KEYNOTE PAPER

The slow evolution of electronic publishing

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ABSTRACT

How will scholarly publishing evolve? The history of other technological innovations suggests the shift to electronic publications will be rapid, but fundamental changes in the nature of scholarly communications will be much slower.

1. Introduction

Technological predictions are notoriously hard to make correctly. As an example, we have:

> There is no reason anyone would want a computer in their home.
>
> Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977.

We know what has happened for Digital, the former high-flyer, in the last decade, and might be tempted to conclude that it was the result of poor predictions, such as the one above. However, other, more successful, companies have been guided by leaders who were not much better at predicting the future. For example:

> 640K ought to be enough for anybody.
>
> Bill Gates, 1981

The difficulties of predicting developments in technology have discouraged many.

> I confess that in 1901, I said to my brother Orville that man would not fly for fifty years...Ever since, I have distrusted myself and avoided all predictions.
>
> Wilbur Wright, 1908

While the predictions quoted above were all too conservative, the general tendency has been to be too optimistic. For example, in 1913 Edison was expecting the motion picture to transform schools:

> I believe that [it] is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks.

The War on Cancer, declared by President Nixon in 1971, in the aftermath of the successful manned lunar landing, was expected to conquer that disease within a decade. There have also

been frequent predictions, going back to the 1940s, of the imminent arrival of weather control, automated highways, underwater cities, true artificial intelligence, and personal helicopters. Although Leonardo da Vinci and Jules Verne are justly famous for their prophetic speculations, the general record is poor. According to [Schnaars], only about 20% of the documented predictions by experts about technological developments have been accurate. (See also [Corn] for studies of the record of futurology.)

Although the general forecasting record is poor, we do have to plan, and that requires making predictions. A reason to hope that the predictions in this note will be more accurate than most is that we live in the age of Moore's Law. This "law," originally a short-term prediction made in 1965 on the basis of extremely limited data (cf. [Schaller]), states that the number of transistors that can be placed on a chip doubles about every 18 months. It is increasingly being used to denote other cases of rapid but steady and predictable improvements in technology, for example in digital storage capacity and communication bandwidth. Many of the excessively conservative predictions that have been made in the recent past (such as that of Olson quoted above or about growth of cellular telephony) resulted from a lack of appreciation of the persistence and pervasiness of Moore's Law. All the indications are that this "law" will hold for the next 10-20 years, and thus we can count on a continuation of the electronic revolution.

Although Gordon Moore has his name attached to Moore's Law, similar predictions had been made even earlier. For example, [Licklider] made an unusually accurate forecast about electronic publishing back in 1965. (This was the same year that Moore formulated an early version of his "law," but Licklider's book was based on studies he led several years earlier.) By extrapolating trends in processing, storage, and communication, Licklider predicted that digital libraries would become practical around the year 2000. The main contribution of my paper [Odlyzko1] has probably been to demonstrate conclusively that Licklider's forecast was right, and a complete shift of scholarly publishing to an electronic format was finally becoming feasible as a result of developments in computing and communications.

That something is feasible does not mean it will happen. Many proponents of electronic publishing have been frustrated by the continued dominance of print journals. Stevan Harnad, one of the earliest and best known advocates of electronic journals (cf. [Harnad1]) recently confessed in [Harnad2] that "... I've given up trying to predict the day of [shift to electronics] ..."

On the other hand, many people have been surprised by the speed of conversion. The 1991 "Loken Report" of the American Physical Society [APS] did predict technological developments well, but forecast wide availability of journals in electronic format only around 2020. However, all the APS journals will be available electronically by 1998.

The aim of this note is to look at the speed with which various technological innovations have been introduced in distant and recent past. Some tentative conclusions will be then drawn about scholarly journal publishing. It appears likely that the trend of making established print journals available electronically will accelerate, until in a few years there are will be few available exclusively in print. A shift towards much less expensive electronic-only journals might take on the order of a decade. These will continue to be basically just online versions of traditional print journals, though, of the sort that are often derided by electronic publishing

enthusiasts as "shovelware" (print material that has been shoveled onto the Web). The emergence of more modern communications systems that take full advantage of the interactive potential of the Web will probably take several decades.

