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Working Party on the Information Economy

DIGITAL BROADBAND CONTENT: SCIENTIFIC PUBLISHING

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FOREWORD

This report was presented to the Working Party on the Information Economy in December 2004 and was declassified by the Committee for Information, Computer and Communications Policy in March 2005.

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PREFACE

Digital content and digital delivery of content and information are becoming increasingly ubiquitous, driven by the expanding technological capabilities and performance of delivery platforms, the rapid uptake of broadband technologies and improved performance of hardware and software. Network convergence and widespread diffusion of high-speed broadband has shifted attention towards broadband content and applications that promise new business opportunities, growth and employment.

At its March 2003 meeting, the Information, Computer and Communications Policy Committee (ICCP) discussed interlinked broadband and digital content developments and policy issues. The Committee adopted two tracks for this work, agreeing to work: *i)* towards a Committee statement on promoting broadband development; and *ii)* to develop a work proposal on digital content. At its October 2003 meeting, it was agreed that the ICCP Committee should undertake more comprehensive analysis on digital broadband content, focusing on growth and value creation, drivers and barriers to growth, and changing market structures and emerging issues with development of new delivery platforms.

In February 2004, following preparation in the ICCP Committee, the OECD adopted the Recommendation of the Council on Broadband Development (see Box), setting out ten recommendations for OECD member countries when establishing or reviewing their broadband policies. These policy recommendations recognise the increased policy attention towards broadband content and applications. The ICCP Committee has been asked to monitor the development of broadband in the context of this Recommendation within three years of its adoption and regularly thereafter.

At its April 2004 meeting the ICCP Committee agreed to the work plan on digital broadband content, with this work being undertaken in the Working Party on the Information Economy (WPIE) in conjunction with the Working Party on Telecommunication and Information Services Policies (WPTISP). The WPIE is undertaking stocktaking studies of sectors where digital content is transforming value chains and business models. Initial sectors studied are: scientific publishing, music, online computer and video games and mobile content services. The studies are designed to further identify analytical, policy and measurement issues, and prepare the ground for more in-depth analysis of horizontal issues and challenges to broadband content development and applications. The WPIE held a Digital Broadband Content Panel in June 2004 and a Digital Broadband Content Workshop in December 2004.[1]

Further policy analysis is being undertaken in the area of digital content. For more information see: www.oecd.org/sti/digitalcontent.

OECD Recommendation of the Council on Broadband Development, 2004

The OECD Council recommends that, in establishing or reviewing their policies to assist the development of broadband markets, promote efficient and innovative supply arrangements and encourage effective use of broadband services, Member countries should implement:

- Effective competition and continued liberalisation in infrastructure, network services and applications in the face of convergence across different technological platforms that supply broadband services and maintain transparent, non-discriminatory market policies.
- Policies that encourage investment in new technological infrastructure, content and applications in order to ensure wide take-up.
- Technologically neutral policy and regulation among competing and developing technologies to encourage interoperability, innovation and expand choice, taking into consideration that convergence of platforms and services requires the reassessment and consistency of regulatory frameworks.
- Recognition of the primary role of the private sector in the expansion of coverage and the use of broadband, with complementary government initiatives that take care not to distort the market.
- A culture of security to enhance trust in the use of ICT by business and consumers, effective enforcement of privacy and consumer protection, and more generally, strengthened cross-border co-operation between all stakeholders to reach these goals.
- Both supply-based approaches to encourage infrastructure, content, and service provision and demand-based approaches, such as demand aggregation in sparsely populated areas, as a virtuous cycle to promote take-up and effective use of broadband services.
- Policies that promote access on fair terms and at competitive prices to all communities, irrespective of location, in order to realise the full benefits of broadband services.
- Assessment of the market-driven availability and diffusion of broadband services in order to determine whether government initiatives are appropriate and how they should be structured.
- Regulatory frameworks that balance the interests of suppliers and users, in areas such as the protection of intellectual property rights, and digital rights management without disadvantaging innovative e-business models.
- Encouragement of research and development in the field of ICT for the development of broadband and enhancement of its economic, social and cultural effectiveness.

The Council also instructs the Committee for Information, Computer and Communications Policy to monitor the development of broadband in the context of this Recommendation within three years of its adoption and regularly thereafter.

Source: OECD (2004), *Recommendation of the Council on Broadband Development*, C(2003)259/FINAL, www.oecd.org/dataoecd/31/38/29892925.pdf.

TABLE OF CONTENTS

FIGURES AND TABLES

SUMMARY

This study of *scientific publishing* spans both scientific and scholarly research publishing. The analysis covers:

- Scientific, technical and medical (STM), social sciences, humanities and arts publishing.
- Journals, research monographs, reference books and research databases as forms of content.
- Academic publishing and some aspects of professional publishing.

It focuses on the transition from print to digital delivery, to shed light on that transition, and it recognises scientific publishing as a central element in creation and dissemination of knowledge and in innovation systems.

Advances in digital technology are radically changing capabilities to reproduce, distribute, control, and publish information (see OECD 2004a). These advances are increasingly central to scientific activity, but they may conflict with some existing practices and policies that shape traditional publishing (CESTMJP 2004, p7). The key issue is whether there are new opportunities for science communication systems to better serve researchers, communicate and disseminate research findings to users.

The importance of scientific publishing

The importance of scientific publishing lies in its role in the production and diffusion of scientific and technical knowledge, and how this diffusion of knowledge drives economic growth and further research. Publishing is also a significant economic activity in its own right, and scientific publishing has the lead in digital delivery and in the emergence of new digital content business models in the print media.

OECD countries spent USD 638 billion on R&D in 2001 (OECD 2004b), and all OECD countries have paid increasing attention to both research and its dissemination and commercialisation. Scientific publishing is central to the efficiency of research, to the dissemination of research findings and the diffusion of scientific and technical knowledge. Scientific publishing plays a key role in innovation, and underpins economic growth and social development (*e.g.* education, health, environmental management, etc.). Scientific publishing is at the forefront of the digital delivery of content, and scientific and professional publishers have invested heavily in digital publishing. In 2003, an estimated 75% of scholarly journals published were available on line (Cox and Cox 2003).

High and increasing use of digital content has led to fundamental changes in research practices and the dissemination of scientific and technical knowledge. The US National Research Council (2001) noted that: “the rapidly expanding availability of primary sources of data in digital form may be shifting the balance of research away from working with secondary sources such as scholarly publications... New automated systems, and perhaps new intermediary institutions for searching and authenticating information, will develop to provide these services, much as libraries and scholarly publications served these roles in the past.” The UK’s Joint Information Systems Committee (2002) suggested that: “multimedia and distributed computing grids are developments which extend the processes of scholarly communication, while at the same time presenting considerable management challenges.” They pointed to

new pricing and publishing models, new applications of intellectual property law and new approaches to the preservation of digital content.

Responses have seen the development of new publishing business models, including: the so-called "Big Deal"; open access publishing; open access archives and repositories; and a variety of mixed and hybrid models. These responses put scientific publishing at the forefront of the development of new digital content business models.

The scientific publishing industry

The scientific publishing industry is a sub-part of the larger printing and publishing industry. The printing and publishing industry in the United States recorded shipments of EUR 260 billion in 2000, while production value in the EU-13 countries exceeded EUR 234 billion. According to the US Census Bureau (2004), print publishing accounted for USD 143 billion or around one-third of the gross revenues of the US copyright industries in 2002. By comparison, motion picture and video publishing gross revenues were USD 62 billion (*i.e.* less than half of print publishing), and sound recording and music publishing gross revenues were USD 14 billion (*i.e.* one tenth of print publishing). The core scientific publishing market is estimated at USD 7 – 11 billion (EPS 2004a; Simba 2004).

Scientific publishing produces a range of content products and related services. Primary content products traditionally include: journal articles and books in text form; journal articles published as collections grouped together into regular journal titles; and research monographs typically published on a one-off basis although in many cases as a part of a series or thematic collection. Three main types of organisations are publishers of scientific content: *i*) commercial, for-profit firms; *ii*) membership-based societies; and *iii*) institutional publishers. The business models adopted by each of these organisations vary, although the underlying economics of publishing and the changes in economic forces are the same for each.

The use of ICTs in research has led to a proliferation of data, new forms of research output and reporting, and new modes of presentation and analysis. Researchers are now producing a wide range of "born-digital" objects integral to their work, in addition to journal articles and research monographs. These include: collections of observations and data, some of which are the result of automated observation and data collection (*e.g.* from the Hubble Telescope); data rich results, which take the form of data that others can use (*e.g.* gene sequences); algorithms and elements of computer software that can be used by others (*e.g.* open source and object libraries); and a range of digital compositions (*e.g.* audio, video, still images, maps, etc.). The ongoing challenge is to use ICTs to provide an integrated and sustainable science communication system that encompasses all forms of research output, and that makes it easy for researchers to communicate their results and interpretation and for users to access and exploit these outputs.

Digital delivery and online access

This report analyses the adoption of e-commerce in publishing, digital delivery, and the use of e-journals, e-books, databases, archives and repositories by research authors and research users. It analyses the drivers of, and potential for, digital delivery and online access for authors and users as well as publishers, levels of adoption and use, barriers to further adoption, and some of the impacts of digital delivery and online access to scientific and scholarly content. ICTs are transforming the products and services that are produced in content publishing industries as well as changing the organisational processes in these industries. Thus the impacts of ICTs and digital delivery on scientific publishing are two-fold. First there are impacts of digital content and digital delivery on the nature of the content publishing business – impacts that are unique to content publishing industries. Second, there are impacts of e-

commerce and e-business activities on processes within and between businesses – impacts that are felt by all industries to a greater or lesser degree.

The impacts of e-commerce and digital delivery on media and publishing enterprises include: changes to workflow and the value chain, with some steps in the value chain becoming obsolete and some being taken over by other players; increased opportunities to collaborate with suppliers, customer and competitors; changes in product and service possibilities, and related changes to business models; and changes to corporate strategies to take advantage of new challenges and opportunities. At the industry level, impacts include: the possibility of economies of scale and greater market reach increasing concentration; digital delivery opportunities encouraging cross-media ownership; and the potential for the industry to diverge into two quite separate groups of very large multinational enterprises and smaller players (E-business Watch 2002, 2003).

ICTs, e-commerce and digital delivery in publishing are both *sustaining technologies* that improve the performance of established products and business models, and *disruptive technologies* that bring different performance characteristics, enable the introduction of alternative business models and change the ways that industries function (Christensen 1997). New sustaining technologies (*e.g.* more efficient editorial production systems, cheaper colour print technologies, and the use of e-business technologies to improve production and communication between supply chain partners) lead to economies and efficiencies. However, disruptive technologies have the potential to introduce new combinations of media, erode existing revenue models, develop new business models and change relationships with the user/consumer. There are opportunities for disintermediation within the supply chain and for the creation of new intermediaries, combining resources, assets, knowledge and information to create new business models and to develop new relationships with the consumer (Pira International 2003, p117).

There is both disintermediation and the emergence of new intermediaries – with publishers increasingly dealing directly with their research library customers and some subscription agents being squeezed out, and the emergence of new intermediaries between providers of research outputs and users, including hosted distribution service (*e.g.* HighWire Press) and a range of open access archives (*e.g.* arXiv and CogPrints) and institutional repositories (*e.g.* ANRO and CERN Document Server).

New value chains and business models

This report analyses recent developments in scientific publishing value chains and business models (see OECD 2004c for a summary of the approach to analysis of digital broadband content). Three major business models depending on digital delivery are emerging:

- The so-called "Big Deal" – where institutional and other subscribers pay for access to an online digital content aggregation of journal titles through consortia or site licensing arrangements.
- Open access publishing supported by author charges or other forms of institutional support on the research output supply-side – where authors and/or their employing or funding organisations contribute some or all of the costs of publication (*e.g.* BioMed Central).
- Open access archives and repositories – where organisations support institutional repositories and/or subject archives (*e.g.* CogPrints, eScholarship, etc.).

Each is analysed in terms of what is happening and how it works, impacts on publishing value chains and business models, impacts on science and scholarship (supply and use of research outputs), advantages and disadvantages, and arguments in the literature on their sustainability. Mixed and hybrid alternatives are also discussed.

In the immediate future there is likely to be a period of experimentation around the "author pays" version of open access publishing, combined with the emergence of a range of hybrids based around mixes of subscription-based and different forms of open access. In the longer term, some of the objects and activities that have been central to scientific publishing in the print era may gradually be replaced. Many developments in research practice, communication and publishing are emerging from increased use of ICTs and Internet that may enhance and/or replace current practices, activities and objects. Any changes in the current system of research journals and peer review will depend on: the roles of existing stakeholders, objects and activities; changing needs of researchers and the impacts of e-science and the "data deluge"; the opportunities afforded by rapidly developing information and communication technologies; and the underlying economic characteristics of information.

Emerging issues

With digitisation, digital delivery and changing ways of accessing and distributing scientific information and the associated impacts on scientific publishing, there is great interest in continuing to realise and enhance the benefits of digital delivery and maximising returns on R&D investments through the breadth and quality of access to research results, findings, and digital data of all kinds by both researchers and users. Fundamental changes in generation, organisation and access to information are the context for the issues outlined below. In this context OECD Science Ministers in January 2004 adopted a Declaration entrusting the OECD to work towards the establishment of access regimes for digital research data from public funding.[1]

There is a wide range of commercial, not-for-profit and public sector organisations involved in the production, dissemination and use of scientific publications, and in a framework of established practices, businesses and business models, publishers have rapidly adopted digital delivery and adapted their business models as new ICT related developments have opened new opportunities. However there are also much broader issues involving new expectations of research, increased focus on accountability for R&D expenditures, increased awareness of the importance of knowledge creation and distribution, and the emergence of broader ICT related opportunities (*e.g.* e-science), and there may be opportunities to develop new and improved systems to serve research, research users and research funders more effectively and efficiently, that better integrate actors and activities in innovation systems and increase returns to investments in R&D and enhance the innovative capacity of OECD economies.

Areas where governments and other stakeholders can contribute to improve access and dissemination of research findings cover the general framework for research, diffusion of research results and skills development. More specifically for scientific publishing and publications, they cover development of infrastructures, improved information and analysis, removal of specific barriers to digital content supply and use and standards and interoperability issues.

- *Research funding*. Public funding and funding agencies (including private agencies) are very important in R&D and related activities that generate research data, databases and scientific publications. Access to public and government-funded research content is a crucial issue, and there is considerable potential for governments to provide a lead in enabling digital delivery and

[1] Meeting of the OECD Committee for Scientific and Technological Policy at Ministerial Level, 29-30 January 2004 Final Communiqué. In the Communiqué Ministers emphasised the importance of ensuring the long term sustainability of the research enterprise and the need to involve civil society and business more effectively in the governance of public research. They concluded that "Coordinated efforts at national and international levels are needed to broaden access to data from publicly funded research and contribute to the advancement of scientific research and innovation. To this effect Ministers adopted a Declaration entrusting the OECD to work towards commonly agreed Principles and Guidelines on Access to Research Data from Public Funding". Final Communiqué available at: http://www.oecd.org/document/15/0,2340,en_2649_33703_25998799_1_1_1_1,00.html

enhanced access to publicly funded scientific and technical information. The principle is to enable maximum access to findings from publicly funded research to maximise social returns on public investments. This general approach is captured in the "Declaration on Access to Research Data from Public Funding" adopted by OECD Science Ministers meeting in January 2004, which recognised "that open access to, and unrestricted use of, data promotes scientific progress and facilitates the training of researchers" and "will maximise the value derived from public investments in data collection efforts", and entrusted the OECD to work towards the establishment of access regimes for digital research data from public funding.

- *Research evaluation*. Funding agencies (public and private) set ground rules for research evaluation as well as being major funders of research. They can play important roles in digital research content development and dissemination by: encouraging research evaluation that is neutral across different forms of publishing, while maintaining or raising quality; developing new ways of measuring the significance and use of open access archives and repositories to improve research evaluation by funding organisations, research suppliers and users; working with other institutions and researchers to respond to new challenges in disseminating research results in new media (SQW 2003; p30); and contributing to a climate that promotes diversity of public and private sector sources for information, in order to enhance access to scientific and technical information.

