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Review

Electronic journals and user behavior: A review of recent research

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1. Scope, purpose, and limitations

The business, managerial, and cultural challenges marking a tectonic shift from scholarly communication based on print resources to one predicated on online resources have been considerable. For many academics, the transition from a traditional pattern of research and scholarship to a primarily digital workflow has occurred in a few years—an uncomfortably short time for many of us.

This review attempts to capture some of the key aspects of changes in journals systems, especially in their use, over little more than a decade. A literature review by Tenopir (2003a) for the U.S. Council on Library and Information Resources Council covers similar ground for the period 1995–2003. The interested reader is strongly recommended to read her findings. The Tenopir report was deliberately not read in detail until a very late stage in this research, since it was important to approach the later work from a fresh and hopefully complementary perspective. The materials examined here are thus based on a systematic search of recent, "post-Tenopir" materials. They also fill some minor gaps in her coverage.

Four other previous literature reviews are very relevant to this study. King and Tenopir (2001) conducted a substantial meta-analysis for the *Annual Review of Information Science and Technology* that covers the literature over the past half-century or so. Its particular value lies in its thorough treatment of a number of major ("Tier 1") studies such as SuperJournal, OhioLink and JSTOR, which lie outside the scope of this update. The review by Kling and Callahan (2003) is less concerned with empirical findings and reflects more on the broad

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socio-cultural aspects of electronic journals, the Internet, and scholarly publishing. Greco, Wharton, Estemali, and Jones (2006) offer a different perspective on two decades of scholarly journal publishing. They address more practical questions about the changing economics of the sector and the implications for authors, librarians, publishers, and administrators. As well as summarizing the key economic and business trends very succinctly, they provide a wealth of useful primary research based on ISI data that clothe these trends with fact.

Wang (2001) offers a more specialized report reviewing the various methodological approaches that have been brought to bear on user behavioral research. Finally, a short review by Miller (2002) is included here for the sake of completeness. It is relatively limited in scope, but conveniently brings together some useful materials on the advantages and disadvantages of print and electronic journal formats.

The present study covers English-language, primary research articles, the vast majority of which are published in mainstream peer-reviewed journals. The studies analyzed vary widely in terms of

- sample size (variation over three orders of magnitude),
- unit of analysis (journals, institutions, formats, disciplines),
- research design (qualitative, quantitative, primary, secondary, conceptual and, in one case, anti-theoretical), and
- ideological perspective (considerable grinding of axes in some papers).

Many of the articles have a local institutional focus and are written by library professionals. They typically ask questions such as, "What impact does electronic journal provision have on use of the print legacy at the University of Uttoxeter?" A high proportion of the materials cited in this report are studies in (mainly U.S.) health library settings, raising a further issue: the extent to which findings in one discipline can be extrapolated to other settings. Many of the empirical research studies reported use small, purposive samples. Few give much consideration to issues of non-response or non-use. This is not altogether surprising given the strong library professional bias of the authors. It is perhaps less of a fault than some of the writings by industry commentators and library school professors, which err too far in the other direction: bland, largely unsupported statements which leave some fundamental issues as uncontested territory. Despite these limitations, an attempt is made to summarize the key findings, even if this sometimes suggests that more work is needed to resolve some flatly contradictory conclusions from the literature.

2. Changing contexts for scholarly production and use

This introductory section provides a general context for the materials that follow by examining some of the larger-scale trends that are shaping the research landscape and patterns of scholarly journal communication.

2.1. Changing research needs and practices

A study of research practices in the digital environment by Houghton, Steele, and Henty (2003, 2004) offered useful insights into ways that the self-reported behavior of Australian researchers is changing in response to pressures bearing down on the academy. Their main assertion was that the context within which research is conducted is increasingly shaped by the needs of society and the national economy rather than the natural curiosity of scientists. The study used a framework developed at the Science Policy Research Unit (SPRU) in Sussex in the early 1990s (Gibbins, 1994). The authors found considerable evidence for a fundamental shift from basic Mode I (researcher-driven, tightly disciplinary bound) to developmental and applied Mode II (funder- or problem-led, highly interdisciplinary) knowledge production. As evidence, they cited highlights from their survey findings:

- 56% of respondents said that their research was becoming "increasingly interdisciplinary;" 22% that it was "more applied."
- research is being conducted in a wider range of settings: 60% of respondents reported an increase in the diversity of their collaborators' locations.
- collaboration is spreading into the humanities, arts and social sciences, with more than 50% of respondents reporting an increase in team collaboration. The main reasons are access to specialist skills, intellectual property, and equipment.
- 74% said they now worked as part of a team.

The trend toward more intensive author collaboration has been noted by many commentators. A 2003 paper by Liu provides further evidence of the increasingly collaborative nature of the research enterprise (see Table 1). Liu performed a longitudinal analysis of three major US journals using a century's worth of data (1900–2000). He presented evidence of increasing author collaboration in three very different fields, with a particularly dramatic increase in the case of chemistry. Note, however, that Price's (1965) prediction of the death of the single-authored article is still some way off: 55% of authors in sociology, 57% in mathematics, and 1.5% in chemistry were singletons in the year 2000 (Liu, 2003).

Liu also presented some interesting new data on a century's growth of the journals literature in these three disciplines (see Table 2). He used numbers of journal pages produced per annum as the key metric.

Houghton, Steele, and Henty (2003) claimed that, in spite of the enormous growth in scholarly outputs, 82% of their respondents are making greater use of primary materials than

Table 1
Average numbers of authors per paper (after Liu, 2003)

Year	Chemistry *(Journal of the American Chemical Society)*	Mathematics *(American Journal of Mathematics)*	Sociology *(American Journal of Sociology)*
1900	1.36	1.04	1.00
2000	4.30	1.45	1.58
Increase	216%	38%	58%

Table 2
The growth of the journals literature (after Liu, 2003)

Year	Chemistry	Mathematics	Sociology
1900	414	388	864
2000	13,040	1308	1840
Increase	3050%	237%	113%

before. In other words, they are reading more articles. King, Tenopir, Montgomery, and Aerni (2003) also noted that the amount of academic reading has increased over the past 25 years. This is the result of a large increase in bibliographic searching; more people use library collections as personal subscriptions decline. They too argue that academics are reading across a wider range of sources. Further evidence of this comes from Boyce, King, Montgomery, and Tenopir (2004). They estimated the range of journals consulted by the typical academic researcher has grown from at least 1 article per year from 13 titles in the late 1970s, to 18 in the mid-1990s, to approximately 23 titles by 2001. This they attributed to greater awareness as the result of wider access to generic end-user search tools.