2. Pace of transition

The general perception is that the world is changing much more rapidly than before. A software industry representative was quoted as saying: "The length of eternity is 18 months, the length of a product cycle" [Schaller]. Ed McCracken, the CEO of Silicon Graphics, says that his company does not do any long-range planning, since relevant technologies change too rapidly. There is also quantitative evidence of faster change, with shorter design cycles, and a larger fraction of products having been recently introduced. This is in line with the explosive growth of the Internet, Fig. 1. Mosaic, the first widely used graphical browser, was released unofficially in early 1993, and officially in the fall of that year, and by the end of 1994 http traffic (which comes from using the World Wide Web) had become more than half of total Internet traffic.

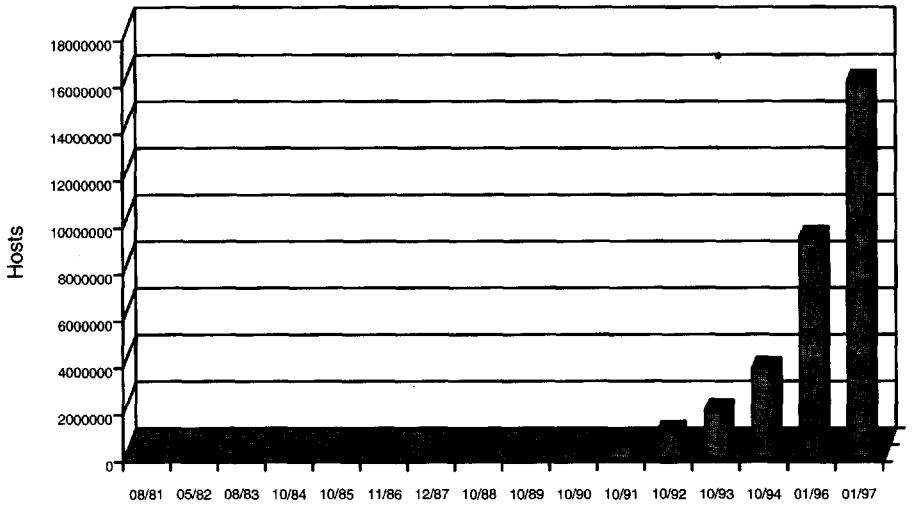

Figure 1: Growth in number of Internet hosts

In publishing, there is the standard example of the Ginsparg preprint server [Ginsparg]. Within 12-18 months, it became the dominant mode of communication among Ginsparg's fellow high energy theoretical physicists. It has grown ever since by taking over other areas, and processes around 20,000 submissions per year.

A complete change in 12 to 18 months is indeed "Internet time." Many regard it as normal, and the frustration of some proponents of electronic publishing is that they do not see motion that is that fast. However, in general "Internet time" is not typical.

> A modern maxim says: "People tend to overestimate what can be done in one year and to underestimate what can be done in five or ten years."
>
> (footnote on p. 17 of [Licklider])

While over three decades have passed since Licklider wrote this note, it still applies. A decade does seem to be the time scale on which new technologies are fully adopted. This is considerably less than used to be common. For example, steam-powered ships took a century to displace sailing ships, and electricity and the telephone took several decades to reach more than half the households in the United States. More recent innovations, such as jet airplanes and the fax have been adopted faster, but not all that much faster, and usually not on "Internet time." Fig. 2 shows the evolution of the market for prerecorded music, from vinyl LPs to CDs. This evolution towards clear dominance of CDs took two decades.