- *Skills*. Governments play a role in ensuring that there are the necessary education and training programmes for basic ICT skills and advanced skills, although full-time education is not currently the main source of many specialist ICT skills. Given rapid changes in technologies and skill needs new strategies, partnerships and programmes may be needed focusing on the ICT and related business skills necessary to support sustainable digital delivery and the development of new business models that enhance access.

- *Infrastructure*. Various publicly funded programmes support the development of hard and soft infrastructures that enable digital delivery and enhance access, including data bases, archive and preservation initiatives, and various kinds of legal deposit requirements.

- *Information*. High quality, independent information and analysis are crucial in rapidly evolving digital content applications. Industry associations, learned societies and publicly funded specialised research and dissemination agencies can provide information on new developments in scientific digital content publishing, and the supply, purchase and use of online content (*e.g.* support for case studies, research into emerging business models, and dissemination of information to the providers of research results and the purchasers and users of this information).

- *Technology neutrality*. Digital delivery and access can be enhanced by removing barriers and disincentives to use by minimising regulatory differences between digital content and other forms of content. These include regulatory impediments or differences in treatment of physical/print and online/digital alternatives (*e.g.* different taxation treatment of print and electronic content to the extent that the products are the same). Similarly, research evaluation systems may need to ensure that there is equal treatment of equivalent research outputs in various forms.

- *Standards and interoperability*. Standard-setting bodies play an important role in ensuring the framework for dialogue and co-operation in setting new standards and ensuring interoperability to the extent possible among new technologies. Governments help set the supportive frameworks necessary for cross-industry co-operation among standards developers and users. Specifically they can encourage co-operation within the publishing industry on interoperability across access systems and platforms; encourage co-operation among publishers, research libraries and users more generally to facilitate development of business

models that suit all parties; and work with industry and professional associations to ensure that all stakeholders are appropriately involved in new developments.

A combination of these informing, enabling and facilitating initiatives can support continued development of sustainable digital delivery business models that enhance access to scientific and technical information, improve the efficiency of research and increase returns on the very substantial public investments in R&D.

INTRODUCTION

This study of *scientific publishing* spans both scientific and scholarly research publishing. The analysis covers:

- Scientific, technical and medical (STM), social sciences, humanities and arts publishing.
- Journals, research monographs, reference books and research databases as forms of content.
- Academic publishing and some aspects of professional publishing.

It focuses on the transition from print to digital delivery, to shed light on that transition, and it recognises scientific publishing as a central element in creation and dissemination of knowledge and in innovation systems. [2]

Advances in digital technology are radically changing capabilities to reproduce, distribute, control, and publish information. These advances are increasingly central to scientific activity, but they may conflict with some existing practices and policies that shape traditional publishing (CESTMJP 2004, p7). The key issue is whether there are new opportunities for science communication systems to better serve researchers and communicate and disseminate research findings to users.

The central role of scientific publishing

Scientific publishing has a central role in the production and diffusion of scientific and technical knowledge and is at the forefront of digital delivery and the recent emergence of a number of new online content business models. Publishing is also a significant economic activity.

In 2000, the US printing and publishing industry recorded shipments valued at EUR 260 billion, while production value in the EU-13 countries exceeded EUR 234 billion. According to the US Census Bureau (2004), publishing accounted for USD 143 billion or around one-third of the gross revenues of the US copyright industries in 2002. In comparison, motion picture and video publishing gross revenues were USD 62 billion (*i.e.* less than half), and sound recording and music publishing gross revenues USD 14 billion (*i.e.* one tenth). Industry estimates put the core scientific, technical and medical (STM) publishing market at between USD 7 billion and USD 11 billion (EPS 2004a; Simba 2004). Reflecting the rapid increase in the generation of scientific and technical information, scientific publishing has been one of the fastest growing media sectors (Morgan Stanley 2002).

In 2001, OECD countries allocated USD 638 billion to R&D (OECD 2004b), and recent years have seen increased attention to both research and to its dissemination and commercialisation. Scientific publishing is important because it is central to the efficiency of research, as well as to the dissemination of research findings and diffusion of scientific and technical knowledge. Indeed, scientific publishing plays a key role in innovation systems, and underpins economic growth and a range of social development activities (*e.g.* education, health, environmental management, etc.). Scientific publishing is at the forefront of the digital delivery of content and scientific and professional publishers have invested heavily in digital publishing. In 2003, an estimated 75% of the scholarly journals published were available on line (Cox and Cox 2003).

There is extensive and increasing use of online sources in scientific and scholarly research communities. Education for Change *et al.* (2002) found that electronic journals and other sources were regarded as essential by 53% of UK-based researchers, electronic pre-print archives by 30% and computerised datasets by 25%. Similarly, Friedlander (2002) found that researchers in the United States used multiple sources, with more than 80% of biological and physical sciences researchers using electronic journals, as did around 75% of researchers across the sample. Healy (2002) found that 66% of those in law used electronic resources for research all or most of the time, as did 56% of those in business and management, 48% of those in biological sciences and engineering, 46% of those in physical sciences, 37% of those in social sciences and 25% of those in arts and humanities.

This high and rapidly increasing use of digital content has led to fundamental changes in research practices and in the dissemination of scientific and technical knowledge. The US National Research Council (2001, p5) noted that:

> *The rapidly expanding availability of primary sources of data in digital form may be shifting the balance of research away from working with secondary sources such as scholarly publications. Researchers today struggle to extract meaning from these masses of data, because our techniques of searching, analysing, interpreting, and certifying information remain primitive. New automated systems, and perhaps new intermediary institutions for searching and authenticating information, will develop to provide these services, much as libraries and scholarly publications served these roles in the past.*

The UK's Joint Information Systems Committee (2002) suggested that: multimedia and distributed computing grids are developments which extend the processes of scholarly communication, while at the same time presenting considerable management challenges. They pointed to the need for new pricing and publishing models, new applications of intellectual property law and new approaches to the preservation of digital content. Responses to date have seen the development of a range of new publishing business models, including the so-called Big Deal, open access publishing, open access archives and repositories, and a variety of mixed and hybrid models. Such responses put scientific publishing at the forefront of the development of new content business models.

ICTs and the rapid development of the Internet and Internet-based solutions have brought new opportunities for both research and its dissemination, and there is increasing recognition of the potential for enhancing access to research findings and the development of new models for the communication and dissemination of technical and scientific information. But, broader issues involving the effectiveness and efficiency of knowledge creation and diffusion include: which emerging models for scholarly communication best support the knowledge economy, boost technology transfer, and promote the move from research to product? Which best allow small and medium enterprises to take advantage of government investments in research? Which best promote an environment of entrepreneurial start-ups in emerging high-technology fields?

Analytical themes

This paper analyses major developments in scientific publishing in order to shed light on the changes taking place and identify possible industry developments and policy issues. Questions addressed include:

- *What is the current situation in the scientific publishing sector* – covering such issues as current industry structure and business models, recent market and industry trends, characteristics and dynamics.

- *To what extent are digital content products complements to, or substitutes* for, existing products, and what might be the demand and/or supply constraints, if any.

- *What are the drivers of the digital delivery of content* – covering such issues as new product possibilities, customer expectations and demands, market access and expansion, efficiency, cost reduction and regulatory change.

- *To what extent is the digital delivery of content being adopted* – covering such issues as the current level and rate of adoption, and the effects of different distribution channels.

- *What are the major impediments to the digital delivery of content* – covering such issues as suitability of the content to digital delivery, access to and cost of necessary infrastructure, skills and awareness, innovation by suppliers and users, market structures and regulatory barriers.

- *What are the impacts of the digital delivery of content* – covering such issues as what established activities are affected and what are the impacts on business models, performance and growth, efficiency and productivity, industry structure and competition among content producers and providers, and on other related industries (*e.g.* media, communications, broadcasting, education, research and technical services, etc.).

- *What are the major policy issues arising with the digital delivery of content* – covering such issues as network infrastructure, standards, intellectual property and digital rights management, payments and transactions, security and trust, trade, investment, taxation, etc.

Outline of the report

This report begins with a brief introduction to the principal actors and activities involved in scientific publishing, publishing value chains, industry structures and the economics and business models of the print publishing era. The next section analyses the drivers and potential of e-commerce and digital delivery in scientific publishing, levels of adoption and use by publishers, authors and readers, and the barriers to and impacts of e-commerce and digital delivery on publishers and their customers. Subsequent sections analyse the issues and business models emerging as a result of the transition to digital delivery and explore possible futures before concluding with a discussion of emerging issues. The report summarises the recent historical development of scientific publishing, focusing on the transition from print to digital delivery and on the impacts of digital delivery on publishing cost structures and business models. The report is a detailed literature review focusing on issues relating to digital delivery and the wider opportunities arising from the emergence of e-science and new online communication possibilities.

SCIENTIFIC PUBLISHING

This section presents a brief overview of scientific publishing activities, the role of scientific publishing in a knowledge-based economy and the scale and scope of scientific publishing activities.

Knowledge, information and scientific publishing

The knowledge economy has been defined as: "…one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth. It is not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activities." (DTI 1998). In a knowledge-based economy, innovation and the capacity of the national innovation system to create and disseminate the latest scientific and technical information are becoming increasingly important determinants of national prosperity. Scientific publishing plays a key role in the communication and dissemination of knowledge and is an important part of national innovation systems. Access to, and diffusion of, scientific and technical information lies at the heart of systems of innovation and is crucial to the realisation of maximum economic and social returns to investment in R&D.

Knowledge and information are fundamentally different from the physical resources that underpinned the economy in the industrial era and provided the basis for traditional economic analysis. These differences have implications for the way information industries and knowledge economies are organised. The economic implications of the special characteristics of information products and services have been analysed in the economic literature and are reasonably well known, but their implications for the emergence of new industrial structures and new business models are only now being worked through.

Information displays public good characteristics, lacking excludability and being non-rivalrous in consumption. If, for example, one person consumes a sandwich, it is gone: no-one else can consume it. If, however, one person reads a journal article and gains knowledge from it, the information in the article remains. Any number of people can consume it, and it can be consumed again and again. This “scarcity-defying expansiveness of knowledge” is one of its most important defining features (Stiglitz 1999). The social value of ideas and information increases when they are shared with, and used by others. The more information goods are consumed, the greater the social return on investment in them. Hence, the value of knowledge and the return on investment in research depends, in part, upon wide distribution and ready access.

Scientific publishing is an important mechanism for providing dissemination and access to a wide range of scientific, technical, medical, economic and social information. Scientific publishing also plays an important role in making research more efficient (HCSTC 2004a, p10). Dissemination of findings helps other researchers define their research work, minimises duplicative activities and may provide data which might otherwise have been collected again. Moreover, as an evolving process of building on findings, rapid publication and dissemination help to accelerate the advancement of science and, thereby, economic development.

The scientific publishing industry

The scale of publishing activities can be seen in terms of the employment and revenues earned by publishers and the quantity and value of published output. However, because it is difficult to separate scientific publishing from more general education, media and entertainment publishing activities, such data provide no more than a guide. This section analyses some of the economic dimensions of publishing in order to convey a sense of the scale of the scientific publishing industry and its activities.

In North America, official industry classifications under NAICS 2002 include an information sector (NAICS 51), within which NAICS 511 is the publishing industries (excluding Internet publishing), NAICS 51112 is periodical publishing and 51113 book publishing. Elsewhere, official industry classifications continue to tie publishing to the media manufacturing process, printing and, to a lesser extent, to information-related services. Hence, NACE Rev.1 includes division 22 – publishing, printing and reproduction of recorded media, within which 22.1 refers to publishing, 22.11 refers to book publishing and 22.13 refers to journal and periodical publishing (SIC Rev.3 2211 and 2212, respectively). Scientific publishing includes a subset of both periodical publishing (*i.e.* scholarly journals) and book publishing (*i.e.* scientific, professional and some educational monographs and reference works), but it does not map readily onto these classifications. This section presents a brief overview of the publishing industry. In light of these classification difficulties, it is followed by a section that scopes scientific publishing activities.

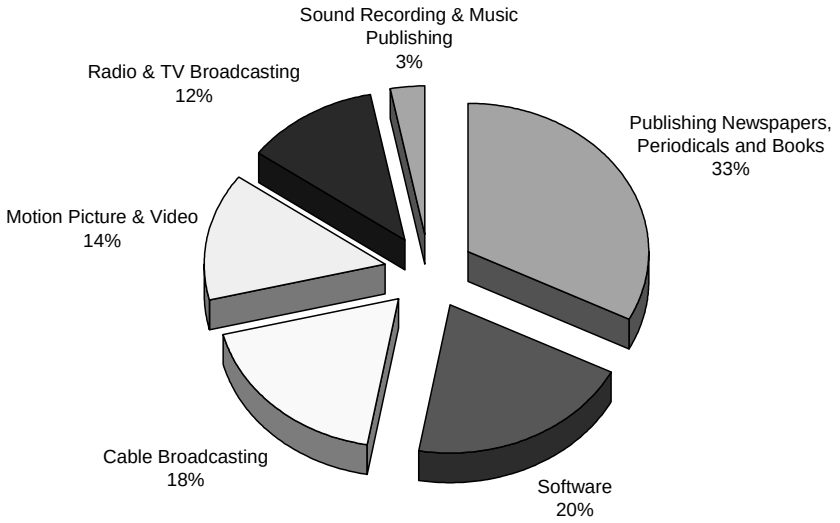
North America

Publishing of newspapers, periodicals and books accounted for around USD 143 billion or one-third of the gross revenues of the US' copyright industries in 2002 (Figure 1). By comparison, motion picture and video publishing gross revenues were USD 62 billion (*i.e.* less than half), and sound recording and music publishing gross revenues USD 14 billion (*i.e.* one tenth) (US Census 2002). In the United States, there were 31 597 establishments in the publishing industries in 2002 (NAICS 2002), total revenue amounted to USD 232 billion and employment to just over 1 million. In 2001, there were 1.1 million employed by US publishers, of which 133 245 (12%) were employed by periodical publishers, 89 676 (8%) by book publishers and 45 097 (4%) by database and directory publishers (US Census 2004a). Employment in the industry has been stable over the last decade (BLS 2004).

The US book market grew 3.3% during 2003 to USD 27.8 billion while unit sales slipped by about 1% to 2.22 billion. Professional and scholarly books accounted for the largest share in 2003 at USD 5.1 billion (18%) of the total market. The top five publishers accounted for 47% of the total market by value. The US market for magazines increased in value by 1.4% during 2003 to almost USD 30 billion. Consumer magazines were the largest segment, with sales worth USD 26 billion (87%) of total market sales. The top five publishers accounted for 27% of the total magazine market by value (Euromonitor 2004). Estimated US book publishers' net sales were USD 23.4 billion during 2003, of which scholarly and professional books accounted for USD 4 billion and higher education for USD 3.4 billion (AAP 2004).

In Canada, there were an estimated 619 book publishers in 2000-01, with 8 626 full-time and a further 1 631 part-time employees. Total sales revenue amounted to CAD 2.4 billion (USD 1.5 billion). Canadian book publishers produced 15 707 titles during 2000-01, of which 3 221 were textbooks. In 1998-99, Canadian periodical publishers' sales were worth almost CAD 1.3 billion (USD 830 million) and they employed 5 889 full-time and 2 375 part-time employees, of which scholarly periodicals accounted for CAD 71 million (USD 46 million), 373 full-time and 698 part-time employees (Statistics Canada 2004).

Figure 1. Gross revenues of copyright industries, United States 2002
(per cent)



Source: US Census Bureau (2002), *Services annual survey*, Census Bureau, Washington DC.

Europe

In 2000, the value of publishing and printing sector production in the EU-13 countries was EUR 234 billion, of which publishing (NACE 21.1) accounted for EUR 121 billion (52%). Value added amounted to EUR 101 billion, of which publishing accounted for EUR 49 billion. There were 1.2 million employed in the sector (excluding the United Kingdom). The sector has grown rapidly in recent years, with production value increasing 53% between 1997 and 2000. On average, publishing industry production accounted for 4.6% of manufacturing production in the EU-13 countries, ranging from highs of 10% in Ireland, 7.8% in the United Kingdom and 7.4% in Denmark to lows of 3% in Italy and 3.7% in Portugal. The largest European publishing industry activity by value was in the United Kingdom, followed by Germany, France and Italy. Employment in publishing accounted for an average 5.1% of manufacturing employment (E-Business Watch 2002) (Table 1).

