survey of 451 faculty and researchers at the University of Tennessee, Knoxville, as part of a University Libraries needs assessment study in progress.
- ⁴ Reading is defined as going beyond the title and abstract to the text of the article. Time spent reading is estimated from questions asked in a "critical incident" study of reading.
- ⁵ Personal subscriptions are defined as those which are personally addressed to one at his or her home or office regardless of who pays for it.
- ⁶ Results from studies done for Procter & Gamble Co., DuPont, and the University of Tennessee.
- ⁷ Readership surveys asked questions concerning the article last read by the respondent. For the last article read, respondents were asked approximately how many articles were read the last year from the entire journal. Responses were weighted to account for the fact that articles from frequently read journals are more likely to be chosen in the survey than those from infrequently read journals.
- ⁸ The article costs for some scholarly journals may be substantially higher. For example, Odlyzko (1993) indicates that AMS reports mathematics articles' costs range from \$900 to \$8,700 with the median being about \$4,000. On the other hand, both Odlyzko and Ginsparg in personal correspondence suggest that even \$2,000 per article is much too high based on more recent evidence.
- ⁹ An example of this phenomenon has occurred in statewide interlibrary loan systems in which the system protocol is to distribute requests so that each library lends as much as it borrows. While seeming to be equitable, this policy ends up costing libraries much more than using large libraries for processing loan requests and fulfilling requests (see King et al., 1992).

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