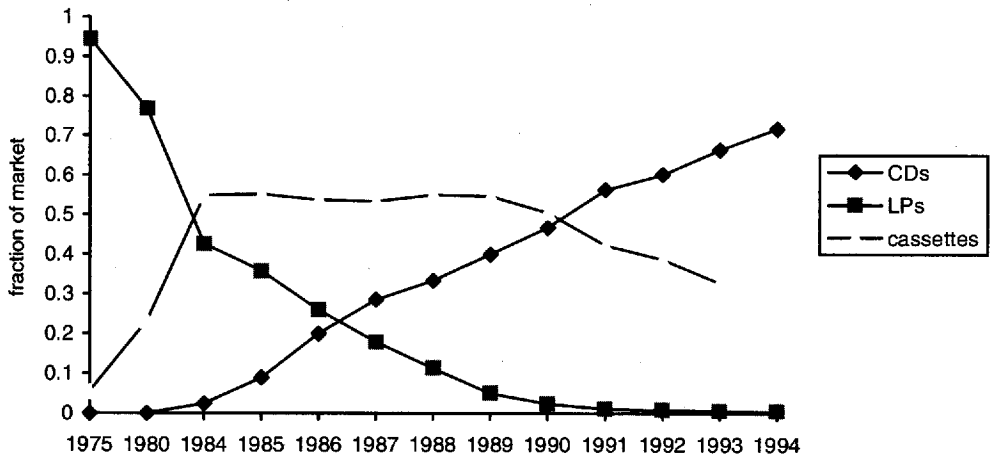

Figure 2: Pre-recorded music sales in the United States, as a fraction of the total

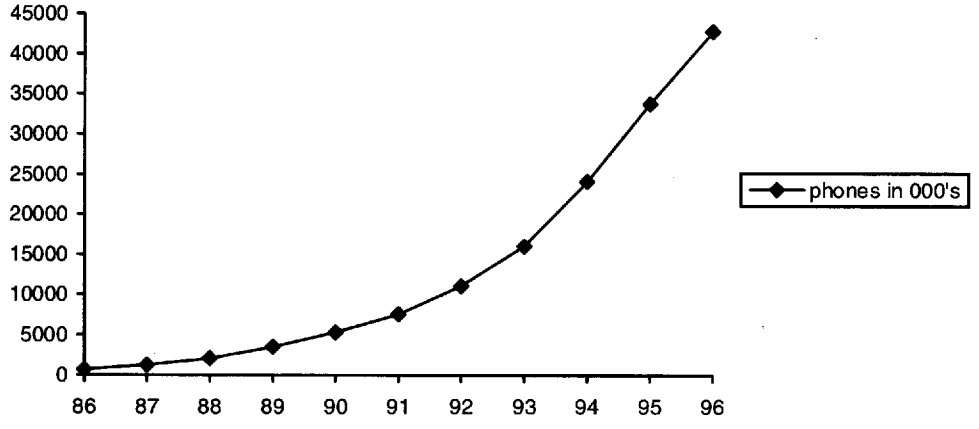

Figure 3: Number of cellular phone users in the United States

Fig. 3 shows (this time in raw numbers) the growth in the number of cellular telephone users. What we see there is the first half of the traditional S-curve that appears to be ubiquitous in studies of new technology dissemination. In the last dozen years, we have had explosive growth in cellular use, and we are now in a period of still rapid, but slowing growth, nearing saturation. Although we do not have reliable data on growth in usage of TEX and its dialects, they appear to have followed similar trends. It did take them 10-15 years to achieve their current dominant position in typesetting in computer science, mathematics, and physics.

Social changes are considerably slower than the diffusion of new technologies. The divorce rate in the U. S. had started increasing in the 1920s and 1930s, and started growing rapidly after War World 2, doubling between 1950 and around 1980, when it started to decline slowly. Those rates of change are typical of many aspects of academia. Fig. 4 shows the degree of collaborative work among mathematicians. (It is based on data provided by Patrick Ion of *Mathematical Reviews*, which he collected for the graph in [GrossmanI]. For more comprehensive data on increasing collaborative work among scientists in all areas, see [HicksK1, HicksK2].)

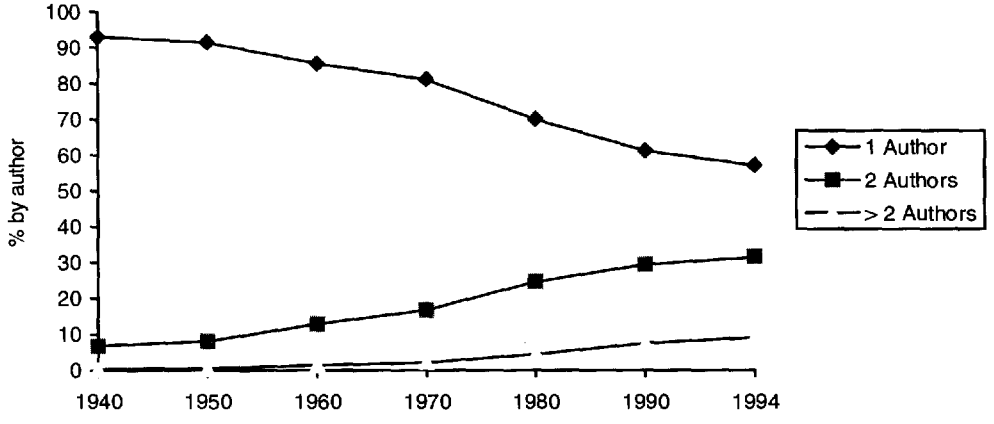

Figure 4: Growth in collaboration among mathematicians. Fractions of papers reviewed in Mathematical Reviews by number of authors.