Spain and the United Kingdom have the highest revealed comparative advantage in book trade, based on the English and Spanish language diaspora. Spain, the United Kingdom and Italy also show relatively high levels of specialisation in book publishing. High levels of imports of periodicals into Austria, Ireland and Sweden also reflect language-based transactions – English-based into Ireland and Sweden, and German-based into Austria (Pira International 2003, pp. 67-70).

Table 1. Production and employment in publishing in Europe, 2000
(NACE 22)

	Production Value 2000		Value Added (At factor cost)		Share in total manufacturing		Employed
	EURm	%	EURm	%	Prod Value	Value Added	No.
Austria	3 997.3	1.7	1 789.8	1.8	4.0	4.8	26 567
Belgium	6 574.0	2.8	2 315.5	2.3	3.8	4.8	38 694
Denmark	5 169.0	2.2	2 271.2	2.3	7.4	9.0	51 830
Finland	3 940.9	1.7	1 644.0	1.6	4.0	5.2	31 490
France	34 018.1	14.5	11 567.5	11.5	3.8	5.3	210 147
Germany	51 335.4	21.9	26 649.9	26.5	4.0	5.9	352 243
Ireland	9 699.5	4.1	3 398.0	3.4	10.0	9.7	20 070
Italy	24 736.7	10.6	8 419.2	8.4	3.0	3.7	177 130
The Netherlands	12 945.9	5.5	5 506.1	5.5	6.4	9.4	93 802
Portugal	2 615.4	1.1	998.1	1.0	3.7	4.9	40 089
Spain	14 697.6	6.3	5 804.9	5.8	4.1	5.6	141 834
Sweden	8 068.2	3.4	2 880.4	2.9	4.6	5.1	57 123
UK	56 111.0	24.0	27 437.5	27.3	7.8	11.1	..
EU-13*	233 909.0	100.0	100 682.1	100.0	4.6	6.4	..

Note: EU-13 no data for Greece and Luxembourg.

Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels.

The UK Department of Trade and Industry estimated the total turnover of publishing in the United Kingdom in 2000 to be of the order of GBP 22 billion (USD 33 billion). As a sector, publishing is significantly larger than pharmaceuticals manufacturing and about half the size of telecommunications. The publishing sector employed 164 000 people in the United Kingdom in 2000, compared with 65 000 in pharmaceuticals manufacturing and 234 000 for telecommunications (SQW 2003, p12). Total UK publishing industry book sales were worth in excess of GBP 3 billion (USD 4.5 billion) in 2000 from the publication of more than 1 million titles, while UK journal sales earned more than GBP 550 million (USD 830 million) from 2 769 titles, of which an estimated 1 940 were available electronically (DTI 2002a).

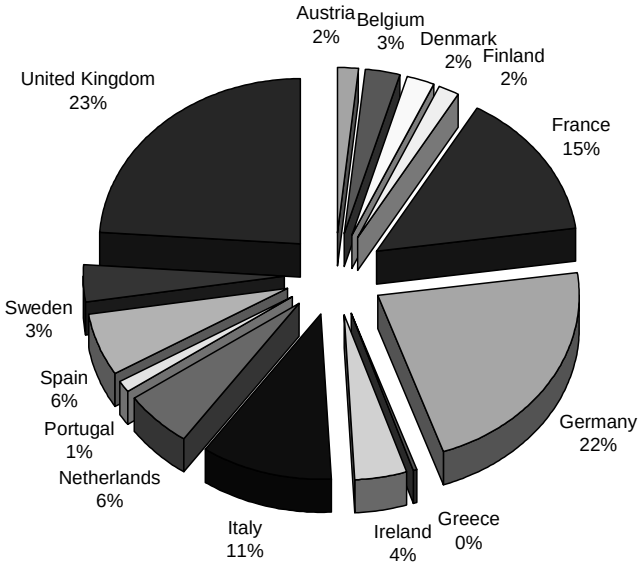
In major European book and periodical markets, Euromonitor (2004) reported that:

- The French book market grew by 1.2% over the year to reach EUR 2.4 billion (USD 2.8 billion) in 2003. The largest sector in value terms was general literature, generating 19% of total sales or EUR 462 million. The value of the French market for magazines fell by 1.3% during the year to EUR 4.1 billion in 2003. Lagardère, owner of Hachette Filipacchi Médias, led the magazine market with a market share of 32% in 2003, while Lagardère Media and Editis (formerly Havas) together accounted for more than 50% of 2003 book sales.

- The German book market fell during the year to just less than EUR 8.2 billion (USD 9.7 billion) in 2003. Non-fiction was the largest market segment, accounting for 80% of the total book market by value. Bertelsmann Gruppe held a leading position in the market in 2003, with 8% of sales, more than 5% ahead of its nearest rival. The German market for magazines increased by 1% during the year to reach 564 million copies in 2003. Consumer magazines accounted for 88% of the market in volume terms, with a circulation of 501 million copies. The leading player in the magazine market was Heinrich Bauer Verlag, which accounted for 10% of total sales.

- The UK book market was worth USD 5.6 billion in 2003, with science/technical books accounting for nearly 40% of sales by value. Bertelsmann increased its book market share to 13% during 2003. The UK market for magazines reached 1.44 billion copies in 2003. Women's weeklies accounted for almost one-third in value terms. IPC Media accounted for 31% of sales by value during 2003.

Figure 2. Share of EU publishing production, 2000
(per cent)



Source: Pira International (2003),*The EU Publishing Industry*: *an assessment of competitiveness*, European Union, Brussels.

Asia Pacific

In Japan, the content market was worth USD 99.3 billion in 2001, of which 21% (USD 21 billion) was non-newspaper publication (Kono 2004). Sales in the Japanese book market were worth USD 7.6 billion in

2002, a marginal increase over the previous year. Non-fiction titles represented the largest share of the Japanese book market, accounting for 70% sales in 2002. The Korean book market was worth USD 2.2 billion in 2002, having grown by 16% since 2001. South Korea is considered to be among the top ten book markets in the world. Reference book publishers accounted for the top six players in the Korean book industry, with a combined market share of 43% in 2002. The most popular channel for distribution of books was bookstores, which accounted for 53% of sales (Euromonitor 2004).

In Australia, 246 specialist book publishing businesses sold a total 114 million books, earned a total income of almost AUD 1.6 billion (USD 870 million) and employed 5 340 people during financial year 2002-03. The 20 largest publishers generated 74% of industry income. Between 2000-01 and 2002-03, the number of books sold decreased by 12% and income from sales was down 1%. However, operating profits before tax increased by 76% and profit margins increased by 2.3 percentage points to 5.6%. The majority of book sales (by value) were to retailers (76%). Twenty-four per cent of sales were transacted directly with customers and an estimated 1.1% (AUD 14 million) of total book sales were made via Internet. Fifty-six per cent of the 8 553 books published in Australia during 2002-03 were educational. Sales of printed educational books were worth AUD 548 million (USD 300 million), while sales of electronic books were worth AUD 7.1 million (USD 3.9 million) – of which AUD 4.4 million came from general and AUD 2.7 million from educational material. Income from sales of books targeting tertiary education amounted to AUD 144 million (USD 78 million), and income from sales of professional and reference books amounted to AUD 92 million (USD 50 million). Indicating significant investment in e-commerce and digital delivery, computer equipment and related software accounted for 20% of Australian book publishers' capital expenditures during 2002-03 (ABS 2004).

In New Zealand, the total turnover of the book publishing industry in 2002 was estimated at NZD 204 million (USD 94 million), with NZD 117 million of this (or 57%) generated by exports. The top 5% of publishers produced nearly 90% of the turnover, while 74% of the publishers together produced just 2%. In 2001, the total turnover of newspaper publishing was NZD 1 071 million (USD 496 million), and that of periodicals was NZD 375 million (USD 174 million). It was estimated that there were more than 3 600 titles published in 2002, of which almost 2 100 were exported. Concentration on educational titles is one of the most striking features of the New Zealand industry, with this making up 56% of all titles published and 66% of exported titles (Dialogue 2003).

The scale of scientific publishing activities

EMCC (2003) reported that educational and professional books and training accounted for 20% of the worldwide entertainment and media market in 2001 (USD 208 trillion). World exports of printed matter and literature rose from USD 7.6 billion in 1980 to USD 25.6 billion in 1998. Books accounted for USD 10.6 billion (41%) of 1998 exports. At that time, the major book exporters included: the United States USD 2.1 billion (20%), the United Kingdom USD 1.8 billion, Germany USD 1.1 billion, Spain USD 653 million and France USD 618 million. The United Kingdom, Spain, Germany, Italy and the United States were the largest net exports, while Canada, Australia, Switzerland and Brazil were the largest net importers. Exports of newspapers and periodicals were worth USD 4.6 billion during 1998, up from USD 1.5 billion in 1980. The largest exporters of newspapers and periodicals were the United States (USD 895 million), Germany (USD 805 million), the United Kingdom (USD 693 million) and France (USD 468 million). The United States, United Kingdom and Germany were the largest net exporters, while Canada, Switzerland and the Russian Federation were the largest net importers (Ramsdale 2000; UNCTAD 2002).

Literary Marketplace (2004) reported that there were 13 574 book publishers worldwide as at June 2004, of which 10 775 (79%) were in OECD member countries (Annex Table A1). The United States (2 989), Germany (1 487), the United Kingdom (1 147) and France (629) had the largest number of

publishers. In Europe, book titles produced per million population averaged 808 in 2000, with a range from 1 404 in the United Kingdom to 184 in Belgium. Book titles in print averaged 9 993, and ranged from 18 827 in the United Kingdom to 2 199 in Ireland. An overall positive trade balance in books across Europe of EUR 230 million, included surpluses of EUR 662 million for the United Kingdom and EUR 556 million for Spain, and a deficit of EUR 212 million for Austria (Pira International 2003, p79).

Registers of publications reveal the number of items published. The total number of records in the register of periodicals increased from 578 315 in 1991 to 1.1 million in 2003, with more than 53 000 new periodicals added during 2003. A reported 22 916 were on line (www.issn.org). *Ulrich's Periodicals Directory* listed 192 920 active titles in August 2004, of which 41 190 (21%) were on line. Of the 45 091 listed active academic and scholarly titles, 15 482 (34%) were available in full text on line (www.ulrichsweb.com). Cox and Cox (2003) reported that in their survey of 275 journal publishers, 75% of the journal titles were available onl ine. ALPSP/CAPP (2002) reported that the worldwide learned journals market involved "some 17 500 publishers publishing millions of articles in about 35 000 journals."

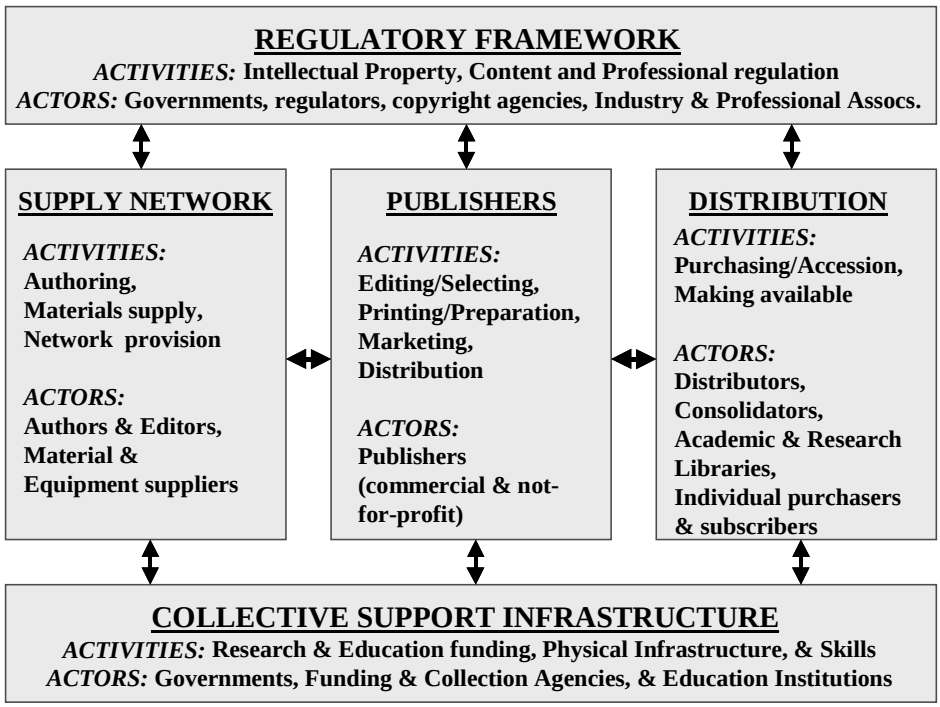
There are two major sources of data on the scientific publishing market. Simba covers a somewhat wider range of research publishing, while Electronic Publishing Services (EPS) focuses more narrowly upon the scientific, technical and medical (STM) publishing market. Simba estimated the global scientific publishing market at USD 11 billion in 2003, up by 3.2% on 2002 (Simba 2004). According to EPS, the STM publishing market (excluding publishing in the humanities, arts and social sciences) was worth more than USD 7 billion in 2002. Scientific publishing and information accounted for around 42% of this total, medical 36% and technical 22%. Geophysical databases accounted for around 5% of the total market and genetics databases for around 3%. Within STM publishing, journals accounted for USD 3.5 billion of 2002 sales (50%), databases USD 1.3 billion, books USD 1.1 billion, metadata (*e.g.* indexes) USD 800 million and aggregation activities USD 300 million. An estimated 61% of scientific and technical information was published in electronic form (*i.e.* digital delivery), as was 42% of medical information. The largest *customers* are academic institutions, followed by medical institutions and practitioners and then by corporate customers (Worlock 2004a). The International Association of Scientific, Technical and Medical Publishers estimated that there are more than 2 000 STM publishers worldwide, publishing more than 1.2 million articles per year via approximately 16 000 journals (HCSTC 2004a, p12).

While none of these data are identical with scientific publishing, they do reveal a substantial economic activity, in terms of production and value added. Publishing activities involve a large number of firms and many thousands of jobs. It is also apparent that scientific publishing is at the forefront of developments in digital delivery. Taken together with the pivotal role of scientific publishing in innovation systems, as a key mechanism for knowledge diffusion, this makes scientific publishing an important topic for study.

INDUSTRY STRUCTURE AND VALUE CHAINS

The section presents an overview of the actors and activities involved in scientific publishing – the structure of the publishing industry, the main players, value chains and market structures. It begins by identifying the main *actors* (*i.e.* commercial, non-profit society and institutional publishers), how each works, their motivations and specialisations. It then identifies the main publishing *activities* (*i.e.* journal, book and database publishing). It concludes with a brief outline of market structures, industry concentration in STM publishing and the extent and focus of recent merger and acquisition (M&A) activities in the media and publishing sector.

Figure 3. The scholarly communication product system



Source: Houghton, J.W. (2001), 'Crisis and Transition: The Economics of Scholarly Communication' *Learned Publishing* 14(3), July 2001, pp167-176.

The actors

There are three main types of organisations that are publishers of scientific content: *i*) commercial for-profit firms; *ii*) membership-based societies; and *iii*) institutional publishers. The motivations and business models of each vary, although the underlying economics of publishing remain the same.

Commercial publishers

There are a range of commercial publishers in terms of size and focus of operations, with some large multinational firms focusing to a greater or lesser extent on scientific publishing, and many thousands of smaller niche commercial publishers. Many of the major commercial publishers of scholarly journals have developed collections of titles. Some are quite general, but others have developed specialisations in particular areas that amount to a significant share of the titles and content in particular fields of research. Some of the larger commercial publishers of research monographs have also developed a strong presence in particular fields.

Large commercial publishers include: Reed Elsevier, Springer, Blackwell, John Wiley, Taylor & Francis, Thomson, McGraw-Hill, Sage, Karger, Holtzbrinck, Mary Ann Liebert, and Havas (Box 1).

Society publishers

Learned and professional societies are significant publishers of journals relating to their particular specialised fields. It is estimated that of the 21 000 peer reviewed journals, monographs and book series listed in *Ulrich's Periodicals Directory 2004*, at least 9 250 were published by not-for-profit publishers (learned societies, professional associations, university presses, etc.) (Worlock 2004b). Typically, the primary motivation of society publishers is scholarship and its dissemination in order to advance knowledge in their field. Nevertheless, for society publishers publication activities are often profitable and provide a source of revenue to support the wider activities of the society. A number have outsourced their publishing activities to commercial publishers (DTI 2002a, p40).