This may be an unduly narrow interpretation—the transition from Mode I to Mode II knowledge production suggests that breadth of reading is not simply a function of ease of access to the literature. These forces may have a direct impact on information-seeking behavior as researchers engage in more trans-disciplinary, problem-oriented work (rather cruelly dismissed by Houghton, Steele, and Henty (2003) as a shift from hypothesis testing to "suck-it-and-see science"). Their argument develops from the observed popularity of generic web search engines and the relatively low use of subject gateways. The exceptions are areas where subject gateways tend to be problem-oriented, e.g., medical and health, or where the discipline remains strong and retains essentially Mode I characteristics, e.g., mathematics. The popularity of electronic journal databases is perhaps in part due to the opportunities they offer to help dissolve disciplinary boundaries.

The long-running growth in the literature has some profound implications for readers: notably lower attention per unit of information as faculty read more, and more widely, but spend less time per article (King et al., 2003; Tenopir, King, & Bush, 2004). Since the absolute level of reading is probably pretty constant (King & Tenopir, 2001), researchers must inevitably be also reading a smaller proportion of each year's output in their field.

2.2. The "Tragedy of the Commons"

The other major contemporary context for information-seeking behavior and use is the so-called "journals crisis." It arises from the inability of libraries to sustain purchasing in the face of higher-than-inflation rises in publishers' prices. A number of recent papers have examined the fundamental mistrust that has developed between publishers on the one hand and librarians and faculty on the other. McGrath (2002) and Miller and Harris (2004) offered clear, if rather general, overviews of the current crisis in scholarly journal communication as seen through the eyes of scholars, editors, publishers, and institutions. Like many other commentators, they saw the problem as essentially an economic issue. They noted a growing understanding and

resentment on the part of editors and their institutions of the extent to which they are subsidizing the scientific publishing enterprise. For them, the solution lies in the academic community's taking active steps to reform the system, employing repository and other tools.

This is a good example of a kind of economic determinism: the inevitability of IT-based cost efficiencies and self-organization by the academic community to cure the ills of the market (Houghton, Steele, and Henty (2003) offer a more extreme example). A more thoughtful contribution is the paper by Davis (2004b). He based his work on the notion of the "Tragedy of the Commons" and argued that authors, publishers, and librarians are in conflict with what is in the best interest of the public good. Scholars rationally attempt to maximize their consumption of information, regardless of expense. Publishers exploit the market for the highest prices it will bear and practice price discrimination. Librarians attempt to build comprehensive collections and maintain free access rights for their users, real or potential. Davis argued that technology does not alter the basis of these incentives. He proposed that librarians seize the opportunity to become guardians of the information commons by

- selecting or rejecting information on the basis of its relevance, cost, and utility, thus moving to an access model based on actual rather than potential use;
- adopting a just-in-time business model, rather just-in-case;
- adopting a cost-sharing model so that scholars become more aware of the true costs of their consumption; and
- developing a model that enhances the library's ability to share with others.

Despite the evident enthusiasm of users for electronic, networked information, some voices within the library community suggest that the shift to e-provision is simply a case of shuffling deck chairs on the Titanic (see also section 3.1). Vaughan (2003) argued that simple economics mean that libraries cannot continue to support a model based on purchasing or licensing scholarly journals. Setting a strategic direction against a background of mistrust, misinformation, and a lack of robust data is naturally very difficult.

Bjørk's (2004) useful, open-minded, conceptual paper that explored the barriers hindering the proliferation of open access publishing, subject, and institutional archiving in repositories. Bjørk argued that a major barrier to open access is that author submission behavior is highly conditioned by the academic reward system. Particularly in the traditional journal system, prestige counts for more than wide, rapid dissemination and easy access. He suggested that the success or failure of subject repositories has relatively little to do with academic rewards; the motivations are more efficient and faster dissemination. Thus, it follows logically that authors should be rewarded financially for archiving in an institutional repository. This would change behavior more effectively than mandatory approaches. Bjørk's overall conclusion was that the barriers to change are formidable and insufficiently focused on author behavior. He drew an ecological analogy by pointing out that while most researchers support open access in principle, getting them to change their behavior is rather like encouraging consumers to save energy and recycle waste on a large scale. They know it's a great idea, but they don't necessarily translate that understanding into action (Bjørk, 2004). Schwarz (2005) was sanguine about the prospects for open access, noting that the public debate has so far been lacking a critical understanding of

the economic realities. She pointed out that open access systems are far from being a less costly alternative. Whether self-archived or with costs met by the author, these systems might well be characterized by redundant expenditures and inflationary pressures.

Other researchers see new opportunities for libraries in an increasingly open digital content environment. Thomas (2006), for example, noted a trend for academic libraries to view electronic publishing and vertical integration into the scholarly communication chain as part of their core mission. He cited Cornell University Library as an example. Correia and Teixera (2005) mounted a powerful argument highlighting the benefits for authors and their institutions of publishing in e-print repositories. They foresaw new roles for librarians as information managers, setting out the policies and standards needed to achieve true organizational benefits. Critical to this success is the notion of e-research literacy. According to Genoni, Merrick, and Willson (2006), this offered an additional role for the academic library: promoting and exchanging good practice in the kinds of skills needed to manage and sustain Internet-based research communities.

Clearly, the benefits of open access transcend the university library. Papin-Ramcharan and Dawe (2006) offered a refreshing view of both opportunities and some unexpected downsides of open access publishing as seen from a developing country perspective. Open access is a powerful ally for the information consumer, but neither the "gold" (pay-to- publish) nor "green" (self-archiving) routes may be available easily to information producers. In a deliberately controversial opinion piece, Nicholas, Huntington, Dobrowolski, and Rowlands (2006) argued that the open access debate is far too narrowly circumscribed and that there is much to be learned from other information business sectors, notably the success of iTunes in delivering low cost access to digital content. Generally, a welcome degree of reality is beginning to temper arguments on both sides of what has been a very heated argument.

3. The digital transition

The transition from a largely print-based to an increasingly electronic-only journals environment raises a number of concerns. The rest of this review explores these concerns, some of which are most unexpected.

3.1. Evolutionary processes

Mahé (2004) and Boyce et al. (2004) identify three phases in the evolution of the electronic journal. These phases provide a useful construct for understanding the dynamics of change. Elements of all three phases co-exist at the present time:

(1) *an early, pre-1993, pre-Web phase*. In this phase, electronic full texts were confined to CD-ROM and a few online services. Article readings were almost entirely confined to print. There were low levels of electronic use, a preference for low-technology resources, and a lack of recognition of e-journals. E-journals were only accessible through limited experimental platforms.