This graph shows that something profound has been going on, with the fraction of singly-authored papers declining from 93% to 57% between 1940 and 1994. Some fundamental shift in the nature of mathematical research, or at least in the sociology of mathematical publishing, has been going on. However, this transformation has taken over 50 years. That is far from "Internet time."

The ubiquity of the S-curve in describing diffusion of new technology has been studied extensively. (See [Moore1, Moore2] for some recent discussions, for example.) I will not attempt to review that literature here. My main concern will be with the speed of change. There are several points that seem worth emphasizing. As was mentioned in the preceding paragraph, social change is almost always slow. Even when the change does not involve any major social transformations, it tends to be slow. Why does it take 10-15 years for widespread adoption of technologies that are as compellingly useful as cellular phones? This results from a combination of factors. Typically, initially a new product or service is expensive, of limited availability, and of poor quality. What is crucial, though, is that for most people, just about any innovation affects only a small part of their life. They have many other things to do, and since it takes time, money, and effort to change, few people rush to do it. Inertia should never be underestimated.

What appear to be inefficiencies can persist for a long time if they are small enough. Coca-Cola currently has the second or third highest stock market valuation of all US companies, even though in blind tastings its principal product often loses to competitors. Marketing has

overcome the lack of distinction in the product. The cost to users is small, so the economic incentives to change are lacking.

Fax machines have been proliferating at the same time that PCs have been spreading. Yet fax might seem redundant in the age of the PC. After all, most messages are first created on PCs, printed, and then fed into fax machines. It might seem much more efficient to just use e-mail. However, there are many reasons for continuing popularity of fax machines. They are cheap and reliable, not all PCs are hooked up to e-mail, handwritten notes are easy to transmit, and so on.

The fax example brings up another important point. The same basic technology that makes an innovation possible often also improves older, competing products. The same microprocessors that made the PC possible made the fax machines cheaper, faster, and more reliable. The steel-hulled, steel-masted "grain racer" sailing ships of from the turn of the century carried up to ten times as much cargo per crew member as their wooden-hulled, wooden-masted predecessors of the Napoleonic era.

Even in areas, such as software, which live on "Internet time," change is not as rapid as the popular opinion holds. While a product cycle may indeed be 12 to 18 months, and there has been tremendous hoopla about Windows95 and Windows97, there are still tens of millions of PCs running DOS. What is it, then, that leads to rapid adaptation of a new technology? Occasionally the innovation is so striking, and meets user needs so well, that its usage explodes. Such was the case with Mosaic. The World Wide Web had been around for several years, and there had been other browsers, but Mosaic was the first one to be available on a variety of platforms and be sufficiently friendly for use by the wide public. The Internet had been growing rapidly before Mosaic, but the introduction of that browser led to a substantial increase in the growth rate of data traffic (although not in the number of hosts that could be traced). There had been a succession of products that were designed to make the Internet easier to use, packages such as Archie, Gopher, and WAIS, but it was not until the combination of the WWW and Mosaic came along that the critical threshold was reached.

Products like Mosaic are rare. More frequently, rapid acceptance of a new technology is caused by network externalities, where the actions of one's colleagues or customers induce a change. That is what drives the software industry. If I am using Word 5.0, and my customer sends me a file in Word 7.0, I have a choice of either inconveniencing that customer by asking for a fax or a conversion of the file to some simpler format, or of upgrading my word processor. The choice is typically clear, and as a result, a software producer only has to convince a small group of power users that the new features in the latest release are likely to be important to them to get an avalanche of upgrades. In standalone situations, people often are quite happy with supposedly obsolete packages.