Examples of society publishers include: The American Chemical Society, Institute of Physics Publishing, The Institute of Electrical and Electronics Engineers, The European Physical Society, The American Medical Association, The American Psychological Association, The American Institute of Biological Sciences, and The American Institute of Physics.

Institutional publishers

Many universities, research centres and schools also support publishing activities. These institutional publishers publish both journals and research monographs. Most are relatively small operations which seek to meet the needs of local and institutional dissemination, but some are major international players operating on a commercial basis (*e.g.* Oxford University Press). There are also a number of international organisations that could be considered institutional publishers (*e.g.* The United Nations and its various agencies, World Bank, International Monetary Fund, European Union/European Commission, OECD, etc.). While there are many institutional publishers that would not consider themselves commercial and have not operated on an overtly for-profit basis, many are required by their founding institutions to be self-supporting and to provide a return on the initial investment. As a result, many institutional publishers have become more commercial in their operations – including both their editorial practices and pricing.

Examples of institutional publishers include: Oxford University Press, Cambridge University Press, Harvard Business School Press, Delft University Press, Edinburgh University Press, University of Chicago Press, and Johns Hopkins University Press.

Box 1. Some of the leading commercial scientific publishers

Reed Elsevier – is one of the world's larger publishers and information providers. Activities include science and medical, legal, education and business publishing. In 2003, Reed Elsevier employed approximately 35 600 worldwide and had a turnover of approximately GBP 4.9 billion. Operating profit was GBP 661 million, with an operating margin of 13.4%. In 2003, 39% of Reed Elsevier's turnover was derived from subscriptions; 31% from circulation and copy sales; 13% from advertising sales; 9% from exhibition fees; and 8% from other sources. By segment, science and medical earned GBP 1 381 million (28% of total revenue), legal GBP 1 318 million (27%), business GBP 1 328 million (27%) and education GBP 989 million (18%). By sector, 2003 operating margins were 33.9% in science and medical, 20.7% in legal, 7.5% in education and 17.2% in business. Reed Elsevier's online access product, ScienceDirect, offers a full text online research tool that holds more than 5 million research articles that can be searched, accessed and linked. Elsevier also publishes a range of secondary material, such as supporting bibliographic data, indexes and abstracts, and tertiary information in the form of review and reference works. Major recent developments include: Scopus, a full-text linking, abstracting and indexing database; and Scirus, a science-specific Web search engine.

Wolters Kluwer – had revenues of EUR 3 436 million in 2003, up 13% on 2002. Net income was EUR 610 million, with an operating margin of 18%. By segment, health earned EUR 663 million and education EUR 302 million. KluwerOnline offered electronic access to more than 650 Kluwer journal titles and 600 e-books. Electronic products accounted for around one-third of revenues for Wolters Kluwer Health. Kluwer Academic Publishers has now been merged into Springer (see below).

Thomson Corporation – employs 39 000 people in operations spanning 46 countries. In 2003, revenues were USD 7 616 million – 55% from electronic products and services and 64% from subscription-based products and services. Operating profit was USD 1 191, with an operating margin of 15.7%. By segment, USD 3.1 billion of 2003 revenues came from legal and regulatory, USD 2.1 billion from learning, USD 1.5 billion from financial and USD 760 million from scientific and healthcare. Thomson's Web of Science and Web of Knowledge products are among its leading growth areas.

Springer – Springer Science+Business Media publishes scientific and specialist literature. Springer has more than 5 000 employees in 18 countries. In 2003, revenues were EUR 833 million (including Kluwer Academic Publishers), of which 56% came from STM publishing and the remainder from a range of professional publishing.

John Wiley – is a publisher of print and electronic products, specialising in scientific, technical and medical books and journals; professional and consumer books and subscription services; and textbooks and other education materials for undergraduate and graduate students and lifelong learning. Wiley employs around 3 500 people worldwide. Wiley's revenues were USD 854 million in 2003, growing at a compound annual rate of 12% since 1993. 2004 revenues were up 8% to USD 923 million, of which professional and trade accounted for USD 393 million, science, technical and medical USD 340 million, and higher education USD 190 million. Wiley has approximately 22 700 active titles and about 400 journals, and publishes about 2 000 new titles in a variety of print and electronic formats each year. Approximately 25% of Wiley global revenues are Web-enabled and Wiley expected to increase that figure to about 40% within three years.

Sources: Compiled from company Web sites and annual reports.

Scientific publishing activities

Scientific publishing involves a range of activities and produces a range of content products and related services. The primary content products have included journal articles and books in text form. Journals publish collections of articles grouped into regular publications with particular branded journal titles. Research monographs have typically been published on a one-off basis, although there have been many cases in which they have appeared as a part of a series or thematic collection.

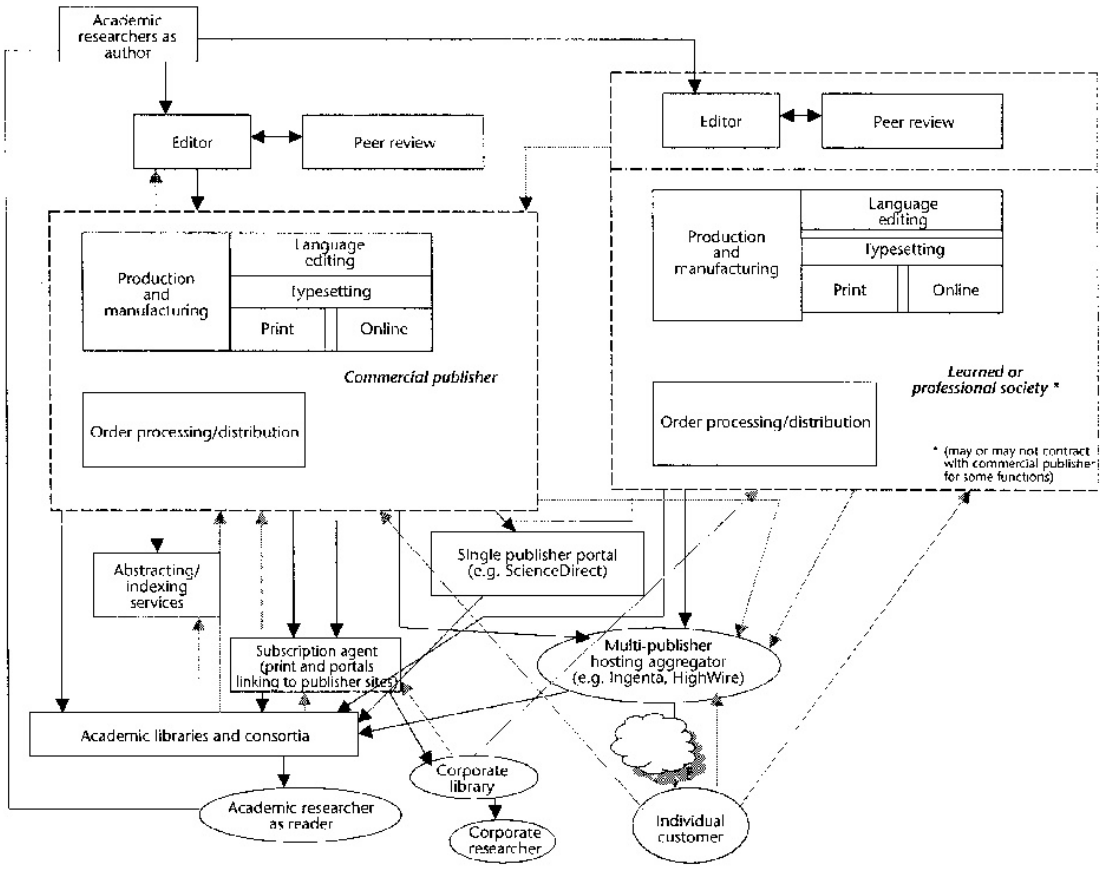
In addition to journal articles and monographs, researchers are now increasingly producing a wider range of "born-digital" objects as an integral part of their work. These include: collections of observations and data, some of which are the result of automated observation and data collection (*e.g.* from the Hubble Telescope); data rich results, which take the form of data that others can use (*e.g.* gene sequences); algorithms and elements of computer software that can be used by others (*e.g.* open source and object libraries); and a range of digital compositions (*e.g.* audio, video, still images, maps, etc.). The use of ICTs in research has led to a proliferation of data, new forms of research output and reporting and new modes of

analysis and presentation of research findings some of which have not traditionally been part of scientific publishing.

Journal publishing

Journals are one of the primary vehicles for the dissemination of peer-reviewed research material and they play an important role in scientific and scholarly communication. They also play an important role in the evaluation of research, with peer-reviewed publication widely seen as the principal output indicator. The market for scientific and scholarly journals is global (*i.e.* the global research community) (DTI 2002a, p40). Figure 4 shows a schematic journal publishing value chain.

Figure 4. The journals supply network



Source: Pira International (2003), *The EU Publishing Industry*: *An assessment of competitiveness*, European Commission, Brussels, p40.

The dominant revenue model for journal publishers has been the purchase of subscriptions to their journals on an annual basis, most often by research and institutional libraries on behalf of their communities. Journals can account for up to 75% of academic libraries' content budgets. Subscriptions from commercial research institutions and individuals also bring revenue, and journals may also generate income through the sale of advertising and the sale of reprints or the rights to reprint articles. Many journal publishers are also active in other forms of scientific publishing (*e.g.* research monographs and textbooks). Subscription revenues deliver strong cash flow and, for the major publishers, profit margins are high – Reed Elsevier's operating profit margin on its STM journals was 36% in 2000 (Pira International 2003,

p163). The industry has undergone considerable consolidation over the last 10 years, and some of the larger publishers have built a "portfolio" of titles in particular research fields.

Typically, journal publishers have operated on an 80/20 principle, wherein 80% of the revenue comes from 20% of their journal titles. Competition between publishers is for recognised editors and authors and to a lesser extent, (and indirectly via editor and author recognition) for a share of research library budgets. Typically, authors contribute content for free. Editors are often paid a retainer. The peer review process is organised by the publisher, but it is conducted by scholars who provide the peer review service free (DTI 2002a, p40-41).[3]

The UK Department of Trade and Industry (2002a) noted the following major issues surrounding journal publishing and the diffusion of information:

- A decline in subscriptions, with renewal rates decreasing due to price increases and the increasing availability of online access (reducing individual subscriptions).
- The rate of new journal launch has decreased as the industry has matured, with fewer journals being started.
- Disintermediation by authors, editors and libraries has become a threat to publishers, as tools to publish on line have improved.
- Initiatives to retain copyright, with many questioning the publishing paradigm in which commercial publishers make money from government-funded research, restricting access to the research.
- Market discontent, with double-digit price increases over many years leading to a backlash among major customers (*e.g.* research libraries); and significant investments over the last 5-10 years in the transition to digital delivery, with higher costs involved in operating a dual print and electronic system.

The issue of the optimum way forward continues to be the subject of intense debate. For example the UK Government in its response to the House of Commons Science and Technology Committee report (HCSTC 2004a) suggested that: "It is only through the profits generated from current products that publishers and learned societies can afford to develop new technologies that will benefit the whole of the academic community. The Government will continue to encourage the publishing community to develop their products to meet the needs of the academic community" (HCSTC 2004b, p22). As this debate continues, publishers, learned societies and other participants are continuing to develop new and innovative revenue-producing products and services in response to these major challenges (see section on new value chains and business models below covering the "Big Deal", open access publishing, and open access archives nd repositories).

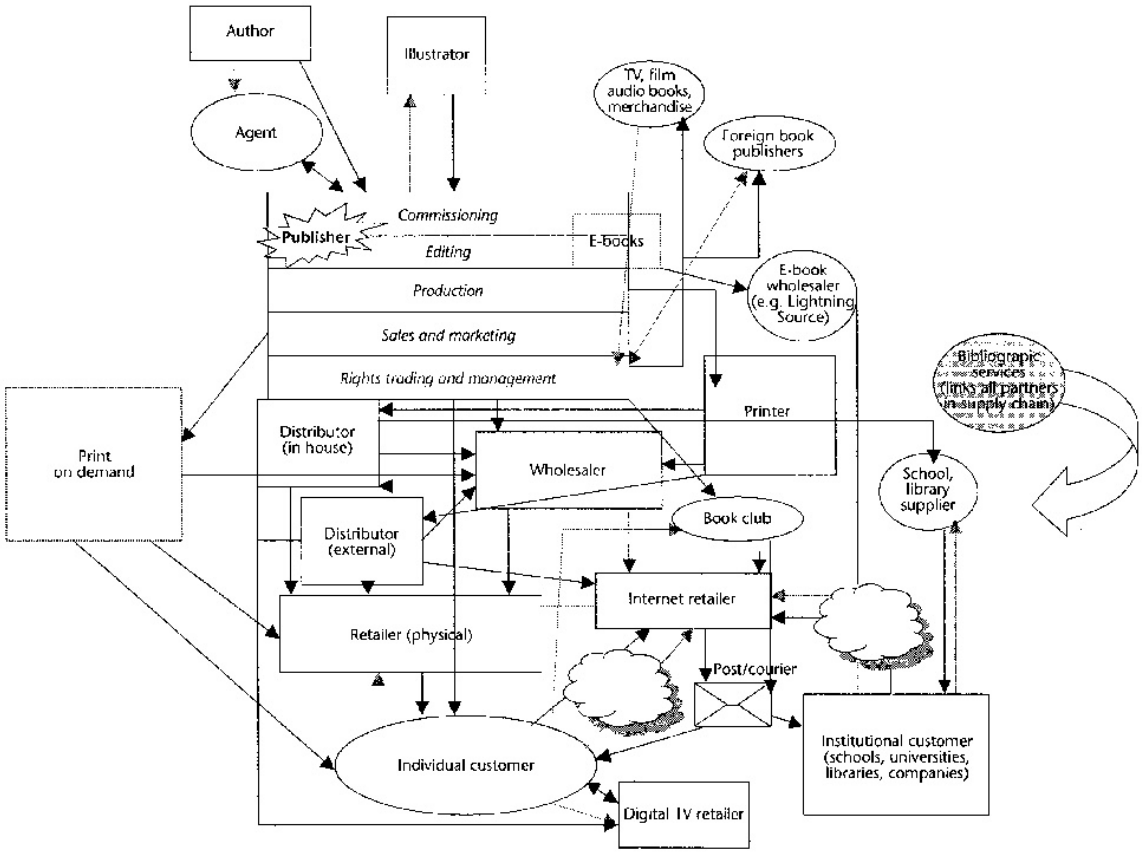
Book publishing

Academic publishing is one of the recognised sub-areas of book publishing, and it is a significant part of some publishers' businesses. The book publishing industry is fragmented, with many thousands of smaller niche publishers. Nevertheless, a significant proportion of academic book publishing is undertaken by a handful of large multinational commercial publishers and a relatively small number of major society and institutional publishers. Often, academic book publishers and scientific and scholarly journal publishers are the same. Figure 5 shows a schematic book publishing value chain.

The value chain for content creation in academic books involves greater efforts by publishers to cultivate authors and generate content than is typically the case with journal articles. Journal article authors often have relatively little contact with the journal publishers, whereas book authors interact much more

directly with their publishers. Proposals and sample chapters may be reviewed externally, but it is common practice for there to be internal publisher reviews of book manuscripts, rather than the independent academic peer review undertaken with journal articles. The distribution channel for books involves the use of distributors rather than subscription agents – a difference between books and journals that has increased with increasing specialisation between subscription agents and distributors, with some agents selling their bookselling wholesalers/booksellers. There is much less online or digital delivery of books – although e-commerce is increasing in sales of physical books, and there are an increasing number of digital library initiatives.

Figure 5. The books supply network



Source: Pira International (2003), *The EU Publishing Industry*: *An assessment of competitiveness*, European Commission, Brussels, p37.