(2) *an evolving phase*. This phase began in the late 1990s and continues into the present. It is marked by the availability of print and electronic alternatives. In this phase, electronic use has increased but has failed to reach critical mass. Research attention is focused on readers and the socio-cognitive factors that enable or inhibit take-up. These factors include technical barriers, lack of knowledge, peer pressure, and the fact that prestige is still associated with print rather than virtual journals.
(3) *an advanced phase.* Some disciplines have already arrived at this phase, which is marked by sophisticated information systems designed specifically to enhance the way that scientists work. An example is NASA's Astrophysics Data System; see Tenopir, King, Boyce, Grayson, and Paulson (2005). Research attention becomes increasingly user-focused as critical mass develops. Knowledge of use becomes more specific, and more detailed, greater sensitivity is shown to differences between disciplines.

Based on a series of longitudinal surveys, Boyce et al. (2004) asked the question, "How have electronic journals changed patterns of use?" They related this to the three evolutionary phases noted above. Their analysis revealed the extent to which electronic formats have displaced print and the significance of the shift from journals to separates (see Table 3).

Brennan, Hurd, Blecic, and Weller (2002) employed a diffusion theory approach in their qualitative study of science faculty members' use of and attitudes towards electronic resources. They concluded that the following characteristics of e-journals determine how easily they are adopted:

Content

- critical mass of issues and volumes for a given title
- critical mass of titles in a subject collection

Table 3
Sources of articles read (Boyce et al., 2004)

Source of article read	Early% 1990–1993	Evolving% 2000–2002	Advanced% 2001–2002
Personal subscription	46.3	36.0	15.2
Print	[100.0]	[67.8]	[54.5]
Electronic	[0.0]	[32.2]	[45.5]
Library subscription	40.6	49.1	49.0
Print	[99.1]	[80.0]	[12.7]
Electronic	[0.9]	[20.0]	[87.3]
Separate copy	13.1	14.9	35.8
Preprint	0.2	1.5	18.5
Archive (ADS)	0.0	0.0	10.2
Colleague provided	9.2	9.2	4.5
ILL/document delivery	3.6	3.8	0.6
Author website	0.0	0.3	0.8
Other	0.1	0.1	1.2
Total	100	100	100

- full equivalence to print issues
- timeliness of appearance.

Functionality

- searching facilities that support browsing, locating known articles and subject/author retrieval
- ease of navigation
- links to other articles
- high-quality printing
- seamless movement among related resources.

For Odlyzko (2002), as for many other writers, the electronic journal is a revolutionary, disruptive technology. Users are now so dependent upon convenient desktop access that content that isn't online might as well not exist. With the use of e-scholarly resources growing at 50–100% per annum and print use static or declining, Odlyzko predicted that electronic formats will become the completely dominant medium in less than a decade.

Flaxbart (2001) also found that electronic access has taken over more completely and more rapidly (in chemistry at least) than many would have predicted in the mid-1990s. Faculty especially used the physical library less often because of the convenience and time-savings that are possible online. As a new generation gradually fills academic posts, Flaxbart argued, the combination of supply-side forces and innate user preferences for e-content will probably "virtually eliminate" print in the day-to-day working practices of chemists.

The breadth of the changes that have taken place in a remarkably short space of time is forcefully driven home by Burrows (2006) in an unusual, very useful article. He addressed the massive changes that have occurred from 1995 to the present on both the supply and demand sides of the equation from the perspective of the Louis Calder Memorial Library at the University of Miami. It is an extraordinary journey.

A more systematic take on this issue is seen in a study by Obst (2003) in a German academic medical sciences library. He compared print and electronic use of 270 matched journals using re-shelving statistics and online user metrics, and found that:

- print usage declined dramatically between 1999–2001;
- electronic journal usage accelerated rapidly, nearly tripling over the same period; and
- journals published in both formats lost 30.4% of their print use within approximately two years. The total loss for print-only titles was 45.8%.

An acknowledged limitation of Obst's study is that the use statistics are very difficult to interpret. They pre-date COUNTER compliance standards, and Obst admitted that interpreting publisher-supplied usage data was exceedingly difficult. He noted a tendency for users to place ease of access at a premium in terms of what they read or purchased. He also noted a tendency for users to get by with a "manageable few" access modes. Within two years of their introduction, electronic accesses were exceeding print uses for matched pairs of journals by a factor of nearly eight. However, this figure disguises wide variation between different

publishers). Obst noted a correlation between frequency of use of a journal title in both formats (0.6 for 1999–2001). In other words, journals that are heavily consulted on digital platforms are very often the same titles that are most often consulted in print. Another factor related to journal usage is frequency of publication. Walter (1996) found that titles published irregularly or less than four times are year have distinctly lower levels of use.

In complete contradiction to these studies, Siebenberg, Galbraith, and Brady (2004) concluded that most print journals at Washington State University's Owen Science and Engineering Library in 2003 were actually used *more* than they were prior to the introduction of electronic journals. They argued that the availability of electronic formats has in fact greatly enhanced the total use of all titles. (This is a broadly similar argument to that employed when VHS technologies were introduced. Rather than "killing" cinema, home viewing created a new consumer experience and expanded size and scope of the overall film distribution market.) Clearly, the time sensitivity of the user's need is a factor here; this may be a function of the user's subject discipline.

Tenopir and Ennis (2002) surveyed academic library members of the Association of Research Libraries (ARL) in 1991, 1995, 1997, and 2001. Their work offers another insight into the impact of the transition to electronic journal formats from a library professional's perspective. They noted

- a big shift from mediated searches to self-service searching, with nearly 20% of libraries reporting that mediated services would be withdrawn within two years
- almost total reference staff dependency on electronic materials to service patron's requests.

They cautioned that these developments are more complex than they might at first appear. Library patrons are often unable to distinguish between free web resources and fee-based electronic resources provided by their library.

As most of the reported trends seem to point towards the imminent demise of print, Vaughan (2003) posed the research question, "In a hybrid print/electronic journal environment, what data are needed to decide when print is no longer needed?" He studied the short-term effects of online journal availability on print use at Duke University Chemistry Library, where Elsevier ScienceDirect was introduced in February 2000. He compared the use of three groups of journals: "Elsevier" (44 journals available in print and online), "electronic" (84 journals available in print and online before the introduction of Science Direct), and 125 print-only titles. His key findings were a big drop in print use across all categories. Even among print-only titles, use was down by nearly a third. This finding was echoed by de Groote and Dorsch (2001), who found that introducing online services had a negative impact on the use of print-only subscriptions at the University of Chicago Health Sciences Library. They pointed out that library patrons may assume that all journals are available in both formats; librarians may have an important awareness-raising role to carry out. In spite of the obvious convenience and attractiveness of electronic formats, this is a disturbing finding and should be a source of concern to information professionals. Vaughan reminded us of the importance of this finding by citing a case at John Hopkins University. In

this case, drug toxicity information available from print sources was not used, resulting in the death of a patient.