Frequently, rapid conversions occur when there is a forcing agent that can push the change through. Such an agent can be a government. Several countries (excluding the US) have successfully introduced large-denomination coins. It appears, though, that most did it by fiat, by withdrawing the corresponding bills from circulation. They did not do it by waiting for the coins to become preferred to bills. In the US, the last attempt to introduce a dollar coin failed both because of poor design of the coin, and because it was offered as just another alternative

to something that worked reasonably well. (This suggests, in analogy, that acceptance of electronic cash may be slow in the absence of strong incentives.)

In medical care in the US, managed health care plans such as HMOs were growing slowly through the 1970s and 1980s. They exploded in size and coverage and changed the medical industry only in the mid-1990s. What happened is that medical costs became so large and were growing so rapidly that corporations took action to change their employee benefit plans. A small number of informed and powerful agents transformed a huge and byzantine system in a few years. In contrast, consider treatment of ulcers. The iconoclastic view that they are almost always caused by bacteria has now been proven and accepted. However, most ulcer patients are still not being treated with antibiotics. The problem appears to be that most doctors rely on pharmaceutical company salesmen to learn about new drugs. There is little profit to be made in selling the generic antibiotics needed to cure ulcers. Hence there are no salesmen pushing doctors to stop using the expensive conventional anti-ulcer medications and switch to the more effective and less expensive antibiotics.

It has often been noted that a new technology is almost always first used just as a substitute for an established product or service. It is only later, as the possibilities of the new invention are explored, that novel applications are developed. Gutenberg's printing press was first used to produce Bibles. Junk mail came centuries later.

We can see the confluence of many of the factors mentioned above in recent technological changes. The rapid acceptance of Ginsparg's preprint server was a case of simple substitution. His research community in high energy theoretical physics had, during the 1980s, developed a culture of massive preprint distribution. Each department would send copies of all preprints (typeset in $\TeX$) in this area to several hundred other institutions. Costs per department ran into tens of thousands of dollars per year. Under these circumstances, shifting to electronic distribution was easy. The main loser was the postal service. However, the Post Office has no voice in departmental decisions. One could also claim that secretaries lost, since there was less work for them to do. However, secretaries do not have much power in decisions of this type either, and in any case, who likes stuffing envelopes?

While Ginsparg's preprint server has been growing by covering more and more areas, the progress has been less dramatic than its initial takeover of high energy theoretical physics. Other fields do not have the same culture of massive preprint distribution, and so the S-curve is less steep. Still, the usage of his preprints and a few other preprints is growing, and once most preprints in an area start getting posted on a preprint server, that server universally becomes the lifeblood of the community.

Another instructive example of rapid change is the rise and fall of Wang Laboratories. In the early 1980s, Wang was the darling of Wall Street. It had a great "franchise," as it is called, with a dominant position in word processors.