Commercial pressures, felt by all types of publishers, have led to concerns in some areas of research that research monograph publishing has become more difficult, with publishers refusing to take manuscripts for which there is a limited market – regardless of the scholarly merit or scientific importance of the work. Even society and institutional publishers are reluctant to take on specialist manuscripts for which they foresee only a limited market. Rapidly escalating journal prices have also squeezed book purchases by research libraries, many of which have cut monograph purchasing in order to continue their journal subscriptions (Thompson 2003; EPS 2004a; etc.). As a result, monograph print runs are smaller and unit costs of production are rising (Pira International 2003, p164). In turn, this has resulted in further monograph purchasing cuts and even greater caution among publishers.

Databases

With rapidly increasing quantities of information and advances in data collection technologies and capabilities, databases are an increasingly important means for both conducting and disseminating research. Commercial, government and non-profit database builders add value to the content in the creation of metadata, editing and provision of search and access capabilities which make the information accessible and more readily usable. They may also provide packaged data and analysis services. There are also issues regarding pricing of data where some comes from publicly funded research, where marginal cost pricing (to widen the accessibility to publicly funded data) is difficult to reconcile with average cost pricing by commercial data base builders adding value and aiming to make a profit, as well as further issues regarding the scope of access to commercial databases where data may come from publicly funded research.

As in other areas, there are various organisation types involved in database publishing, including private sector, government and non-profit society and institutional publishers (Box 2). Various forms of data are made available by commercial publishers, who may be new players specialising in the publication of certain sorts of data or traditional publishers moving into data publishing (*e.g. The Economist*). There is considerable overlap in activities, with many print publications increasingly available on databases (*e.g.* journal articles, newspapers, etc.) and increasingly (hyper)linking into other databases and datasets.

Box 2. Examples of shared research databases

Large shared databases have become important resources in many fields of research in both the sciences and arts and humanities. These databases allow researchers working on different pieces of large problems to contribute to, and benefit from, the work of other researchers and to share resources. Examples of such databases include:

GenBank (www.ncbi.nlm.nih.gov/Genbank/) – the National Institute of Health's annotated collection of publicly available DNA sequences. As of February 2003, GenBank contained more than 29.3 billion nucleotide bases in some 23 million sequences. The number of nucleotide base pairs in its database is doubling approximately every 10 months. As part of a global collaboration, GenBank exchanges data daily with European and Japanese gene banks.

The Protein Data Bank (www.rcsb.org/pdb/) – the worldwide repository for the processing and distribution of three-dimensional biological macromolecular structure data (Berman *et al.* 2000).

The European Space Agency Microgravity Database (www.esa.int/cgi-bin/mgdb) – which gives scientists access to information regarding all microgravity experiments carried out on ESA and National Aeronautics and Space Administration missions by European scientists since the 1960s.

The Tsunami Database (www.ngdc.noaa.gov/seg/hazard/tsu.html) – which provides information on tsunami events from 49 B.C. to the present in the Mediterranean and Caribbean Seas and the Atlantic, Indian and Pacific Oceans. It contains information on the source and effects of each tsunami.

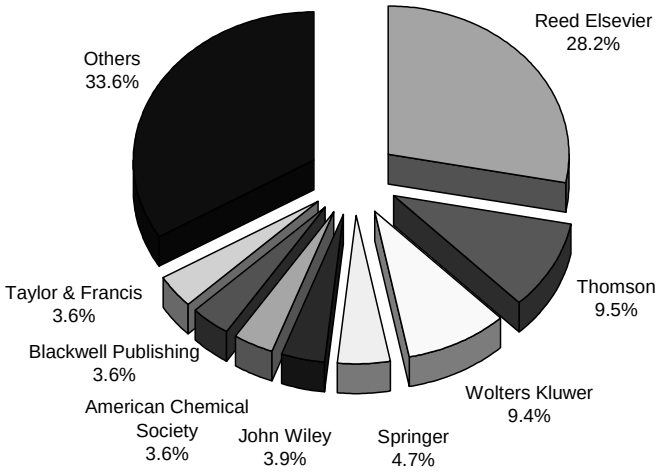
The Earth Resources Observation Systems Data Center (edcwww.cr.usgs.gov/) – which houses the National Satellite Land Remote Sensing Data Archive, a comprehensive, permanent record of the planet's land surface derived from almost 40 years of satellite remote sensing. By 2005, the total holdings will come to some 2.4 million gigabytes of data.

Source: National Science Board (2002), *Science and Engineering Indicators 2002,* Arlington, VA: National Science Foundation, 2002 (NSB-02-1), p8-25; National Institutes of Health, 2005.

Market structure

The Association of Learned and Professional Society Publishers (ALPSP) estimated that there are currently 9 250 peer–reviewed journals published globally by learned societies, professional associations and university presses – around 45% of the total number of such publications. Nevertheless, commercial publishers play a key role in the STM market and are influential in the publication of journals in the humanities, arts and social sciences. In 2003, it was estimated that the four largest publishers accounted for more than 50% of STM market revenue, with the American Chemical Society (with 3.6% of the market) the largest of the society publishers (HCSTC 2004, p13). Reed Elsevier accounted for more than 25% of the world market in 2003, followed by Thomson and Wolters Kluwer (Figure 6) (HCSTC 2004a, p47).

Figure 6. STM publishers' global market revenue shares, 2003
(per cent)



Source: EPS Ltd. Cited by House of Commons Science and Technology Committee (2004), *Scientific Publications: Free for all?* Tenth Report of Session 2003-04, The Stationery Office, London, p13.

There have been a number of mergers and acquisitions (M&As) in publishing over the last decade and increasing concentration in scientific publishing. As a result of consolidation, a relatively small number of large commercial publishers have a large presence in certain market segments. Society and institutional publishers have not provided strong price competition because of their relative scale and increasing focus on realising a return on their publishing activities often to finance their other activities, although competition for authors, editors and content is often vigorous among all three groups of publishers.

Analysing data on M&As in the media and publishing industries between 1990 and 1999, Pira International (2003) noted that in the professional publishing segment, 44% of acquisition targets were in the same segment. There were few transactions in the STM market (two in 2000-2001 and one in 1999–2000) reflecting the specificity of the operations of publishers in this segment, where only a few large international players are able to span subject and geographical markets. Fewer major transactions may also reflect the existing level of concentration, limiting M&A opportunities, and increasing regulatory focus on the STM publishing market (Competition Commission 2001; Office of Fair Trading 2002; SQW 2003; HCSTC 2004a). Nevertheless, the restructuring and consolidation continues through smaller acquisitions and alliances (such as Thomson's acquisition of Current Drugs and Delphion Research, and Taylor & Francis's acquisition of BIOS Books, CRC Press Books, Cass Books, SZP Books and Marcel Dekker Books) and through last year's merger of Springer and Kluwer Academic Publishers. In early 2004, Taylor & Francis announced a merger with Informa (EPS 2004b).

Two interesting features of M&A activity in scientific publishing have been that it is much more transnational than consumer publishing, with 58% of deals concluded during the 1990s being transnational; and that 20% of the deals were for software companies, Internet companies and information agencies, reflecting the growing trend towards the use of non-print digital channels (Pira International 2003, p129).

BUSINESS MODELS

The traditional business models of scientific publishers in the print era have changed as content is made available on line. This section analyses the development of scientific publishing, focusing on production costs and publisher business models in the print era. It also discusses the evolution and development of the so-called serials crisis. This section provides the recent background and context for the following sections on digital delivery and new business models and their potential to overcome recent challenges and improve the efficiency of publishing and access to research results by both researchers and users.

Production costs

Understanding costs within the traditional publishing value chain is an important element in understanding evolving business models. Estimates of *journal* production costs vary widely, with significant variation across research fields – with some requiring simple text presentation and others demanding more complex embedded formulae and images, and different fields of research characterised by very different levels of acceptance and rejection of articles submitted for publication in journals and different rates of growth in publication output. There is little information and even less agreement about costs. Nevertheless, it is possible to identify approximate cost shares and typical cost levels.

Journals and journal articles

Drawing on a range of sources, SQW (2004) suggested that editorial and typesetting activities account for the largest share of journal production costs at approximately 33%, with physical production and distribution accounting for 23%, refereeing 22%, sales and marketing 13% and subscription management 7%. They estimated that first-copy costs per article range from USD 250 - 2 000, depending upon rejection rates, with the cost of producing the first copy for a good-to-high-quality journal being approximately USD 1 500. Fixed costs, including first-copy costs, were estimated around USD 1 650 per article and the total cost of producing an article for a good-to-high-quality journal at USD 2 750, plus a contribution to overheads and profits (SQW 2004, pp10-15). These costs are similar to those outlined by other analysts (Tenopir and King 2000; Bergstrom *et al.* 2002; Dryburgh 2002; etc.). However, it is important to note that these costs do not include overheads or profits. Blackwell Publishing, one of the largest journal publishers, with a total of over 600 journals, generated an average revenue from libraries per paper published across all its journals of USD 1 425 in 2003. If revenue from consortia, copyright fees, advertising, reprints, supplements, sponsored subscriptions, document delivery and members' subscriptions are added to this figure the total average revenue per article for Blackwell in 2003 was just under USD 2 000 (SQW 2004, pp10-15).

Many analysts have argued that there are significant cost savings to be made from switching from print to electronic journals (Bot *et al.* 1998; Harnad 1996; Harnad and Hemus 1997; Fishwick *et al.* 1998; Halliday and Oppenheim 1999; etc.). However, electronic distribution alone is unlikely to lead to significant cost savings. The contribution of ICTs and digital delivery to communication during the refereeing process, the use of standard templates for author formatting of manuscripts and the production and management activities involved in journal production may well lead to greater savings. There are, for example, a number of systems for journal management now available (*e.g.* ESPERE, myICAAP, etc.). Some suggest that up to between 20% and 30% of the cost of a paper journal can be eliminated by switching to e-only publication (SQW 2003, p7).

However, there are also substantial transitional costs. Dual mode publication (*i.e.* parallel electronic *and* print publishing) simply increases costs. According to King and Tenopir (1998), the additional costs of operating parallel print and electronic publishing appeared to be in the range of 3% to 8%, while Regier (1997), reporting on Project Muse, suggested that for Johns Hopkins University Press total costs for both print and electronic editions were about 130% of print only costs. Similarly, running a dual mode subscription *and* open access (*i.e.* "authors' choice") journal would incur additional costs. There are also significant infrastructure and training costs involved in the transition from print to digital delivery, and publishers have invested heavily in their digital delivery platforms in recent years (Fisher 1997; Shirrell 1997; Day 1998; Hunter 1998; etc.). Some of these costs will be ongoing. As a result, many of the cost savings initially expected from e-commerce and digital delivery have yet to be realised.

Texts and monographs

The market for research monographs is typically global, whereas that for textbooks tends to be more national – with texts tailored for local use. Monographs may sell few copies in any one country, but sell globally; whereas textbooks may sell many copies, but only in one country. Either way, the critical factor for the publisher is to estimate the size of the market as accurately as possible in order to avoid unsold inventory or lost sales opportunities (Halliday and Oppenheim 1999). Hence, when considering manuscripts, publishers focus upon estimated sales.

One response among research libraries to the increasing price of journals has been to cut book purchasing. As a result, the market for research monographs has reduced, with publishers reporting a reduction of their print runs from more than 1 000 to 750 and even less. With sales of some specialist titles falling to the low hundreds it is increasingly difficult for publishers to meet monograph production and inventory costs (Watkinson 2001; Dryburgh 2002). As a result, it is becoming more difficult to find a publisher for research monographs.

Electronic publishing of monographs and texts offers opportunities for innovation, cost savings and value adding, but suffers from the great drawback that few users are yet willing to read long works on line. Nevertheless, cost savings may be greater than for journals due to the extent of formatting and editorial work and the high cost of physical distribution to stock and the management of inventory. As is the case with journals, however, dual mode publishing adds costs. However, having the complete works, or part thereof, on line can be important in the decision to buy – enabling the reader to consume enough of the text to know that he/she wishes to buy. The early experience in the United States (*e.g.* National Academies Press) was that if monographs were made available free of charge on Internet, sales of the hard copy increased two- or three-fold (Halliday and Oppenheim 1999; EPS 2004a). If this is the case, increased revenue might compensate for the additional costs of dual mode – although other experience appears to suggest a potentially negative impact, with the experience of the OECD's own publishing being that making viewable but unprintable electronic copies of books available on line is having a marginal or negative effect on sales over time (Green 2004).

A further opportunity for innovation lies in the cross-over between reducing cost and adding value. For example, Wiley's custom publishing service offers teachers the facility to select chapters from a large database of standard texts and custom build a textbook suitable for their course, which is then printed, bound and delivered by Wiley. Similar custom textbook services are offered by Pearson Custom Publishing, Thomson Learning and others. To date, such value adding features for books as reviews, reader ratings, links to related works and works by the same author(s), have been pioneered primarily by innovators in the distribution part of the value chain (*e.g.* Amazon), rather than by publishers themselves. Developments being pushed by publishers include such initiatives as selling subscriptions to e-book lists (*e.g.* Oxford University Press) and renting e-books on a short-term rental basis (*e.g.* Taylor & Francis).

Publishing and publisher business models in the print era

Single academic articles tend to be relatively specialised and many have a very limited market, fixed (first copy) costs must be spread over a relatively small and uncertain number of potential purchasers. Journals emerge from the demands of researchers to publish and read articles in convenient subject groupings. As serials, journals provide a platform for an ongoing dialogue and a record of scholarship. Importantly, journals aggregate individual articles. Varian (1995a, 1995b) provided a description of how aggregation or "bundling" journal articles works (*i.e.* primarily, by reducing the heterogeneity of the consumers' willingness to pay). The publisher can sell the collection of articles at the consumers' average willingness to pay, which will typically be more predictable and more profitable than individual sales. The traditional pricing mechanism for journals, annual subscription per title, also reduces cash flow uncertainty because consumers paid subscriptions in advance (Halliday and Oppenheim 1999).

Books have typically been individually priced. However, many research libraries have purchased books on an "approval plan" and/or "standing order" basis. Acquisitions librarians monitor the output of various publishers and the requests they receive from faculty, and are thereby able to form a judgement as to the relevance and quality of the output of publishers in the various fields of scholarship. Publishers offering approval plan and/or standing order purchasing in thematically organised fields, send everything they publish in that series or field to the libraries who "subscribe" to the plan on an approve or return basis. This reduces transaction costs, as acquisitions librarians do not search for titles and process so many orders, and publishers have somewhat more certainty of market through the expressions of interest from research libraries in certain fields. From an economic point of view, however, the main characteristics of such purchasing are the familiar ones of aggregation and a shift from individual accessions to something closer to list subscriptions.

Prices and purchasing budgets

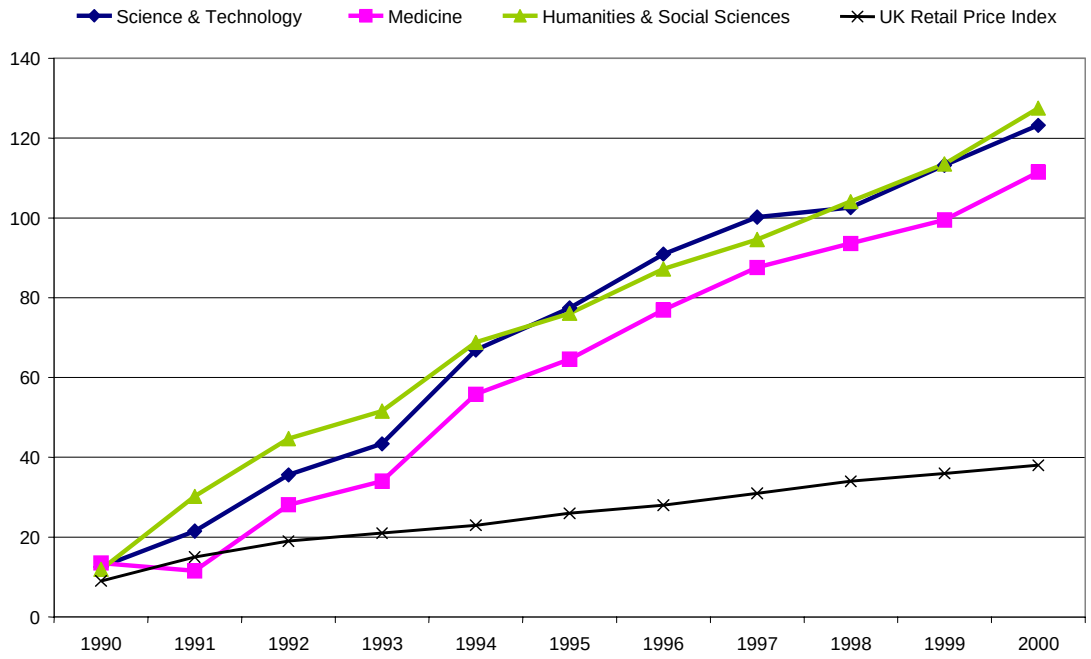
There has been much discussion and analysis of issues surrounding journal prices and subscription budgets as institutions have been faced with how to ensure adequate, and preferably enhanced, access to ever-expanding research content for their users. The mismatch between prices and purchasing budgets has often been termed the "serials crisis". Many commentators have pointed to rapid increase in prices for scholarly and scientific content – especially journals in the science, technology and medical fields (Cummings *et al.* 1992; King and Tenopir 1999; Bosch 1999; Houghton 2001; Lawrence 2001a; Kean 2003; Greenstein 2004; etc.). Journal subscription price increases have been substantially above the underlying rate of inflation, and have spread throughout research fields and to monograph pricing (Watkinson 2001; La Manna 2003; Steele 2003; Bergstrom and Bergstrom 2004a; etc.).

