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Lessons for the future of journals

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Science journals can continue to thrive because they provide major benefits.

Technology is transforming all aspects of the journal system. Despite the current atmosphere of turmoil, more publishers are producing electronic journals, and the proportion of reading from electronic versions is increasing rapidly.

We have tracked the characteristics of US scholarly science journals from 1960 to 2000, received more than 15,000 scientist readership survey responses between 1977 and 2001, and collected cost data on the activities of authors, readers, publishers, libraries and other participants. By observing long-term trends and past successes and failures, we can learn much about the future of journals.

Our results show that, over these years, the journal system has remained surprisingly stable. Scientists still depend on scholarly journals for reporting research results, obtaining information and as reference sources. Also, the number of articles published per scientist, the amount of reading and the indicators of usefulness and value are virtually unchanged. The overall cost of the journal system has stayed relatively constant, although costs have shifted among participants.

The mistaken belief persists that new technologies can easily remedy any weakness in the system. All-or-nothing approaches — an entirely electronic system, or e-print servers or article databases totally replacing journals — have been advocated. This year, in particular, has seen bitter disputes (see below). But such disputes are not new and, if resolved thoughtfully, can benefit journals in the long term.

The journal system is at a critical stage — poor judgement could mean its deterioration or destruction. We believe that insights from the past can provide constructive guidance for innovators and the scientific community alike.

Communication technologies

In the 1960s and 1970s, many scientists believed that journal articles were written largely to satisfy tenure requirements and that publications were overpriced, too slow, unread, proliferating explosively and a huge waste of paper. Meanwhile, hundreds of studies on the channels of scientific communication found that authors write for many reasons, that growth in the literature is strongly correlated with the number of scientists, and that articles are generally well read (depending on the size of the audience) and considered extremely valuable inside and outside the academic community.

Many thought that electronic journals would resolve the flaws in the system. All the main components for an electronic-journal system existed by 1970 — authors could input digital text through magnetic tapes or cards; publishers used computerized photocomposition or computer-driven typesetting; libraries were beginning to automate; bibliographical databases were being searched online; scientists had computers and modems; and the foundations of the Internet had been established.

Yet a 1978 analysis by King Research forecast that it would be 20 years before electronic journals became commonplace, because acceptance of the necessary electronic processes would develop unevenly and slowly, as would their capabilities[1, 2]. In particular, standard codes for text input and better means of processing mathematical equations, chemical compounds and graphics were needed. The analysis predicted that the potential of electronic publishing would not be realized until all the components were fully in place and standardized.

These components continued to develop in the 1980s, and by the early 1990s, electronic journals finally emerged. Today, almost two-thirds of scientific journals are available both electronically and in print, and there are more than 1,000 electronic-only peer-reviewed journals.

In addition to observing long-term trends of information-seeking and reading, we recently resurveyed scientists at two institutions to observe changes before and after electronic journals (Oak Ridge National Laboratory, 1984 and 2000; University of Tennessee at Knoxville, 1993 and 2001). We found that about a third of readings there are now from electronic sources; the amount read by these scientists is up (although time spent reading is about the same) and from a broader range of journals; scientists rely more on online search tools to find articles; the proportion of reading from personal and institutional subscriptions is unchanged; and there is more reading from copies of individual articles rather than whole issues of journals. Scientists continue to value highly the information they find in journal articles, whether print or electronic[3].

Continuing innovation

High journal prices, continued perceptions of inadequacies in the journal system and fascination with new technologies have spurred a rash of innovative ideas for enhancing or replacing traditional journals. Examples are the Open Archives Initiative, the Public Library of Science and the Association of Research Libraries' SPARC initiative. Many of these ideas show promise for improving scientific communication. Multiple options for distributing research results have strengthened scientific communication, and will surely continue to do so. But experience shows that it is much more difficult to adopt new technologies throughout a complex system than one might think.

The quality filters of peer-reviewing, editing, indexing, abstracting and bundling articles together in categories all add to the system's overall value. If we discard the functions performed by librarians and publishers, we will surely need to reinvent them. There is a tendency to promote an innovation as the only solution to a problem when, in fact, it would merely provide a niche satisfying certain information needs.

History shows that a diversity of channels for distribution and publication increases the value of scholarly information. Publishers should not object to web archives, and authors should not abandon journals. Researchers should use multiple distribution channels, including self-archiving and publishing in traditional journals. Journals provide a stable archive of the literature, quality filters and other valuable aspects; web e-print servers allow quick access to more sources of information. Together, they serve the need of today's scientists for more knowledge from a wider variety of sources.

Publishers versus librarians

The 1960s and 1970s also saw efforts to develop central databases or archives of scientific articles, including preprints in physics and medicine. Preprint services were set up, notably the National Institutes of Health Information Exchange Group[4, 5]. But, despite extensive use, this failed through lack of funding. Even so, the growth in the distribution of individual articles was phenomenal — around 40 million copies in the United States by the late 1970s and more than 100 million today.