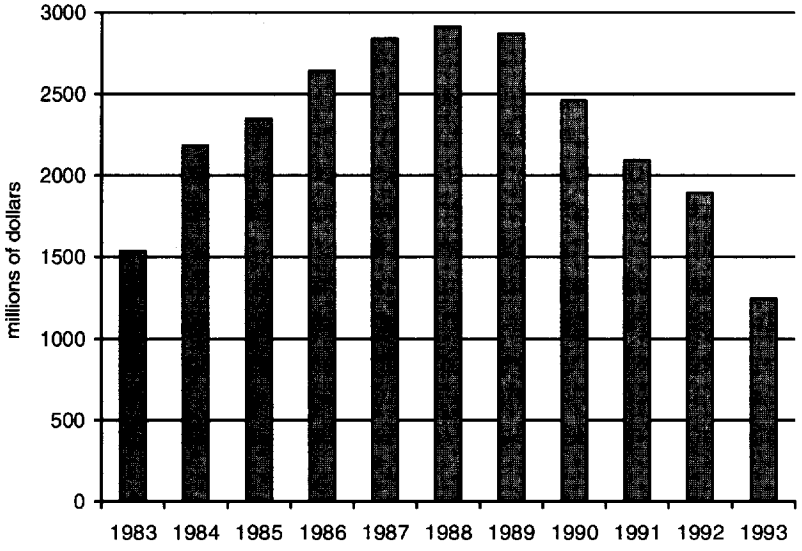

Figure 5: Revenues of Wang Laboratories

Fig. 5 shows Wang's revenues through 1993, when it entered Chapter 11 bankruptcy. What killed Wang was the rise of the PC, which made a dedicated word processor obsolete. Apparently the management at Wang did see the threat posed by the PC. However, they felt that the inertia posed by having millions of secretaries trained on Wang processors would give them time to adjust their products and strategy. Unfortunately the replacement of the dedicated word processor by the PC came several years earlier than Wang expected. What Wang did not take into account is that secretaries do not have power. Even though they might have preferred to stick to Wang processors, once their management told them to take courses in PC word processing, they had to do it, and Wang went into the rapid decline shown in Fig. 5. Had most secretaries been independent contractors, transcribing dictation tapes, say, Wang might have had several additional years in which to transform itself (as it had done at twice before, under the leadership of its founder). The inertia of getting millions of secretaries to decide they needed to change, and then find the time to change, would have come into play.

3. The evolution of scholarly publishing

Eventually paper will be obsolete. In [Odlyzko4] I predicted this will happen in our lifetimes, when we get high resolution portable light screens. However, don't rush to sell short the stock of paper companies. I expect the displacement of paper to take several decades. Some expect a faster transition. For example, Herb Wilf, one of the two founders of the *Electronic Journal of Combinatorics*, wrote (personal communication):

> With a 21" monitor, I am able to do the following: Lean back in my swivel chair, put my legs up on my desk, pull the computer's keyboard over onto my lap, because it has a long extension cable, and then the type is large enough onscreen that I can *comfortably* and without eyestrain read a long manuscript. What I miss mostly is a long enough headrest for my swivel chair so that I would not have to keep my neck muscles flexed to keep my head in position. ... The main reason that print will hold sway for a while yet is that reading

> things onscreen has to get comfy-cozy-cuddly (c^3). When it becomes that, print will be dead. Print is c^3 already because you can place your body in your favorite relaxed position and then pick up the book and read it ... without altering your position.

Personally I feel the same way. The fraction of material I have been reading on the screen has been increasing rapidly. I expect this fraction to increase substantially once I get a 23" screen that will enable me to have two windows side by side, with large type in each. (This will be much more important for my usage than faster connection from the home to the Internet.) However, others react differently (cf. [Grenquist]), and their preferences are likely to keep paper producers going. There are no network externalities or powerful agents to compel use of the screen instead of paper. Anyone will be able to print whatever they want and read it. (The fraction of material that cannot be rendered in print will be increasing, but probably slowly.)

While the attractiveness of easy access and increasing quality of screens will tend to favor pure electronics, this will be partially counteracted by improvements in printing. In a few years we can expect to have inexpensive color printers for the home with 1200 dpi resolution. (For most text material, 600 dpi is already about all that is needed, and is already available, but not as inexpensively as it will be soon.) Hence the competition will be not between getting a journal from a library and reading it on a screen, but between reading it on the screen and printing it out on an attached printer and reading from paper. I expect the screen to win in the end, but the race may not be decided for several decades.

While print appears to have some life left in it, the same cannot be said of the traditional library, particularly the academic one. ([Odlyzko4] discusses the likely divergence in the paths of community and research libraries.) A sheet of paper currently costs around $0.01. When home printers improve to the stage where the costs of printing a two-sided sheet come down to the $0.01 range, the costs of printing a book at home will be far lower than the costs of handling it in a library or bookstore. Therefore the library will be technically obsolete. (It may survive longer, as explained in [Odlyzko2, Odlyzko4], as an institution dedicated to enforcement of usage restrictions. Legal and economic concerns are likely to be more important in this area than technical ones.)

Print as a medium for reading is likely to survive for several decades. The printed scholarly journal will likely disappear much sooner. The number of new electronic-only journals is growing explosively. What is more important, though, is that established print journals are increasingly producing electronic versions as well. Several scholarly societies have converted to dual electronic and paper publications of all their journals, and commercial publishers are doing the same. As an example, by 1998, all the 1100 or so journals from Elsevier (the largest publisher in the world in the scholarly arena) will be available electronically. Publishers are responding to growing demand for electronic access. What they are doing is a simple substitution step, moving their traditional journal online. This is easy, as additional costs are modest, and production processes only have to be modified slightly. Their customers obtain basically the traditional product. In a few years I expect publishers to start phasing out the print versions of their journals. The advantages to them will come from lower costs. Even if publisher costs decrease only by the 30% that is estimated to be spent on printing and

distribution (far higher savings should be possible, see [Odlyzko3]), this will give publishers room to either lower prices or raise profit.