Van Orsdel and Born (2003) looked at the prices charged for those journals appearing in ISI citation indexes over the period 1999 to 2003. They found that the average price of titles originating in North America increased by 41% and the average price of those originating in Europe increased by 33%. Prices for US originating titles in the *Science Citation Index* increased by 40% and those for non-US titles increased by 30%; compared with increases of 40% and 38% for titles from the *Arts and Humanities Citation Index*; and 44% and 36% for titles in the *Social Sciences Citation Index*, respectively. According to Blackwell's Periodical Prices Indexes, the average price of journal titles in science and technology increased by 178% over the decade from 1990 to 2000, compared with average increases of 184% for titles in medicine and 186% for titles in humanities and social sciences (SQW 2003, p2).

Increasing journal prices put pressure on library and other purchaser budgets, which have not kept pace with price increases or with the expansion of research activity and the volume of published output. ALPSP/CAPP (2002) reported that journal subscription numbers were typically falling by 5% to 8% per

year. At the same time, research libraries shifted monograph budgets to serials acquisition to cover serials price increases, such that access to the monograph literature was also affected.

Figure 7. Journal price increases, 1990-2000
(cumulative annual percentage change)



Source: Blackwell's Periodical Prices. Cited by Department of Trade and Industry (2002), *Publishing in the Knowledge Economy*: *Competitiveness analysis of the UK publishing media sector*, Department of Trade and Industry, London, p37.

Detailed analysis has explored the cost and pricing factors which have contributed the increasing mismatch between journal prices and purchaser budgets. King and Tenopir (2000) analysed journal production costs between 1975 and 1995 (*i.e.* in the print era). Their modelling showed a decline of around 20% in the average cost per page published, but they found that the increase in the number of journal titles, the number of articles per issues and the number of pages per article contributed to increasing costs overall (*i.e.* that the increase in published output was driving cost and price increases).

Kean (2003) pointed to a difference in the rate of price increases for journals from commercial and non-profit US society publishers, with prices for society journals increasing by an average of 7.5% per annum between 1988 and 2003, compared with 9.5% per annum for all US periodicals. Similarly, Bergstrom and Bergstrom (2001, 2004a) have shown that journal costs per page and per citation were substantially higher for commercial publishers than non-profit publishers. A point that was also made by the UK Office of Fair Trading (2002, pp10-11). Wyly (1998) noted that, in 1997, Reed Elsevier enjoyed a higher net profit margin than 473 of the S&P 500 listed companies, Wolters Kluwer provided higher return on equity than 482 of the S&P 500, and the margins generated in the science, technical and medical publishing areas of these companies tended to be even higher than these aggregate consolidated corporate margins. This was echoed by the UK Office of Fair Trading (2002, pp12), and the recent UK House of Commons Science and Technology Committee report noted that Reed Elsevier makes an operating profit of 34%, Wiley had an operating profit of 29% in the first half of 2003, Wolters Kluwer 16.3% and Thomson 24.5% (HCSTC 2004a, p31).

McCabe (1999, 2002) used a portfolio approach, linking the monopoly power of the journal title as a product for which there are no close substitutes with the market power of major commercial publishers. He

suggested that prices were positively related to journal portfolio size, and that in the specific case of the merger of Wolters Kluwer and Waverly his model predicted an average price rise of between 20% and 30%. McCabe (1998a, 1998b) has also shown that past mergers were associated with higher prices, suggesting that the Elsevier/Pergamon deal resulted in average journal price increases of 22% for former Pergamon titles and 8% for Elsevier titles. After controlling for scale economies there remained an unexplained inflation residual, which McCabe (1999) attributed to the monopoly power of the large commercial publishers.

The UK's Competition Commission and Office of Fair Trading have suggested that neither journal prices nor market share are sufficient to explain the serials crisis by themselves, it is the interrelation between them that gives cause for concern (HCSTC 2004a, p47). The purchasing practices of research libraries are such that there is limited price competition in the STM journal market, because "if a very well-regarded but expensive journal increases its price further, it is the cheaper, but less-well regarded journals in the same field that are cancelled, so that the subscription to the leading journal can be maintained. This means that a publisher sometimes has the potential to increase his market share by raising his prices" (Competition Commission 2002, p15; Office of Fair Trading 2002, p15). It has also been concluded that "This market does not behave conventionally. It is not well positioned to deliver the benefits of unfettered free markets and if left as it is could produce outcomes which are in the interests of very few" (SQW 2003, 2004, p9; HCSTC 2004a, p47).

The future

Print era issues of prices and budgets are being superseded by new cost, access and diffusion issues as a wide and increasing range of digital content is produced by researchers and as conventional content is increasingly delivered digitally. New ways to organise management and access are needed, and there are new opportunities to integrate new dissemination practices into emerging e-science practices and infrastructures. The question is whether there are new and emerging opportunities to serve the needs of researchers, those that fund research and research users and new opportunities to improve the productivity of science and increase returns on investment in it.

DIGITAL DELIVERY AND ONLINE ACCESS

This section analyses the adoption of e-commerce, digital delivery and use of online access. It explores the adoption of e-commerce and digital delivery in publishing, and the use of e-journals, e-books, databases, archives and repositories by both research authors and readers. It examines the drivers and potential for digital delivery and online access for authors and readers as well as publishers, levels of adoption and use, barriers to adoption and the impacts of digital delivery and online access to scientific and scholarly content.

Drivers and potential

ICTs are changing the organisational processes in content publishing industries and transforming the products and services that are produced. Thus the impacts of ICTs and digital delivery on scientific publishing are two-fold. First, the impacts of e-commerce and e-business activities on processes within and between businesses – impacts that are felt by all industries. Second, the impacts of the digital delivery on the nature of the content publishing business – impacts that are unique to the content publishing industries (E-Business Watch 2002).

E-commerce and e-business processes

There is little industry specific data, but cross-sector surveys indicate that market reach, enhanced customer service and costs are among the major drivers of e-commerce and digital delivery. Evans and Wurster (2000) characterised the impact of the Internet as a movement out of the frontier of richness and reach – where richness refers to the depth and quality of information in an interaction, and reach refers to the number of entities that can be reached via Internet. In the past, it was possible to share rich interactions with a limited number of suppliers or customers. A major impact of Internet-based communication and commerce has been to greatly increase reach *and* increase the number of potentially rich interactions. Organisations can broaden their supplier and/or customer bases (greater reach) *and* make relationships deeper, more tailored and more effective (greater richness).

The evidence from surveys suggests that the early and primary foci for the adoption of e-commerce, supply chain related e-business solutions and digital delivery are indeed improved customer relationships and enhanced market reach. Cost savings and efficiency improvements have typically been lower in the consideration set of adopters. Industry dynamics determine whether businesses focus on new customer attraction or the retention of existing customers, with sectors that lend themselves to recurring relations (*e.g.* scientific publishing) tending to focus on building revenue from existing customers (Dantuma and Hawkins 2001).

In an extensive survey of e-commerce activities in 25 countries spanning Europe, the United States, Japan, South Africa and India, Accenture (2001) found that services innovation and enhancement of competitive position were the major drivers of e-commerce adoption – with 77% of those businesses using e-commerce reporting doing so to offer new services to existing customers. Competition and cost savings were also important motivators.[4] Similarly, in a 10-country study undertaken during 2002, Kraemer *et al.* (2002a) found that expanding markets, both new and existing, and improving co-ordination with customers and suppliers were the major reported drivers for the adoption of e-commerce and e-business solutions.[5]

In a survey of US-based establishments undertaken during 2002, Kraemer *et al.* (2002b) found that the most widely cited drivers for the adoption of e-commerce included: expansion of markets for existing products and services (50% of firms surveyed), entering new businesses and markets (39%) and improved co-ordination with suppliers and customers (42%). Also in the United States, Varian *et al.* (2002) found that across all industries, businesses had adopted customer facing applications first, suggesting that the richness of customer relationships and market reach were major drivers of the adoption of Internet business solutions. They suggested that customer service and support applications were the most commonly adopted, reflecting firms' attempts to get closer to their customers. E-marketing was also widely adopted. The lower adoption levels of back-office solutions, such as finance and accounting, human resources and supply chain management, were thought to reflect priorities with respect to improving relationships with customers.

In the United Kingdom, France and Germany, Varian *et al.* (2002) found a similar focus on customer facing applications – with more than half of the businesses using Internet business solutions having deployed e-marketing and customer service and support, compared with 25% or less deploying finance and accounting or human resources solutions. Similarly, in Japan, the most widely cited drivers for firms adopting e-commerce and e-business solutions in 2002 were: that customers demanded it (37% of firms surveyed), to enable them to enter new businesses or markets (34%), and to improve co-ordination with customers or suppliers (33%) (Tachiki *et al.* 2004).

In a study of UK publishing, DTI (2002a, p109) suggested that the primary motivations for engaging in e-commerce in most of their case study firms concerned: the enhancement of existing processes – in the form of reduced costs, improved service levels, reduced production times (in magazine, newspaper and journal publishing) and reduced time from order to destination (in book publishing).

Digital delivery

Digital delivery of content products radically changes production costs, as well as extending reach and raising challenges for the protection of intellectual property by making it possible to create near perfect copies. The potential to eliminate physical distribution, and thereby inventory, and reduce marginal costs of production to near zero, as well as the potential to tap new markets for existing content, all drive digital delivery.

In a study of UK publishing, DTI (2002a, p110) suggested that most saw the creation of new products and services as something for the future, noting that:

- The opportunity to create new products and services, to target new customer segments and to increase loyalty and trust among value chain partners tended to be seen by book and magazine publishers as by-products of the e-commerce process rather than as motivating factors. For the journal publisher, this was the primary motivation. The journal publisher operates in the most electronically networked of markets, and one where innovation is prized for its own sake. The need to appear innovative in front of customers and other stakeholders is a motivating factor for the journal publisher.

- The largest companies are sometimes able to act independently in bypassing the existing supply chain, and their ability and willingness to do so can galvanise developments (*e.g.* Reed Elsevier's online initiatives). In value chains where this does not or cannot happen, progress may be slower.

- External threats or competition can act as a catalyst for pan-sector collaboration in creating and adapting e-commerce initiatives (*e.g.* CrossRef).

E-business Watch (2002, p7) noted that availability of electronic (digital) content and major structural changes are forcing companies in the media and publishing sector to develop entirely new business strategies. ICTs, e-commerce and digital delivery have brought an erosion of traditional revenue streams, a substitution of traditional products and a replacement of entire steps in the value chain. Printers, for example, face the challenge that parts of the production process for printed goods are becoming obsolete through the increasing "digitalisation" of the workflow. As a response, even small print companies are diversifying from traditional print products into cross media services, such as multimedia design and layout. More importantly, digital products have specific economic properties that require the adoption of new business strategies (*e.g.* high first-copy and near zero replication cost). As a result, entirely new business models are emerging, there is widespread uncertainty about the best model for future content businesses and experimentation with a wide range of alternative and hybrid business models. New players are emerging and new capabilities are required (*e.g.* ICT skills).

Adoption and use

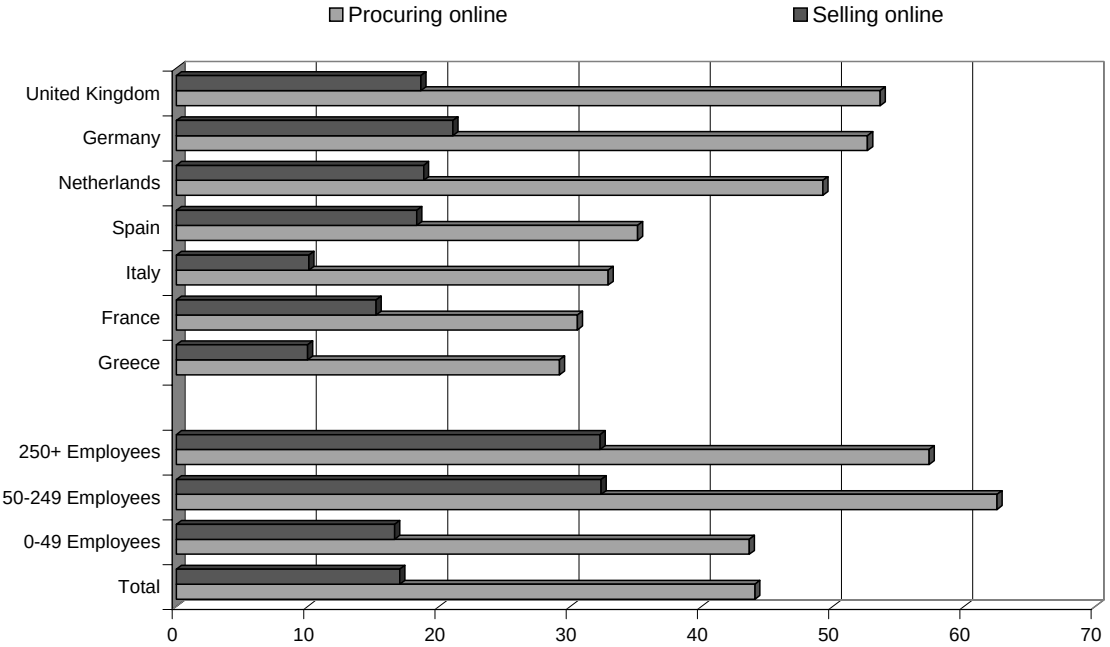
Surveys of the adoption and use of e-commerce, e-business solutions and digital delivery tend to be conducted at an aggregated level – at best spanning media and publishing of all kinds, and hence they are largely indicative of developments. Nevertheless, such surveys do shed light upon the use of such technologies in the media and publishing sector relative to other sectors and highlight sector specific differences. This section presents a brief review of some of the major surveys of e-commerce and digital delivery adoption among publishers (*i.e.* the supply-side) before turning to more focused data on the level of use of e-books, e-journals and research databases by researchers and professionals (*i.e.* the demand-side).

The production supply side

Digital delivery and the integration of e-commerce and e-business solutions within publishing require high levels of ICT infrastructure development and use, and on most counts enterprises in the media and publishing sector are more advanced in their adoption of ICTs and e-commerce than are those in other sectors.

In the United States, 2002 publishing industry revenues amounted to USD 232 billion, of which e-commerce accounted for USD 5.36 billion or 2.3% (NAICS 511). Nevertheless, e-commerce revenue grew 8.5% during the year, while total revenue declined 0.3% (US Census 2004b). In Canada, around 67% of firms in the publishing industry had a Web site in 2002, compared with 29% of firms across the economy. By segment, 72% of periodical publishers had a Web site and 64% of book publishers (Strategis 2004). E-business Watch (2003) reported that virtually all enterprises (98.9%) in the media and printing industries (NACE 22) in the EU-7 countries (*i.e.* France, Germany, Greece, Italy, Netherlands, Spain and the United Kingdom) were using computers by mid-2002, 95% had Internet access, 94% used e-mail, 88% used the Web, 35% had Intranets, 10% had extranets, 23% allowed remote access and 5.6% allowed wireless access. Web site adoption was somewhat lower in Greece and Spain than elsewhere (Annex Table A2).