In what one imagines is an article designed to inflame the debate about the impact of electronic access, Odlyzko (2002) questioned some fundamental assumptions at the heart of formal scholarly communication. He especially questioned the view of journals as the "minutes of science" (p. 17). For Odlyzko, articles are rarely so unique that no substitute can be found for them. This is an extreme example of the convenience argument. It finds some support in the self-reported views of authors in various CIBER surveys (Nicholas, Jamali & Rowlands, 2006; Rowlands, Nicholas, & Huntington, 2004; Rowlands & Nicholas, 2006) and in the detailed analysis of server logs by Nicholas et al. (2003). Odlyzko's position is certainly iconoclastic, especially in relation to his views on the non-unique, substitutable, nature of much that is currently published. On a more positive note for publishers, he highlighted the importance of "digital visibility:" "Whether they like it or not, scholars are engaged in a 'war for the eyeballs' just as much as commercial outfits, and ease of access will be seen as vital" (Odlyzko, 2002, p. 18).

This point finds much empirical support in the work of the CIBER Group at University College London (Nicholas, Huntington, & Watkinson, 2003; Nicholas et al., 2004; Huntington, Nicholas, Jamali, & Watkinson, 2006). This group developed strong parallels between scholarly information seeking and general consumer behavior. Their work showed, for instance, the dramatic extent to which information-seeking behavior can be manipulated by location in a web hierarchy or through the use of incentives, such as free access to "the journal of the month."

3.2. Print versus electronic journals

A number of studies have reported on the relative advantages and disadvantages of electronic and print formats. For example, Bar-Ilan, Peritz and Wolman (2003) undertook a large-scale questionnaire survey of senior academic staff in eight Israeli universities, exploring their use of electronic journals and databases in 2000–2001. They found that e-journals and databases were widely accepted across the academy; more than three-quarters of faculty used them regularly and reported very high levels of satisfaction. There were major differences between broad disciplines: life sciences and medicine were the heaviest users and humanities the lightest. Age appeared to be a big factor: older faculty were much less likely to use e-journals than their younger colleagues (Mine, 2004), who tended to be heavy users and early adopters of electronic journals.

The main conclusion of their study was that researchers preferred print for use in teaching and for catching up with developments in other fields. Most of the researchers who were interviewed held firmly to the view that electronic materials are supplementing print, not supplanting it. However, this research was carried out during a relatively early date in terms of the format revolution. The inherently conservative nature of many academics is reinforced by Houghton, Steele, and Henty (2003) whose respondents also made the point that things had not changed very much and they are doing the same kinds of things as before, only more quickly.

3.3. The digital transition: some theoretical perspectives

The transformation in scholarly communication has naturally attracted the attention of theorists as well as empirical researchers. These theoretical arguments are largely informed by the idea that what is technologically possible will inevitably be realized in the social and economic sphere ("technological determinism"). Jacobs (2001) used discourse analysis to characterize the utterances of researchers and librarians. He found that technological determinism is a deeply entrenched position in both cases. Other arguments act as antidotes to the excesses of the technology determinists by returning to the fundamental communicative and other functions of journals and how to maintain them in the digital universe. For example, Bohlin (2004) argued that publishing research results serves three fundamental functions for scholars: quality control, distribution, and archiving. These functions set it apart from informal communication. In this respect, his arguments are broadly similar to those of Mabe (2001). However, Bohlin's conclusions are very different. His basic argument was that the changes taking place in journal publishing and use are actually much more significant than they currently appear. They are as significant as the impact of the printing press in earlier times, and that the whole system is about to implode. Like many on the left, Bohlin appears to welcome disruption as a way of returning control to scholars. Fyffe (2002) reviewed the scholarly communications crisis from a social theoretic point of view, drawing on the work of Castells and Giddens. His concerns were issues of preservation and the continuity of the scholarly record; he argued that the fragility of digital systems and the resulting possibility of cultural loss are intrinsic features of information technologies. Ffyfe's is essentially an alarmist argument that bewails the increasing dependence of scholarship on business, systems and networks, leaving academia potentially subject to massive disruptive change that are well outside of their control. He called for libraries and administrators to engage in risk management planning immediately.

Kling and McKim (2000) offered a very different perspective. Their conceptual paper argued strongly against the proposition that we are in the early stages of a communications revolution. They said that it is only a matter of time before all academic fields converge on a stable set of electronic forums. Using a Social Shaping of Technology (SST) perspective, they argued that notions of trust and legitimate communication pull against this tendency to convergence and that communications plurality will persist and become more sharply defined. Using high-energy physics, molecular biology, and information systems as examples, the authors noted stark differences in communication patterns and preferences between disciplines. They believed these to be persistent features. They compared "open flow fields" like physics, where researchers share un-refereed articles quite freely, with "restricted flow fields" such as molecular biology. For this reason alone, it is very unlikely that pre-print servers will meet the needs of all scholarly communities. Kling and McKim argued that the electronic publishing reform movement is energized by a core group of highly vocal enthusiasts (Harnad, Ginsparg, Odlyzko). These enthusiasts promote a shared ideology that scientific communication will speed up because electronic materials are less expensive and distribution is easier and wider. The tenets of inevitability and convergence to a common set of tools flow from these arguments. They homogenize the debate and leave big issues, such as the fact that disciplinary needs are different, uncontested.

In a related study, Kling, McKim, and King (2003) explored scholarly communication from a Socio-Technical Interaction Networks (STIN) perspective. They referred to a broad spectrum of Scholarly Communication Forums (SCFs) such as e-print servers, e-journals, and collaboratories. They noted a regrettable tendency to understand scholarly communication primarily in terms of information processing and rationality—thus higher speed networks, Internet access, etc., necessarily imply certain models. They suggested that more emphasis should be given to issues like resources, incentive structures, and stakeholder perspectives. Key to developing all of these theoretical perspectives is the need for more grounded, empirical research. Palmer (2005) argued that we need more insight into and understanding of what researchers actually do when gathering and working with research information.

4. Subject domains and information use

That disciplines vary widely in their communication habits and preferences has been a given point of departure in bibliometric studies for many years. What is new, perhaps, is the emergence of studies that try to model and explain these phenomena. This strand of research might be coined the "Nordic School" since the authors are largely of Danish and Finnish origin. No doubt they were inspired by the earlier conceptual work of Birger Hjørland at the Royal School of Librarianship at Copenhagen (e.g., Hjørland, 1992).

Fry and Talja (2004) observed that most studies of journal behavior tend to focus on

- the use, usefulness, and value of the articles read,
- how scientists learn about the articles they read,
- where scientists obtain the articles they read,
- the format of the articles obtained, and
- the age of the articles read.