Further, what is most important is that conversion to electronic-only formats is likely to relieve some of the cost pressures on libraries, especially if back issues are made available electronically, so that old collections can be sent to inexpensive storage warehouses. (It seems necessary to keep pointing out that the cost crisis in scholarly publishing is more a library cost crisis than a publisher pricing problem. Costs of running libraries are twice as high as spending on acquisitions of books and journals [Odlyzko1, Odlyzko3]. The best hope for publishers to maintain their revenue is to squeeze costs out of the library system.) Thus in this case I expect it will be a small number of agents (publishers) with a clear idea of their self-interest, who will be pushing the change through. They will be able to offer lower prices and faster publication as inducements to give up print.

Won't the abandonment of print journals be too radical a change for scholars to accept? I suspect not. This will be a simple substitution of method of delivery. Instead of going to the library, making a photocopy of an article, and reading it back in their offices, scholars will be able to print those papers on the printers in their offices. The new method of operation will be superior to the old, and provide the same functionality. What about browsing? Many scholars profess to be addicted to it. However, I doubt this will be a barrier. There have been cases of academic libraries that instituted document delivery services for their campus. Faculty can look at tables of contents on their screens, electronically order the articles they want, *and* receive them the next day via campus mail (with copies made from campus collections). Where such systems are comprehensive and efficient, they have often resulted in the faculty drastically reducing their visits to the library, with the change taking half a dozen years or so.

So far all the changes that I project are likely to be gradual. The one case where I suspect there might be rapid change is in scholarly journal publishing. There free or inexpensive electronic journals might take over in a short period from traditionally expensive print or electronic journals. The reason for this expectation is that the scholarly journal arena has powerful movers who can force change, namely university administrators. Information sources are proliferating, and the academic library (which is what funds the bulk of scholarly publishing) is becoming less and less important [Odlyzko2, Odlyzko4]. Preprints, in particular, are becoming common in more and more fields, are used as the primary information sources by scholars, and are increasingly being placed on the Web. At some point academic decision makers will realize that their faculty can get along without the expensive traditional journals, and will start seriously cutting library budgets. Such cuts are not likely to start at elite schools. Harvard is the largest spender on libraries, devoting over $60M per year to them. However, Harvard will probably be among the last institutions to cut its library budgets. Its libraries are among its competitive strengths, attracting scholars, students, and alumni donations. Cuts are more likely to start at less prominent schools. Their timing will surely depend on when the next series of financial crises hits higher education. Right now the economy is booming, and schools do not have an urgent need to control spending. That can easily change. R. E. Norris [Norris], in describing how a digitization project at the U. S. Naval Postgraduate School was finally pushed through, at a time of fiscal crisis, when the prospective savings were clearly documented, noted:

> None of this is rocket science, but without the looming fiscal crisis, our silly arrangement would have continued. A lesson from our experience would be that the technology exists to fix the problem, but the system is institutionalized and it takes a strong impetus to overcome barriers. In our case, logic alone, was not persuasive. You might be surprised at how fast your Deans get onboard when you change the accounting system to uncover and attribute costs, and then show them how to save money.

Many corporate libraries have already gone through the downsizing that I expect to hit academic libraries. The end result is likely to be a forced shift to much less expensive journals than we have now.

Will there be any journals left, once libraries downsize, as opposed to less expensive ones? I expect there will be, and again because of the speed with which various changes are likely to be accepted. The rate of change shown in Fig. 4 is typical of academic sociology. Scholars are used to the journal and are not likely to give it up easily. Even Ginspargs high energy physicists, who have been relying on his preprint server for half a dozen years, are publishing most of their papers in conventional journals. Journals still fill important roles in academia, primarily in quality certification. The problem is that these roles do not require any particular library to subscribe to any journal. Knowing that an article was published in a particular journal (which can be learned from a variety of sources) and having access to a preprint is usually enough. Existing electronic-only journals have demonstrated conclusively that it is possible to operate at far lower costs than with traditional journals. Hence if there is a sudden journal crisis, with catastrophic subscription losses and collapses of traditional journal, I expect new or existing electronic-only journals would quickly pick up the slack.