Figure 8. Online procurement and sales in media and publishing in Europe, mid 2002
(percentage of enterprises)



Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

Online purchasing was relatively well developed in the European media and publishing sector by mid 2002, but the proportion of online to total purchases was not significantly higher than was the case in other industries (Figure 8). Forty-four per cent of media and publishing enterprises procured on line by mid-2002, of which 64% were procuring maintenance, repair and operations (MRO) goods and 46% direct production goods. Online procurement accounted for more than 50% of all procurement for just 2.7% of those procuring on line, and less than 5% of total procurement for 42% of enterprises procuring on line (Table 2). Twenty-nine per cent of enterprises in Greece were procuring on line, compared with 53% in the United Kingdom and Germany. The relatively high adoption of Web sites reflected the use of Web sites both for sales and as a vehicle for the delivery of the product itself (E-business Watch 2003).

Selling on line also means two things in the publishing industry – making online sales *and* digital delivery of the content. Again the publishing and media sector makes more online sales than is the case in most other sectors. Sixty per cent of publishing and media sector enterprises had a Web site by mid-2002 and 17% were selling on line – although online sales accounted for more than 50% of sales for just 2.3% of enterprises making online sales, and for almost 46% of enterprises online sales accounted for less than 5% of total sales. Ninety-one per cent of media and publishing enterprises selling on line were doing so through the company Web site, 70% were selling on line to customers, 55% were selling to other businesses, 38% allowed online payments and 43% provided after sales service and support on line (Table 3). The proportion of enterprises selling on line was somewhat lower in Greece and Italy than elsewhere, although they were most likely to have enabled online payments (E-business Watch 2003).

Table 2. Online procurement media and publishing Europe, mid 2002
(percentage of enterprises)

	Online procurement (all enterprises)	Online procurement of MRO goods (enterprises procuring on line)	Online procurement of direct production goods (enterprises procuring on line)
Total	44.1	64.4	46.1
0-49 employees	43.7	64.5	46.0
50-249 employees	62.5	58.9	49.5
250+ employees	57.4	74.5	50.0
EU-4	45.5	70.0	47.2
Germany	52.7	73.7	40.0
Greece	29.2	34.1	24.8
Spain	35.2	33.7	28.7
France	30.6	56.6	70.9
Italy	32.9	69.1	52.1
Netherlands	49.3	31.7	67.0
UK	53.6	71.6	43.9

Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

Table 3. Online sales in media and publishing in Europe, mid 2002
(percentage of enterprises)

	Selling online *(all enterprises)*	E-commerce through company Web site *(enterprises selling on line)*	Online sales to consumers *(enterprises selling on line)*	Online sales to other businesses *(enterprises selling on line)*	Enabling online payment *(enterprises selling on line)*	After-sales-service provided online *(enterprises selling on line)*
Total	17.0	90.9	69.8	55.1	38.3	43.5
0-49 employees	16.6	90.9	70.4	54.3	38.0	43.9
50-249 employees	32.4	90.9	54.9	70.8	44.7	31.3
250+ employees	32.3	94.5	64.7	75.8	46.3	53.5
EU-4	16.9	90.1	71.9	57.7	39.9	40.9
Germany	21.1	91.3	88.4	60.7	17.9	40.4
Greece	10.0	68.5	70.4	66.5	94.1	40.9
Spain	18.3	100.0	54.8	36.4	28.1	63.6
France	15.2	77.9	54.5	45.5	43.8	44.5
Italy	10.1	100.0	56.6	43.0	56.6	55.9
Netherlands	18.8	84.0	74.7	58.4	24.2	33.8
UK	18.6	91.2	72.3	63.7	46.6	36.4

Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

E-business integration is comparable to other sectors, with the larger enterprises in the sector making more use of e-business integration systems than do SMEs. Almost 20% of those European media and publishing enterprises with a Web site had content management systems in place by mid-2002, although less than 3% of all enterprises had supply chain management systems, 6.3% had customer relationship management systems, 5.8% had enterprise resource planning systems and 5.1% had knowledge management systems. Enterprises in the United Kingdom and Netherlands lagged those elsewhere in Europe in the use of content management systems, but not in the use of other internal process systems (Table 4) (E-Business Watch 2003).

Table 4. Use of internal process management systems in media and publishing in Europe, mid-2002
(percentage of enterprises)

	Percentage using a content Management System (enterprises with Web site)	Percentage with an implemented SCM system (all enterprises)	Percentage with an implemented CRM system (all enterprises)	Percentage using a Knowledge Management Solution (all enterprises)	Percentage using an ERP system (all enterprises)
All Sectors EU-4	..	1.5	6.6	5.2	6.6
Total	19.2	2.3	6.3	5.1	5.8
0-49 employees	18.7	2.2	5.9	4.9	5.5
50-249 employees	27.6	3.1	21.5	12.6	15.9
250+ employees	53.3	12.8	31.5	31.3	38.0
EU-4	18.8	1.7	6.2	4.8	6.1
Germany	21.5	1.8	4.6	2.7	7.5
Greece	35.3	0.2	13.3	11.1	4.0
Spain	24.3	6.7	3.5	5.2	3.8
France	20.3	0.0	3.7	0.1	3.9
Italy	25.7	3.0	1.5	7.2	8.7
Netherlands	11.3	3.4	13.4	7.9	7.9
United Kingdom	13.8	1.7	10.2	6.8	5.1

Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

The use of online technologies in support of internal processes and activities in the media and publishing sector in Europe varies by country and activity, but is higher than is the case in other sectors. Overall, almost 41% of media and publishing enterprises used online technologies to share documents and perform collaborative work in the EU-7 countries in mid 2002, just 4.4% did so to automate travel reimbursement for employees, 11% used online technologies to track working hours and production time, and 10% used online technologies to support human resource management. Fifty-two per cent of enterprises in the sector used online banking by mid-2002, and almost 10% posted job vacancies on line (Table 5) (E-Business Watch 2003).

Table 5. Use of online technologies in support of internal activities in media and publishing in Europe, mid 2002
(percentage of all enterprises)

	Use of online technologies to share documents / to perform collaborative work	Use of online technologies to automate travel reimbursement of employees	Use of online technologies to track working hours and production time	Use of online technologies to support human resources management	Use of online technologies for e-learning	Posting job vacancies on Internet boards
Total	40.6	4.4	11.3	9.9	11.7	9.8
0-49 employees	40.2	4.2	10.8	9.5	11.3	9.1
50-249 employees	49.8	8.4	31.3	21.8	23.8	29.8
250+ employees	80.8	20.7	35.7	38.1	35.0	53.4
EU-4	40.1	4.5	11.2	9.3	12.2	9.4
Germany	23.2	3.8	8.2	5.6	9.8	11.8
Greece	47.3	3.7	7.0	10.5	12.4	10.5
Spain	49.9	3.5	13.5	15.1	10.1	11.8
France	44.0	0.1	7.3	8.7	10.1	15.4
Italy	35.9	4.3	8.6	11.5	10.1	2.9
Netherlands	20.3	4.9	10.4	5.7	4.6	10.7
United Kingdom	48.5	6.8	15.3	10.5	15.3	8.7

Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

The use of online technologies in support of external processes and activities in the media and publishing sector in Europe also varies by country and activity. While it is not always significantly higher than is the case in other industries, in some activities it is (*e.g.* sharing documents on line). There is evidence of extensive use of online technologies to co-operate with other enterprises in the value chain. Overall, almost 22% of media and publishing enterprises collaborated on line with business partners in the design of products in the EU-7 countries in mid 2002, just 7.3% collaborated on line to forecast demand and 10% used online systems to manage capacity and/or inventory. Fifty-nine per cent of enterprises in the sector exchanged documents with suppliers on line by mid-2002, 62% did so with customers and almost 24% were able to negotiate contracts on line (Table 6) (E-Business Watch 2003). Thus, sharing documents on line to perform collaborative work was by far the most important use of online technologies in the media and publishing sector (E-Business Watch 2002).

In the United Kingdom, a survey of publishing firms revealed that 70% of those with Web sites were able to take orders on line and 54% could accept payments on line, while 33% had the ability to place

orders on line and 39% to pay suppliers electronically. Sixty-four per cent had a Web site for content delivery and 87% for information purposes. Sixty-two per cent of publishing firms had intranets and 41% had operational content management systems (DTI 2002a).

Table 6. Use of online support systems for external activities in media and publishing in Europe, mid-2002
(percentage of enterprises with Internet access)

	Online collaboration with business partners for designing products	Online collaboration with business partners to forecast product demands	Online management of capacity / inventory	Electronic exchange of documents with suppliers	Electronic exchange of documents with customers	Online negotiation of contracts
All Sectors EU-4	12.7	10.3	8.9	42.0	39.3	16.0
Total	21.6	7.3	10.2	58.9	61.6	23.5
0-49 employees	21.3	7.0	10.0	58.8	61.7	23.7
50-249 employees	28.8	16.1	16.2	58.0	57.2	13.3
250+ employees	43.3	21.3	35.2	67.8	61.7	20.0
EU-4	23.8	7.1	10.2	59.4	62.2	23.7
Germany	21.2	3.9	7.2	49.7	61.1	6.9
Greece	30.3	6.9	1.8	45.9	48.5	18.3
Spain	6.9	8.5	11.8	59.1	64.0	21.9
France	24.7	12.5	5.5	52.7	61.2	20.9
Italy	22.1	16.2	19.2	44.1	38.4	22.0
Netherlands	16.2	6.7	10.1	52.6	49.6	26.3
United Kingdom	25.6	2.2	9.4	74.5	74.4	34.3

Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

Online products and digital delivery now account for a substantial and rising proportion of scientific publishing content. For example, Wolters Kluwer reported that sales of electronic products accounted for 32% of turnover in the first half of 2002, up from 26% on the previous year, and that Internet revenues rose by 50% while total sales grew by 6% (Pira International 2003, p164). More recently, Blackwell reported that sales and usage of online material doubled in 2003. Most scientific publishers now have most of their content on line.

To date, *sales of books on line* far exceed sales of *online books* (*i.e.* e-books). Online sales accounted for around 6% of UK book sales in 2003, or GBP 215 million in a GBP 3 billion market (ResearchMarkets 2004). Sales of books on line in the United States reached USD 2.8 billion during 2003 (BookWeb 2004), and sales of books on line from leading online retailers were also very high (FonnerBooks 2004).[6]

Anderson Consulting (2000) suggested that e-books could account for 10% of the consumer book publishing market by 2005. Open eBook Forum (2004) reported that there were 421 955 e-books sold worldwide during the first quarter of 2004, 46% up on the first quarter of 2003. E-book sales were worth USD 3.2 million during the quarter, so while e-book sales are reported to be growing rapidly they still account for a very small share of total book sales. However, *scientific publishers* are now selling subscriptions to e-book collections/libraries (*e.g.* the OECD publishing operations), integrating e-books into their e-journal delivery platforms (*e.g.* Elsevier ScienceDirect, Springer LINK, Wiley Interscience, Blackwell Synergy, etc.) and their use is taking off (EPS 2004a).

The development of e-journals is more advanced.[7] *Ulrich's Periodicals Directory* listed 192 920 active titles in August 2004, of which 41 190 (21%) were on line and 1 149 were open access. Of the 45 091 listed active academic and scholarly titles, 15 482 (34%) were available in full text on line and 889 (2%) were open access (www.ulrichsweb.com). Cox and Cox (2003) reported that in their survey of 275 journal publishers spanning the United Kingdom, Europe, the United Sates, Canada and Asia, 75% of the journals published were available on line – 83% of STM titles and 72% of the humanities and social sciences titles. They also found that: 85% of the publishers surveyed were making back volumes available on line; 72% of the commercial publishers were providing continuing access to volumes actually paid for to former subscribers, as were 54% of not-for-profit publishers; and 52% of the commercial publishers and 45% of not-for-profit publishers had formal provisions for long-term preservation (*i.e.* archiving). These data suggest that the majority of scholarly journals are already available on line, but the majority of them are also still available in print. They also reflect rapid development of online products and services by scientific publishers.

The user demand side

The increasing use of online sources in scientific and scholarly areas is transforming both research dissemination practices and the scientific publishing industry. This section analyses recent evidence of levels of adoption and use of a range of online digital sources, including electronic journals (e-journals), e-books, research databases, archives and repositories.

Education for Change *et al.* (2002) found that electronic journals and other sources were regarded as 'essential' sources by 53% of UK-based researchers, electronic pre-print archives by 30% and computerised datasets by 25% (archives and repositories are described below in detail). There were notable disciplinary differences, with:

- 'Electronic journals and other electronic publications' considered 'essential' sources by 73% of researchers in the medical and biological sciences, 62% in physical sciences and engineering, 57% in social sciences, 26% in area studies and languages and 22% in arts and humanities.

- "Electronic full text services" considered 'essential' sources by 75% of researchers in the medical and biological sciences, 57% in physical sciences and engineering, 56% in social sciences, 27% in area studies and languages and 24% in arts and humanities.

- 'Electronic archives' considered 'essential' sources by 44% of researchers in the medical and biological sciences, 45% in physical sciences and engineering, 25% in social sciences, 12% in area studies and languages and 10% in arts and humanities, and

- 'Computerised datasets' considered 'essential' sources by 31% of researchers in the medical and biological sciences, 28% in physical sciences and engineering, 27% in social sciences, 12% in area studies and languages and 14% in arts and humanities (Education for Change *et al.* 2002, p20).

All UK researchers surveyed saw the future being strongly focused on the provision of electronic information and anticipated increased use of e-books, e-journals and the Internet.

Similarly, Friedlander (2002) found that researchers in the United States used multiple sources, with more than 80% of biological and physical sciences researchers using electronic journals, as did around 75% of researchers across the sample. Healy (2002) found that 66% of those in law used electronic resources for research all or most of the time, as did 56% of those in business, 48% in biological sciences and engineering, 46% in physical sciences, 37% in social sciences and 25% in arts and humanities. In Australia, peer-reviewed journal papers in electronic form were regarded as 'essential' sources by around 60% of researchers surveyed during 2003, online conference papers were regarded as 'essential' by almost 50%, online alerting services and e-mail-based newsletter subscriptions were regarded as 'essential' by around 30%, and discussion groups (*e.g.* listserv) were considered 'essential' sources by 20%. Less than 5% suggested that electronic books were an 'essential' source. Researchers in science and medical fields reported higher use of electronic journals, with 70% saying that they were 'essential' compared with 45% of researchers in social sciences, humanities and arts (Houghton *et al.* 2003).

E-Just (2002a, 2002b) suggested that e-journals had reached a mature stage among life scientists and clinicians in the United States, where almost everyone uses them regularly. Almost 80% of respondents had used e-journals during the week before responding to their 2002 survey, 8% had used e-journals more than a month ago, and 12% had used them during the last month. Only 2% were non-users. Smith (2003), focusing on US-based science and social science faculty use of electronic journals, found that more science faculty members (77%) reported reading articles from electronic sources than did social scientists (69%). Nevertheless, Palmer and Sandler (2003) showed that, by an overwhelming margin, social science researchers preferred electronic access. Economics faculty were the most enthusiastic and anthropology faculty somewhat less so – but there was much less variance than expected. Overall, 75% of the faculty interviewed expressed a preference for electronic access either exclusively, or with some print backup. Of the remainder, 15% expressed a preference for access to both formats, while 6% preferred print only.

Swan (2003) reported that pre-print archives were regarded as an important source by 32% of UK-based researchers surveyed in 2003, with as many as 55% of those in physics regarding them as important sources. Posting to pre-print archives and repositories is somewhat less common, with an average of 11% reporting doing so. Post-print archives and repositories were a more highly regarded source, reflecting the value that researchers place on peer review. Across the sample, 62% regarded post-print archives and repositories as an important source, with as many as 69% in medical and veterinary fields and 66% in business and management fields regarding them as important sources (Table 7). In the future, 78% of researchers suggested that subject-based post-print archives would be an important channel of research dissemination and 44% said subject-based pre-print archives would be, while 60% said institutional post-print repositories would be an important channel of research dissemination and 33% said institutional pre-print repositories would be.