This approach is of limited value, however, since it fails to explain the reasons underlying use and non-use, especially between disciplines. Most of the studies Fry and Talja cited are limited to a single institution or discipline or compare very broad disciplinary groupings (e.g., physical sciences, health sciences). They focused on use rather than non-use, thus skewing perceptions further. But they argued convincingly that we should embed journal use studies within a specific theoretical framework: we should be more aware of the organizational and cultural contexts of users and their domains, with specialties or disciplines as the unit of analysis. Moreover, we should conceptualize the epistemic and social organization of disciplines along two dimensions: the axes of task uncertainty and mutual dependence.

Task uncertainty refers to the degree to which task outcomes and research processes are predictable, visible, and clearly connected to general goals. Mutual dependence refers to the degree to which a specialty depends on knowledge produced elsewhere (for example, environmental studies) and the extent to which researchers are required to show how their work is

connected to others. This aspect varies enormously in importance. This model reveals why, for example, "topic" and "systematic review" can be understood as almost entirely different concepts in different disciplines (see Table 4).

Talja and Maula (2003) also noted major differences in use of electronic networked resources by subject. They argued that these should be related to factors such as the size of the domain, the degree of literature scatter, and domain-specific relevance criteria. This lead them to the following conjectures:

- Research areas with high numbers of topically relevant materials are best searched by browsing
- Research areas with middling numbers of topically relevant materials are best searched by directed subject searches
- Areas with very sparse ("needle in a haystack") numbers of relevant items are best searched by linking (citation chaining from known documents)
- Access to e-journal services and databases covering several domains helps counter scatter in high-scatter domains
- E-journals and databases are likely to be used more heavily in fields in which topical relevance is the primary relevance criterion and less in fields where paradigmatic relevance is the primary relevance criterion.

Further, issues such as professional orientation (e.g., teaching versus research, local versus international, basic versus applied modes of enquiry) will have a major influence on information-seeking strategies and journal use.

Table 4
A domain perspective on the journals literature (Fry & Talja, 2004)

Features of the universe of documents	High mutual dependence and low task dependency	Low mutual uncertainty and high task uncertainty
Literature review	Formal: shows how the contribution fits with existing knowledge	Based on choice of theory and discourse communities: less need to incorporate specific results and ideas into the existing literature of the field in a systematic way
Density of relevant literature	Due to the relative stability of the research object, the density of topically relevant material is quite low	Due to the relative instability of the research object there is a greater density of potentially relevant material
Scatter	Relevant materials concentrated in core disciplinary resources	Relevant materials scattered across diverse fields
Primary relevance criterion	Topical relevance	Paradigmatic relevance
Primary search method	Directed reading, descriptor-based subject searches	Following up references, semi-directed browsing
Book versus article production	Predominant reliance on journal articles and centralized resources such as e-print servers, preference for e-journals	Books, articles, conference papers, grey literature, and decentralized web resources; preference for print-based journals

The implications of these issues for digital library design should be obvious. They include the fact that the usefulness of e-journals and aggregated services may be limited in fields that are low in mutual dependence and high in task uncertainty. Domain differences offer a valuable corrective to the technologically determinist thinking of authors like Odlyzko (2002). These authors seem to assume that the ease, speed, and seamless experience offered by electronic journals mean that all fields will eventually settle on a stable set of common electronic fora: preprint servers, discussion lists, and e-journals. This is effectively projecting the physics arXiv modelonto all disciplines as a technological inevitability. It is an example of implicit thinking in a whole range of debates, from open access publishing to institutional repositories. Brown (2001, 2003) provided some interesting and useful analysis of the usage and citation characteristics of the physics arXiv and Chemical Preprint Servers.

The domain perspective advocated by Hjørland, Fry, Talja, and Malua (and, to be fair, as a general principle by many information science authors from Garfield onwards) are intellectually appealing. However, there are few empirical studies that systematically explore disciplinary and organizational differences. Exceptions are Torma and Vakkari (2004) and Kortelainnen (2004)'s studies of disciplinary differences in the use of digital journal materials in the Finnish National Electronic Library (FinELib) by means of nationwide survey data. These studies were also good examples of trying to make these concepts work out in practice. Discipline was the independent variable in their analyses; frequency of use and satisfaction were dependent variables scored on a Likert scale.

The key findings of Torma and Vakkari (2004) were that:

- the perceived availability of relevant materials in the FinELib digital library was a better predictor of use than the users' discipline;
- a perception of the resources as being "good" led to more frequent use, regardless of discipline; and
- satisfaction did not vary with discipline; again, perceived relevance was the key predictor.

If these results seem somewhat surprising in the context of this section on the primacy of domain differences, the authors were the first to admit that the six disciplinary categories they used were simply too broad to be useful and masked substantial within-group variation. Here lies the real challenge: how do we design studies at a meaningful, definable level of disciplinary aggregation?

5. Changing user behavior

This section considers how users actually interact with journal collections: how they find articles, what they read, and how they integrate journal materials into their working practices. Much of the research stresses the need for studies in scholarly communication to provide deeper insights into reader motivation and behavior.

5.1. Writing articles

There is a major gap in the literature relating to how electronic tools influence writing practices. This is particularly surprising given the arrival of online manuscript submission and post-peer review mechanisms. The most recent major study appears to be that of McKnight and Price (1999),which is based on research at an early juncture in the evolution of the electronic journal. However, Borgman (2000) covered a range of author-related issues in her article. She set out a broad research agenda for scholarly communication and digital libraries:

- How do researchers disaggregate documents and re-aggregate them in different ways?
- What is the "social life" of a document?
- By what criteria do scholars choose publication outlets, and how could knowledge of this better inform the design of digital libraries?

She argued that scholarly publishing is inherently a social process and should be studied with that fact firmly in mind (Borgman, 2000).

5.2. Finding articles

How do authors identify and retrieve the articles they want to read, especially in electronic networked environments? Eason, Yu, and Harker (2000) analyzed the value to users of a range of functionality ("bells and whistles") in electronic journals. Their study arose out of insights from the SuperJournal project, an early benchmark. Their key findings were that

- the indispensable functions of digital libraries are basic browsing, printing, and search facilities;
- directed searching is used less intensively than browsing features; researchers are not very good at searching; and
- features such as alerting, saving, and customizing are peripheral (i.e., dispensable) for most users.

An interesting observational study by Worel (2004) examined the form in which patrons presented specific bibliographic references to the reference desks at an academic health sciences library and a governmental library. Despite major differences in the size and orientation of the two libraries (one academic, one practitioner-focused), both cases yielded a very similar profile and evidence that library users seem to place considerable reliance on large generic databases, like PubMed, and on "chaining" from one document to earlier documents by following up references.