Libraries avoided the cost of buying infrequently read journals by obtaining copies of articles through interlibrary lending. The high cost of labour-intensive bibliographic verification and location, coupled with frequent unfilled requests, led to a proposal for a 'one-stop' US national periodical centre. But this was defeated in Congress, largely due to heavy lobbying by publishers and, oddly, some libraries. Its reported purpose was to replace the thousands of sources for obtaining copies of articles, although

privately many felt that a central database would ultimately become electronic and replace the need for individual journals.

Publishers were concerned about the central database and convinced that they were being 'ripped off' by inter-library lending. A bitter and impassioned battle with librarians ensued, which was only partially resolved by the 1976 US copyright revisions. However, statistical studies[6], [7] subsequently revealed that interlibrary lending was not seriously affecting publishers' revenue. In fact, after the US Copyright Clearance Center (CCC) was established, revenue from royalty payments for lending was so low that the copyright requirements were broadened to cover all photocopying in an organization, which at least provided enough income to cover the cost of CCC operations. Factual information acquired earlier might have avoided much of this acrimony and expense.

The 1980s increase in journal prices has reopened the rift between librarians and publishers. Commercial publishers were called "the devil" at the Association of College and Research Libraries' annual conference this year, and the Association of American Publishers complained of "the serious issue" of libraries giving away electronic copyrighted materials (Washington Post, 2 July 2001). This web debate explores many conflicting viewpoints on the Public Library of Science's call for an author boycott of publishers, which started last month[8]. (It is too early to measure the effects of this action.)

Journal prices have certainly increased faster than inflation[2], [9], whereas, over the same period, the publication cost per page for print journals, the overall publication costs per scientist and the costs per reading have decreased. This paradox is partly explained by the inherent nature of publishing costs. Publishers provide three basic article-related services: (1) collecting manuscripts of interest to readers in a discipline; (2) ensuring trust and quality; and (3) providing distribution and/or access. Many journals provide other useful information, such as editorials, letters, commentaries, reviews, guides to literature and database links (see Box 1 Objectives of scholarly journals).

Most publishers are reluctant to reveal their real costs, but we have derived a comprehensive model[9]. Essentially, journal publishing has large fixed costs, regardless of circulation, involving (1) and (2) above, other information-processing costs and overheads. To recover these costs, a low-circulation journal must charge more than a high-circulation journal. For example, a journal with 500 subscribers and typical costs must charge at least $800 to recover fixed costs, but the same-size journal with 5,000 subscribers need charge only about $110. It had been thought that electronic publishing would reduce costs (and prices), but print reproduction and distribution costs are typically only about $25–35 per annual subscription. Electronic access avoids these costs, but has a substantial additional fixed cost — putting up full text on the web, staffing, software and other technology issues including design, functionality, searchability and speed. All of this significantly affects price.

Also, the numbers of articles and pages in journals have increased appreciably over the past 20 years, increasing the total costs of information content and distribution, despite reductions in the cost per page. Inflation and increased journal sizes together account for more than half of price increases. The combination of electronic and print versions has increased fixed costs and, therefore, prices. The average number of personal subscriptions per scientist has roughly halved over 20 years, so publishers have had to recover their fixed costs by accelerated price increases to libraries, where demand is less price-sensitive (see ref. 9).

The fall in personal subscriptions does not mean that scientists are reading less, rather that they are using more library-provided articles, document-delivery services, interlibrary lending and full-text databases. An average university scientist reads three times more library-provided articles than in 1977, and scientists in other organizations average seven times more.

Despite increases in price and amount of reading, the total subscription revenue to publishers has remained relatively constant when normalized by numbers of scientists and amount of reading. University libraries have borne the brunt of the price increases because of the fall in personal subscriptions.

The extraordinarily high prices of commercial journals are due in part to their low circulation. For example, in 1995 the median circulation for commercial publishers was 1,400 subscriptions, compared with 5,600 for society publishers. Of course, commercial publishers tend to serve new, small scientific specialities. It is certainly not true of all journals or all publishers that high prices are due to exorbitant profits. Commercial prices are correlated with the number of titles published[10]. This suggests that market power achieved through size permits higher prices and profits, but larger, labour-intensive publishers almost certainly have higher overheads on direct costs. Yet being large means that publishers can do research and their own technical design. This is why projects such as BioOne seek to bring these advantages of size to small publishers.

Benefits of knowledge

Publishers, scientists and librarians need to base their actions on facts, not emotions. Publishers are not a barrier to access. Much of the current ill will stems from ignorance — librarians and scientists do not understand the causes of rising journal prices, and publishers, just as with interlibrary lending, are afraid of becoming obsolete if readers have access to articles without paying for them. As before, there is no solid evidence that this will happen. One potential bridge between publishers and librarians is the expanding use of site licences, which can minimize the effects of factors that increase prices, and allow librarians and publishers to negotiate their differences.

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