In some ways, the predictions above are all bland. By and large, aside from conversion to an electronic and eventually much less expensive format, they are for a continuation of current styles. This may seem disappointing. However, I think it is realistic. First there is the matter of scale and inertia. To quote from [Odlyzko4], rough estimates of the current annual production rates of various "information goods" are as follows:

major movies	500
books	50,000
scholarly articles	2 million
newspaper articles	100 million

It is unrealistic to expect wholesale conversion to the high-tech, multimedia productions that some are predicting. There will be continued growth in the use of graphs in publications, but there won't be a quantum jump in the elaborateness of scholarly articles, since it still takes a major effort to do something sophisticated that is of real use. (A similar point was made in the context of educational materials in [Solomon].) Further, there is the basic conservatism of academics, shown so clearly in Fig. 4. Many new electronic-only journals are deliberately conservative, since they are striving to establish themselves as respectable alternatives to traditional print journals.

In debates about the future of journals, such as those of Hibbitts and Zariski [[Hibbitts2, Zariski], and of Harnad and Rowland [Harnad2, Rowland], I tend to side with Harnad and

Hibbitts, but expect that their vision will take considerable time to emerge. My predictions for journals are indeed bland. However, journals are not where the interesting action is.

I do expect the full potential of electronic communication to be realized eventually, but it will take time, and most of the evolution will be through channels other than journals. There are interesting developments going on in novel uses of electronic communication by scholars [Brody1]. However, the even more interesting things are the integration of scholarly discourse with netnews and related informal communication [Brody2, Odlyzko1]. Eventually we may see a different scholarly communication system, in which the ideas of a publications continuum [Harnad1] or a combined publications and peer review continuum [Odlyzko1] are carried much further. Instead of presenting detailed projections, let us look at the history of print, and how it affected scholarly discourse.

Gutenberg's invention of movable type did prove to be revolutionary. Initially, though, it was an extremely conservative development [Cook, Eisenstein, Steinberg]. It did enable considerably less expensive production of large runs of books (as well as of indulgences). Still, it took considerable further development, technical, social, and economic, before the full impact of movable type became apparent.

The first books had initial letters in paragraphs hand-colored, and were produced in ungainly folio volumes. There was also extensive resistance to print by scholars [Hibbitts1, O'Donnell], which included calls for banning the new technology. Many of the objections have a familiar ring to them (only trash was getting into print, books were not as durable as parchments, etc.). For a long time print was treated with suspicion. What is interesting is that many of the criticisms were serious ones. Although this view is generally discredited, even some modern scholars (cf. [Eisenstein]) have felt that initially print reduced the variety of scholarly information that was widely available. (Setting the type for a book was much more expensive than copying the manuscript by hand, and it was only the large number of copies that could be printed at once that reduced the per-copy cost.) There were also more subtle effects. Scholars of the 15th century were trained in the art of comparing a variety of copies of a treatise to figure out the mistakes of the scribes and thus discern the original words of the author. With print, that was impossible! A mistake made in typesetting would be propagated in all copies in that print run. Indeed, some of the mistakes that slipped through were egregious, as in the "wicked Bible" in 17th century England, in which the Seventh Commandment was rendered as "Thou shalt commit adultery" (p. 204 of [Steinberg]). Of course, methods (such as proofreading and printed errata) to compensate for such deficiencies were invented, and we have developed a culture of print. Scholars work with the mental image of an edition, a definitive work that stays immutable. Many of the objections to electronic publications (such as that of [Quinn]) are based on perceived threats to this model. Yet before movable type was invented, there were no definitive editions, and scholars lived in a much more fluid world. Electronic publishing removes the choke point that the step of going to print represented, and is likely to lead to a much more diffuse (and also much more effective) communication system. However, the habits developed over 500 years are not easy to break, which is why I am not astonished by the slow evolution of electronic publishing.

It was easy around the turn of the century to predict that the arrival of the horseless carriage would lead to a dramatic decline in the population of horses in central cities. I am not aware of anyone forecasting then the eventual decline of the central city that the internal combustion

engine brought about. Similarly, I am reasonably comfortable making predictions for the next decade or two. It appears that we can forecast technological developments in that period with some confidence, and the inertia of the scholarly community will limit changes. Fifty years from now, though, much more of the potential of electronic publishing is likely to be realized, and scholarly publishing is likely to be very different.

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