Returning to the work of Boyce et al. (2004) and their summary of survey data collected over a long period, we find a very substantial shift over the past few years in favor of directed online searching and away from browsing behaviors (see Table 5). However, using colleagues as information gatekeepers and "following up the literature" remain important despite technological advances.

Table 5
Method of learning about article (Boyce et al., 2004)

Method of discovery	Early % 1990–1993	Evolving % 2000–2002	Advanced % 2001–2002
Browsing	57.6	46.4	20.6
Print	[100.0]	[65.3]	[45.2]
Electronic	[0.0]	[34.7]	[54.8]
Online search	8.5	14.4	39.0
Other			
Colleagues	15.5	22.0	21.1
Citations	5.6	12.8	16.0
Other	12.8	4.4	3.3
Total	100	100	100

On digital publishing platforms, referral logs offer a very useful resource for helping us to understand how users navigate to the documents they deem worth downloading or printing (Nicholas & Huntington, 2003). A study by Davis (2003) started from the proposition that although we may think we know quite a lot about information-seeking behavior, the networked information environment throws up new challenges. Specifically, in this case, Davis asked what pathways researchers at Cornell took to get to American Chemical Society servers. His findings suggested that users employ a wide range of strategies to find chemistry articles; they particularly value library catalogs (24.9% of all referrals), bibliographic databases (23.8%), and electronic tables of contents (18.2%). The key significance of Davis's work is that despite the range of strategies exhibited across a whole population, most individuals tend to rely consistently on a small sub-set. This has implications for librarians and publishers and encourages information redundancy. Davis's findings support the view that librarians do not necessarily duplicate their efforts by having information in multiple places—for example, when they maintain links to journal URLs from the library catalog as well as having the same information on a university e-journal list.

The complexity of the issues and the difficulty of making sweeping generalizations are underlined by the work of Bontrhon et al. (2003). Theirs was a medium-scale investigation into electronic journal use by 35 faculty and 500 students at Edinburgh University. The starting premise was that the move to electronic formats affects serials management practices in libraries. The study explored the implications for the ways that faculty and students incorporate electronic journal usage into their working patterns. It found that faculty made very little use of the library's electronic journals web page and its subject trees, preferring to go directly to bookmarked tools such as the Web of Science, Beilstein, or PubMed to find relevant articles. Staff generally seemed to make very little use of the value-added features of electronic journals, such as tables of contents or mailing features. Most got their articles by bookmarking Internet sites or using links from databases such as the Web of Science. The library web page was used as a last resort.

Several studies underline the convenience of electronic journal services for off-site users. Jacoby and Laskowski (2004) found that the majority of e-journal use at the University of

Illinois, Urbana-Champaign, took place off campus (69% of accesses in 2002, 83% in 2003) or on campus. In-library use accounted for only 7% and 4.5%, respectively. At any time of the day, extramural usage was an order of magnitude greater than in the library: e-reserves were used more heavily off campus at 4:00 a.m. than at any time during the library's working day!

Further evidence of the popularity and convenience of electronic networked services comes from a study by de Groote and Dorsch (2003) at the University of Chicago. They found very high levels of electronic access among medical faculty and students. However, take-up varied enormously between different journal platforms. Patrons strongly preferred to use services with which they were already familiar. This suggests a lack of awareness of the richness of provision offered.

Both Davis (2002, 2004a) and Ke, Kwakkelaar, Tai, and Chen (2002) reported on the highly asymmetric patterns of digital library use as reflected in their server logs. In the case of ScienceDirect On Site, Ke et al. reported that nearly 50% of full-text downloads came from the 100 most active IP addresses out of a total population of more than 30,000. In a later paper, Davis (2004b) explored these patterns more systematically, using monthly COUNTER full-text download reports from 16 HighWire participating institutions. The other primary variable was the number of unique IP addresses, a surrogate for the number of users. Multiple regression methods were used to estimate the number of unique users across all titles. Scatter plots revealed a very strong linear relationship between l*n* downloads and l*n* unique IP addresses ($R^2 = 0.96$). Therefore, Davis contested that article downloads are a good predictor of the number of unique reader proxies (IP addresses), constant across time and institutions.

Sandstrom (2001) also offered some intriguing new thinking about information search behavior. She used the metaphor of animals foraging for food to explain some of the dynamics of human information searching. She argued that principles of least effort and the density and distribution of information resources determine information-seeking behavior. This might be a highly appropriate new model for helping us to understand information-seeking behavior across multi-disciplinary journal platforms such as ScienceDirect.

5.3. Reading articles

How is the reading behavior of researchers changing in relation to electronic access and the "journals crisis"? A good starting point for tackling this question is the work of Belefant-Miller and King (2003), who profiled reading behavior at a medium-sized U.S. university. Their work re-examined a 1993 study, presenting the situation from 1993 to the electronic era. It is a useful benchmark for subsequent studies. They concluded that, on average, faculty

- read 384 documents per annum, of which 161 were journal articles;
- had 4.2 personal journal subscriptions; and
- published three articles per annum.

Tenopir, King, Boyce, Grayson, and Zhang (2003) provided a rich synthesis of earlier surveys and literature on reading behavior. Their key findings may be summarized as:

- The number of personal subscriptions per scientist has decreased steadily from 5.8 (1977) to 2.2 (currently), signaling a shift from a journal economy to an article economy.
- Author web sites have not caught on; they account for less than one percent of readings in both the early and advanced phases.
- There has been a massive increase in electronic formats for reading.
- The journal publisher makes a big contribution to knowledge creation. Average readings per scientist have increased from 87 per annum (1977) to 148 (currently), the large majority of which are supplied from library collections in print or digital form.
- The usefulness of the articles read and indicators of their value suggest that information content has not changed much, but its overall value to the scientific community has increased as more articles are read and can be accessed more conveniently.

These data accord reasonably well with Mabe and Amin's 2002 study, which concluded that the average researcher reads 97 articles, 204 abstracts, and 1,142 titles and gives 21 citations each year. Of course, disciplinary differences will show considerable variation within these global figures. Jones, Hanney, Buxton, and Burns (2004) also pointed out that within the context of British psychologists working in the National Health Service, there is a significant difference in the median number of journals read annually between those with academic commitments and those without.

What role do electronic journals play in the weekly reading behavior of researchers in the sciences and social sciences? Smith (2003) reported on a survey at the University of Georgia (2001) that suggested that print plays a much higher profile in terms of weekly reading habits than might have been expected. Personal subscriptions were still an integral part of scholarly pursuits: 91% of faculty in both the natural and social sciences used print personal subscription materials on a weekly basis. Print accounted for more than half (54%) of the articles read each week. Franklin and Plum (2004) made the point that print plays a really important role in the context of supporting funded research, even though electronic accesses are now more frequent.

Huntington, Nicholas, Jamali, and Tenopir (2006) and Huntington, Nicholas, Jamali, and Watkinson (2006) provide thought-provoking insights into the microcosm of individual reader experience through their work analyzing transactional web logs. Their ongoing research raises more questions than it answers—for example, they asked, "How much do we really know and understand about online reading behavior?" It is very clear from their work that we are in great danger of constructing too much meaning around such basic concepts as the article download.

5.4. Using articles

A noticeable trend, albeit slight and from a low base, is an increase in bigger-picture studies that attempt to capture the value of journals in increasing the efficiency and effectiveness of

research. Drawing on experience and data from the pharmaceuticals sector, Koening (2001) advanced the argument that research productivity is a direct function of organizational information culture. Environments characterized by openness, richness of information resources and communication tools, and serendipity are more productive and creative places to work.

Many of the authors cited in this study emphasized the convenience of electronic desktop access. Indeed, it is easy to overlook the frustrations and sometimes harsh realities of using printed journal collections. Shaw-Kokot and de la Varre (2001) offered one of a surprisingly low number of journal availability studies in a print-based collection. The context of their study was an academic health sciences library at the University of North Carolina. They showed that user groups had problems locating journal articles: finding and photocopying items took a long time out of busy schedules. User errors (bad citations, lack of understanding of the way journals are shelved) or bibliographic error and local issues (reshelving, binding, missing issues, articles in use) compounded the problem.

Sathe, Grady, and Giuse (2002) studied the impact of print versus electronic journals on research processes at the Vanderbilt University Medical Center. They asked, "Do researchers use print and electronic formats for the same purposes?" They discovered that some of the differences in the ways that print and electronic journals are used at different points in the research cycle are significant.

- Researchers favored print over electronic sources for browsing ($p<0.001$)
- Researchers favored electronic sources over print for checking references ($p<0.05$)
- Researchers favored print over electronic sources for reading tables of contents ($p<0.001$)
- Researchers favored electronic sources over print for printing or photocopying ($p<0.005$).

This confirms the idea that patrons may limit their research to easily available electronic journals simply for convenience, regardless of whether other sources would better suit their information needs. This is an older study (reporting 1999 data) but it does offer an interesting approach.

Having found an article, what value do researchers extract from journals? Tenopir, King, and Bush (2004) surveyed medical faculty at the University of Tennessee regarding their use of journals and the values they attach to their readings (see Table 6).

These figures illustrate the critical value of journals in underpinning and supporting primary research and delivering front-line health care.

According to Brennan et al. (2002), access to electronic journals is changing research habits. As well as being more convenient, electronic access allows for greater opportunities to follow up on relevant cited articles. This facilitates a more comprehensive treatment of the literature. A fundamental shift in attitudes to the body of knowledge may be taking place. One respondent observed that he does not feel the "need to retain knowledge as long as access is maintained" and that his attitudes are now changing to reflect the fact that "the aggregation of knowledge is now paramount" (Brennan et al., 2002, quoted on p. 523). Another respondent mentioned the explosion of meta-analyses in the last couple of years. This research form was previously so cumbersome as to be impractical.

Table 6
The value of medical journals (Tenopir, King, & Bush, 2004)

Principal purpose for reading	Proportion of readings (%)	Average ratings of importance [a]
Primary research	29.9	5.1
Background research	6.5	4.2
Current awareness	22.1	4.6
Teaching	16.9	4.9
Writing	11.7	5.6
Consulting	3.9	6.0
Other purposes	9.0	4.3
All	100.0	

[a] Importance ratings: 1 (*Not at all important*) to 7 (*Absolutely essential*).

Finally, a really important question: can we translate the convenience offered by electronic information services into a financial value? Kurtz et al. (2000) studied the NASA Astrophysics Data Service (ADS), an abstracts service with rich links to full text documents. They offered one of the very few attempts to place a value on the impact of an information platform on a whole discipline. Use of ADS is clearly very intensive: in a typical month (March 1999), an average scientist made 29 searches and read 20 abstracts and 5.5 articles. What difference does this make? With certain assumptions about the time researchers save on going to the library, finding an article, and copying it, Kurtz and his team estimated that the ADS increased the efficiency of astronomical research by about 333 full-time equivalent researcher years per annum. Placing a financial value on the contribution of electronic journal access to the greater efficiency of the science base could have major policy ramifications.

Rowlands and Olivieri (2006) also considered the contribution that the journals system makes to the science base through a survey of immunologists and microbiologists. They reversed the logic of the Kurtz team's approach by asking what the key barriers to research productivity are. While not suggesting that scholarly communication flows are unimportant, scientists seem to rate other barriers (such as bureaucracy around grant-getting and human resource issues) more highly as barriers to realizing their full potential. Both studies emphasized the difficulty of operationalizing "productivity" as an independent variable. Much more work needs to be done in this critical area.

5.5. Ageing and obsolescence studies

There are some interesting and important questions to be asked about ageing and obsolescence processes in digital journal collections. Does use follow the same patterns of temporal decline that we observe for citations? What implications would flow from a better understanding of obsolescence as seen through the eyes of readers (downloads) as opposed to authors (citations)?

In an early, print-only study using 835 medical journals as a test-bed, Tsay (2003) began with the working hypothesis that there is no difference between the age distributions of use (as measured by re-shelving statistics) and citation. Tsay's study found that

- use decays exponentially, with maximum use in Year 1
- citation shows a sharp initial rise from a low base to Years 3 or 4, then an exponential decay
- a comparison of the two curves shows that there is a very dramatic difference in Year 1, and the two curves intersect between Years 2 and 3. After Year 3, the citation curve exceeds the one for use age, though both curves fall off exponentially beyond this point.

Tsay used Kolmogorov–Smirnov two-sample tests to show that the working hypothesis had to be rejected and that the ageing profiles of use and citation are indeed significantly different, at least for print titles in medicine.

Moving from Tsay's study into an increasingly electronic environment, what impact, if any, will ease of access have on the age profile of use? Boyce et al. (2004) suggested little change in reading patterns before and after the introduction of electronic access. However, Liu (2003) conjectured that since older papers have a much lower visibility in the digital age, both reading and citation habits may change to accommodate the ease of accessibility of digital materials. Houghton, Steele, and Henty (2004) also made this point. Kurtz et al. (2000) also found that frequently cited papers tend to be frequently read. This echoes the findings of Wulff and Nixon (2004) and Obst (2003), although the correlation is not very strong. A further question is what will happen to readings for articles that pre-date the digital archive, given the drastic fall-off in print readings noted earlier in this report.

6. Key findings

The following summary conclusions attempt to capture a range of key issues reflected in the current literature. It is difficult to be sure how valid these general messages can really be, given the many limitations of the research in this area. We are also at an interim stage in the full evolution of the digital library, so much remains provisional. More than anything, these broad conclusions will suggest some fruitful lines for further research.

6.1. Changing contexts for scholarly production and use

- Researchers appear to be reading more primary journal materials from a wider range of sources than ever before. The key drivers appear to be the availability of end-user search tools and changing working practices as researchers engage more in Mode II knowledge production.
- Specialist secondary services remain strong only in a few areas with strong Mode I characteristics. Generic services like the Web of Knowledge and Scopus are very much up and coming.

- Researchers spend less time per article reading. They "see" an increasingly narrow view of their own discipline as a result of the accelerating growth in the literature.
- Despite many problems with the current publishing system, there is little consensus on the best way forward. Positions are entrenched both in terms of stakeholder tribe and adherence to economic, technological, or behavioral determinist positions.

6.2. The digital transition

- Where implemented, electronic versions of journals have displaced print use dramatically and at a much faster rate than many anticipated.
- Introducing electronic journal platforms has a strong negative impact on print-only titles. The convenience and consumer acceptance of the new medium raise big issues for the continuing value of the print legacy.
- In bald contradiction, an isolated study suggests that introducing e-platforms actually increases print use by raising the profile of journals as an information source. This merits further investigation.
- There has been a major shift from a focus on the journal to a focus on separates, with brand management implications for publishers.
- Convenience and digital visibility are critical factors in the new information landscape.
- There is a strong correlation between print and electronic journal use in that the more popular titles tend to be used relatively more heavily in both formats.
- Mediated library services are declining rapidly in favor of user self-service. In some cases, mediated services are nearing the point of extinction.
- Much of the current thinking about the digital transition lacks sensitivity to some deep-rooted domain differences. It is not tenable that all disciplines are moving towards the common end point emblemized by the physics community.

6.3. Subject domains and information use

- Specialties or disciplines are a more useful, more natural unit of analysis for studies of scholarly communication than studies at the institution or journal level. This observation should be taken much more seriously at the research design stage.
- Greater sensitivity to disciplinary variation is needed in the design of user behavior studies.
- A theoretical perspective ("domain analysis") which begins to explain some of the scholarly communication preferences of different user groups is beginning to emerge. However, it remains a high-level concept. It is difficult to operationalize effectively in practice, either in terms of designing research studies or digital libraries.

6.4. Changing user behavior

- The introduction of databases of electronic journals signals a major shift from browsing to search behaviors.

- Researchers are not technically proficient at searching and employ a range of coping strategies to navigate digital libraries.
- Despite the huge increase in the use of electronic reserves, print is still an important aspect of the day-to-day life of the typical academic.
- Print-based and electronic systems are used for different purposes and at different times in the information seeking-cycle.
- In astrophysics, digital libraries offer major cost savings in terms of time savings and productivity enhancements. This assertion needs to be quantified for other research populations.
- The long-term value of the journal literature is perceived very differently by authors engaged in citing the literature and by readers. The age of readings and citations exhibit different rates and patterns of decay. This has major implications for journal pricing, citation behavior, and the cost-effectiveness of providing deep retrospective access.

7. Areas for further research

It is inevitable that a review of this nature can do little more, to paraphrase Donald Rumsfeld, than to benchmark a few "known knowns," point to a great many more "known unknowns," and speculate on a few "unknown unknowns."

One of the truly known issues in scholarly communication research is diversity. We know, beyond any doubt, that it is impossible to make generalizations about scholarly information behavior that transcend discipline. It is often shown that demographics such as age, academic status, and gender are powerful predictors of how researchers in a given discipline might behave in a given situation. However, we have no systematic base of evidence to make such predictions. Research in scholarly communication, often local and on a small scale, merely offers tantalizing glimpses of insights that might be of value to practitioners including publishers, librarians, or research managers. Perhaps we need to start thinking about creating much bigger datasets and, taking a leaf out of Wal-Mart's book, subjecting those datasets to serious geo-demographic profiling. After all, both publishers and librarians increasingly evince values that subscribe to the consumer culture outside the university. The Wal-Mart model evidently works—they understand their markets.

Intelligent readers will already have filled in many of the "known unknown" boxes for themselves by contextualizing those questions in their own milieu. The really interesting questions are the blue-sky "unknown unknowns" such as what value publishers, editors, referees, and librarians add to the knowledge production chain through the journals system. (This is not such an innocent question when deans and provosts are faced with large bills for journal renewals.) The biggest question of all is, of course, what kinds of functionality authors and readers really want from an Internet-based scholarly communications system. If we were to invent the journal today from scratch, what would it look like and how would it be paid for? These kinds of higher-level policy issues are beginning to assume real importance in an era characterized by a breakdown of consensus over the fundamental purpose of the journals system.

7.1. A note on search strategies

The majority of the papers used in this literature review were identified online using the Social Science Citation Index on Dialog Classic (File 7). Researchers used a multi-pronged search strategy and restricted retrieved documents to publications in the period 1995–2006.

The search strategy employed a number of key authors who have made major contributions to understanding the complex relationships between journals and scholarly behavior:

Search 1	All papers authored by (au=) or citing (ca=) King D
Search 2	All papers authored by (au=) or citing (ca=) Latour B
Search 3	All papers authored by (au=) or citing (ca=) Pullinger D
Search 4	All papers authored by (au=) or citing (ca=) Tenopir C
Search 5	All papers authored by (au=) or citing (ca=) Woolgar S

In addition, some broad topical strategies were employed, searching for terms and noun phrases in the title, corporate source, abstract, and descriptor fields:

Search 6	"SuperJanet"
Search 7	"scholarly communication"
Search 8	information seeking behavio(u)r AND (journal or journals)
Search 9	"electronic journals" OR "online (journal or journals)" OR "digital (library or libraries)"
Search 10	"reading behavio(u)r" AND (journal or journals)
Search 11	"digital reference"

All these statements were combined (using OR) to create a very large set that was subsequently limited to articles or reviews (thus excluding book reviews, notes, letters, and editorial material). It was also limited by publication date. Citation searches were carried out on a number of interesting papers to see if they had subsequently been incorporated. This search strategy was admittedly very inefficient; it was deliberately designed to maximize recall at the expense of precision. Titles and abstracts were viewed and relevance decisions made as to which materials to include. Documents covered in Tenopir (2003a, 2003b) were screened out. As a further check, less formal searches (and a lot of browsing) were undertaken using the ScienceDirect, Ingenta, and Emerald digital journal platforms and Google's Advanced Search facility. This yielded a few more references. Given the imprecise nature of the terminology and ISI indexing delays, it is not possible to guarantee that every relevant article has been included.

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