Research databases play an increasingly valuable role in research activities. In a study of UK-based researchers, Education for Change *et al.* (2002) found that 48% of the researchers they surveyed were using computerised datasets of primary data, and 34% thought that their use would increase in the future. They found that the use of databases was higher in the sciences, but still considerable in the arts and humanities. By research field:

- 31% of UK-based medical and biological sciences researchers considered datasets to be essential to their research, a further 24% used them and 44% believed that their use would increase.
- 28% of physical sciences and engineering researchers considered datasets to be essential to their research, a further 23% used them and 39% believed that their use would increase.

- 27% of social science researchers considered datasets to be essential to their research, a further 24% used them and 31% believed that their use would increase.
- 33% of areas studies and languages researchers considered datasets to be essential to their research, a further 12% used them and 23% believed that their use would increase, and
- 14% of arts and humanities researchers considered datasets to be essential to their research and a further 23% used them (Education for Change *et al.* 2002).

Table 7. The use of archives and repositories by researchers, 2003
(per cent)

	Pre-print archives and repositories		Post-print archives and repositories	
	Important source	Deposit articles	Important source	Deposit articles
Business and management	33	8	66	11
Chemistry	33	7	62	9
Earth sciences	19	4	44	6
Engineering and maths	39	18	64	16
Life sciences	20	5	61	8
Medical and veterinary	29	6	69	5
Physics	55	32	62	16
Psychology and social sciences	24	4	61	11
Total	32	11	62	11

Source: Swan, A. (2003), 'What researchers really value: The ALPSP study', paper presented at ALPSP forum "Who Pays for the Free Lunch?" ALPSP, April 2003. Available www.alpsp.org.

In a survey of scientists and engineers in the United States, the National Science Foundation found that 34% reported using digital libraries and data repositories, and a further 23% expected to do so in the future (Atkins *et al.* 2003, pB5). In Australia, a third of all researchers responding to a small 2003 survey saw databases as 'essential' and a further third reported using them. Their use was higher in the sciences, with 75% of science and medical researchers reporting using databases and more than 40% suggesting that they were 'essential'. Nevertheless, almost 60% of social sciences, humanities and arts researchers reported using databases, with 15% regarding them as 'essential' (Houghton *et al.* 2003).

These data suggest that publishers are relatively advanced users of e-commerce and e-business solutions in publishing related processes, while being no more advanced than some other sectors in non-publishing related processes (*e.g.* online recruitment). Perhaps more importantly, scientific publishers are at the leading edge of digital delivery of their content, and that content is being widely used by researchers in their daily research activities.

Box 3. Broadening access to biomedical Information: HINARI and PatientINFORM

Publishers have invested to improve access to the biomedical journal literature. The following are examples of projects designed to broaden access.

HINARI: The HINARI (Health InterNetwork Access to Research Initiative) project was set up in 2000 with the aim of increasing access to journal literature for research and professional workers in developing countries. The project, in which some 22 publishers of medical journals are working with the World Health Organization, provides free access to over 2 000 core medical journals to the world's poorest nations. Sixty-nine countries qualify for free access and another 43 countries are eligible for significantly reduced subscription rates. Medical, nursing, public health and pharmacy schools; research centres; medical libraries; universities; and government offices working in the health sector in developing countries have access to online biomedical journals. HINARI is aimed at helping to bridge the digital divide and improve health care in the developing world. The HINARI project is being continually expanded (http://www.healthInternetwork.org). An evaluation of HINARI (and the sister AGORA program in agriculture) is being developed to assess how the network is being used and the results should be available in 2006.

PatientINFORM: Scheduled to launch at the end of May 2005, patientINFORM (http://www.patientinform.org) is a free, online service dedicated to disseminating original medical research directly to consumers. A collaborative effort of voluntary health organisations, scholarly and medical publishers, medical societies, and information professionals, patientINFORM is aimed at providing patients and caregivers with online access to up-to-date, reliable research for specific diseases, focusing initially on cancer, diabetes and heart disease. Participating voluntary health organisations (the American Cancer Society, the American Diabetes Association, and American Heart Association) will integrate information on prevention, diagnosis and treatment into materials created for patients that will provide free access to selected referenced full-text research articles and additional selected material on journal Web sites.

Source: Web sites and company information.

Barriers

Organisations face a range of impediments to the adoption of e-commerce and digital delivery, with suitability of the particular products or services, concerns over security and privacy, internal and external skills availability, infrastructure and implementation costs and regulatory barriers among the more commonly cited. This section analyses both supply-side (publisher) and demand-side (user) barriers, many of which are scientific publishing-specific examples of more general barriers to adoption across a wide range of digital content industries.

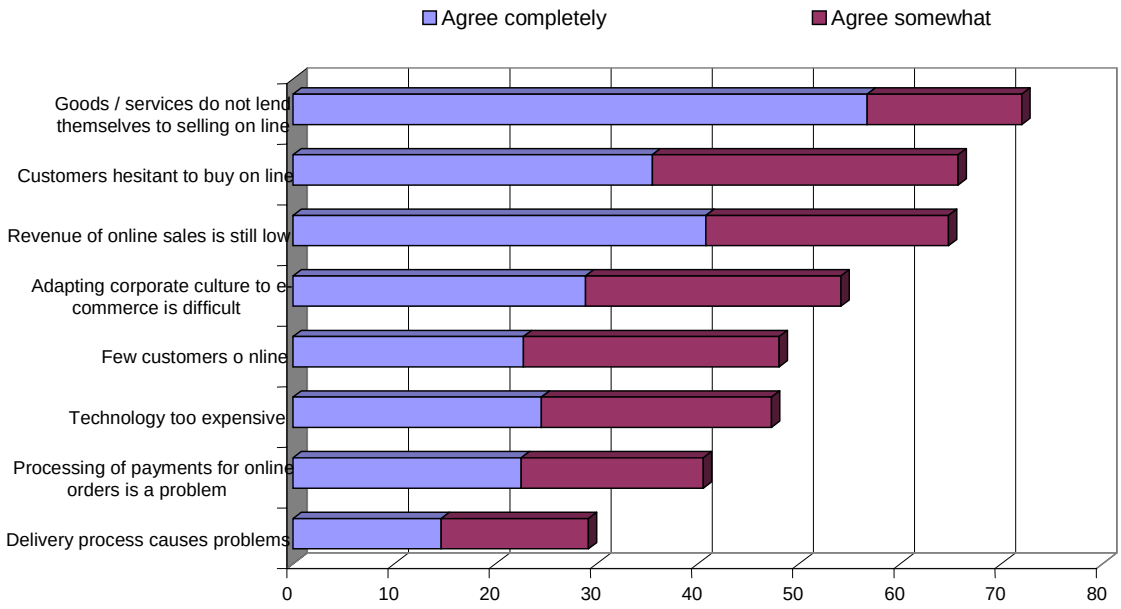
Supply-side barriers

In an extensive survey of e-commerce activities in 25 countries spanning Europe, the United States, Japan, South Africa and India, Accenture (2001) found that: 74% of businesses surveyed cited security concerns as a barrier to further development of e-commerce; 67% cited the lack of a transparent regulatory framework; 66% cited concerns over privacy; 59% cited lack of payments standards and 59% cited a lack of ability to successfully implement new technology; 57% cited lack of capital to fund implementation projects; 50% cited costs of communications access and usage; and 42% cited over-regulation. Similarly, in a 10-country study undertaken during 2002, Kraemer *et al.* (2002a) found that the most widely cited barriers to the adoption of e-commerce and e-business solutions were: concerns about privacy and data security (44% of firms surveyed), inadequate legal protection for purchasers and the unsuitability of their products and services (34%). Implementation costs, lack of customers on line and inability to find skilled staff were also widely cited barriers.

E-business Watch (2002, 2003) reported on the barriers to online sales and procurement among enterprises in the media and publishing sector in Europe (EU-7 – *i.e.* France, Germany, Greece, Italy, Netherlands, Spain and the United Kingdom) in mid-2002. The most widely cited *barriers to online sales* were: that the goods and services did not lend themselves to online sales (72% of enterprises agreed), customers were hesitant to buy on line (66%) and the revenue from online sales was still low (65%).

Relatively few found technical barriers to online sales – such as delivery problems (29%), problems processing payments from online orders (40%) or that the technologies were too expensive (47%) (Figure 9). Given the potential for digital delivery, it is perhaps surprising that unsuitability of goods for online sales should be such a widely cited barrier for media and publishing firms. It may be due to the mix of services and content firms in the sector and/or the lack of sufficient bandwidth in many countries in mid-2002 to support digital delivery of some content (*e.g.* movies). It may also reflect security and copyright concerns. As broadband penetration increases, however, one would expect to see a marked reduction in citation of this barrier.

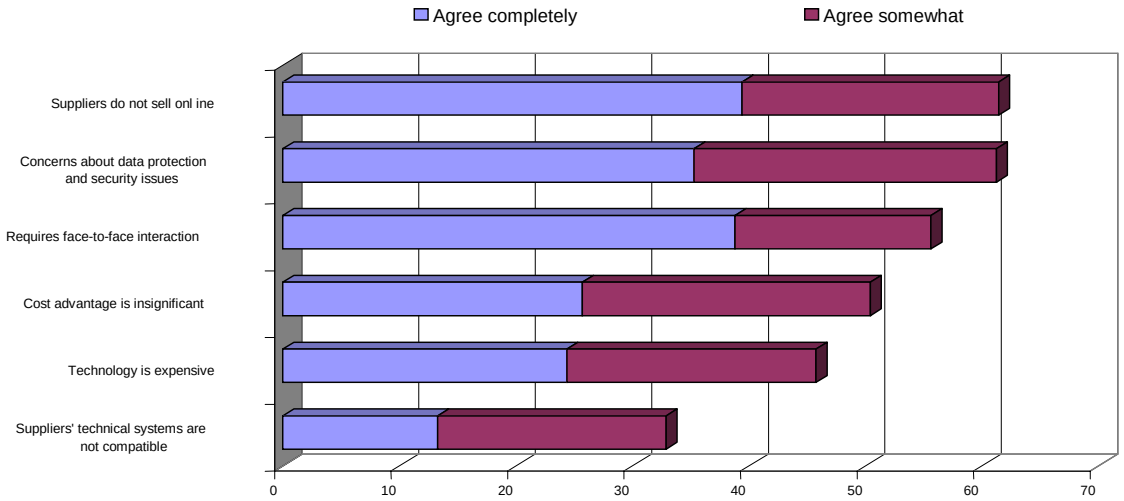
Figure 9. Barriers to selling on line in media and publishing in Europe, 2002
(percentage of all enterprises)



Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

The most widely cited *barriers to online procurement* were: that their suppliers did not sell online (61% of enterprises agreed) and concerns about data protection and security (61%) (Figure 10). Barriers to procuring on line play a larger role for SMEs than for larger enterprises in the sector, with SMEs citing more technical problems and issues of affordability (E-business Watch 2002, 2003).

Figure 10. Barriers to procuring on line in media and publishing in Europe, 2002
(percentage of all enterprises)



Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

In the United Kingdom, a 2002 survey of publishers found that a lack of interoperability with suppliers and customers was one of the main obstacles to the adoption of e-commerce. Relatively few reported other technical problems (DTI 2002a). This issue is also being addressed in the follow-up to the 2004 OECD Ministerial declaration on access to digital research data from public funding.

A Canfield Survey conducted during March-May 2003 found that: 77% of publishers' Web sites supported content delivery, 66% accepted online orders and 51% accepted electronic payments (Daut-Mohamud and Sackett 2004). For UK publishers surveyed during 2002 the most important obstacles included:

- Human and cultural issues, including: access to technical skills, fear of the impact of changes in work practices and internal power relations, and some fear of technology among smaller firms.

- Technical issues, including: difficulties with legacy systems and proprietary nature of specialist publishing software which was not easily adapted to open, Web-based environments; interoperability problems due to a lack of agreed standards; and operation of multi-channel customer relationships and the potential for channel conflict, and

- Market structure and competition issues, including: direct competition making it difficult to co-operate to develop standards and implement interoperable systems; the tendency to defend existing investments and relationships; and obstruction by players fearing disintermediation.

For journal publishers, the creation of electronic content and lack of interoperability with suppliers and customers were important barriers, while for book publishers, it was the creation and distribution of electronic content (DTI 2002a, p111).

Demand-side barriers

Despite the high levels of adoption and use of electronic sources, there remain a number of barriers. One important one is cultural. Many research authors want to see their work in print and feel that it has not been 'properly' published until it is in print. There is a sense that their peers, employers and funders do not value electronic publication and that traditional print publications carry more weight in research evaluation (Swan 2003; Houghton *et al.* 2003, p123; Swan and Brown 2004; etc.). This is reflected in the divergence of opinion among researchers as readers and as authors, with many wanting to access online sources but far fewer seeking to publish on line. For example, Swan (2003) reported that 32% of UK researchers surveyed saw pre-print archives as an important source and 62% saw post-print archives as an important source, and yet just 11% deposited articles in them (See Table 6 above).[8] This is, in part, a matter of time: being in part a matter of generational change among researchers, and in part due to the long-term repute of existing publications and forms of publication relative to newer ones.

Digital delivery has evolved rapidly. One result of this has been the development and proliferation of proprietary access and hosting platforms, with publishers and aggregators developing their own systems. Users have reported considerable difficulty managing, navigating and dealing with the many different distribution platforms and channels (CESTMJP 2004, p25) although there are now efforts to offer multi-publisher access through some of the major access and hosting systems (*e.g.* ScienceDirect) and an increasing sharing of platforms.[9]

A further barrier to the adoption of digital only scientific and scholarly content is uncertainty about the long-term maintenance and accessibility of the archival record (Bide *et al.* 1999; Morris 2000; Lavoie 2003; HCSTC 2004, pp89-93; etc.). Long-term preservation is a vital part of the record of science. Digital content creates many technical difficulties, in terms of format and medium (*e.g.* whether particular disk or file formats will be readable in the future). In addition to purely technical issues, this raises the question of whether to preserve the content or the object, or both. There are also important questions as to responsibility, accessibility and cost. Some jurisdictions have extended legal deposit to digital publications, but there remain issues relating to the definition of publication, what should be collected, how and by whom. Again it is an area in which there has been much progress. Early concerns about the loss of the scientific record if entrusted to private firms, exacerbated by cases of removal/deletion (see, for example Liblicense-List, January 2003 www.library.yale.edu/~llicense/ListArchives/0301/maillist.html), are now being addressed by national and university libraries and private publishers. For example, the US National Library of Medicine's PubMed Central, a digital archive of life sciences journals literature, and the US National Agricultural Library, a digital archive of agricultural information, are two examples of publicly funded efforts to preserve and maintain unrestricted access to the electronic literature, and an overarching example is the US National Digital Information Infrastructure and Preservation Program, led by the Library of Congress to preserve digital material. An example of a private sector initiative is Reed Elsevier's agreement with Koninklijke Bibliotheek, Netherlands (SQW 2003, p9). Nevertheless, a shift to online/digital only will not gain universal support until the fundamental and major issues of archiving have been resolved.

In some jurisdictions there are also barriers relating to differential taxation of print and digital content (ALPSP/CAPP 2003; HCSTC 2004, p43; etc.). In the United Kingdom, for example, the full VAT rate applies to digital publications while print publications are zero rated. This may represent a disincentive for purchasers of digital content to the extent that online and offline products are identical. However many online products provide a range of other capabilities (much more functionality, access to archives, real-time updates, etc). OECD work (OECD 2003) has noted that "some businesses remain concerned that by defining digitised products as "not goods" (as was confirmed by the Ottawa Taxation Framework Conditions) differing channels of delivery can result in different tax rates. The most quoted example of this is the online newspaper that may, as a result of its classification as a service, be liable at a standard rate of

VAT/GST, whilst the conventional version will often benefit from a reduced rate. Governments largely take the view that the different functionality inherent in the online version means that typically the electronic product is significantly different from its hard copy version. But it remains the case that for those businesses with an interest in supplying such online products this will remain problematic." To the extent that anomalies remain it is important that these be addressed.

Pira International (2003, p14) also noted that: the digital environment has fundamentally challenged traditional assumptions and possibilities in the distribution of content and the private use of rightfully acquired material. Many content providers are facing a challenge from the illegal distribution of digital content over the Internet [see analysis in the OECD music study DSTI/ICCP/IE(2004)12/FINAL and the OECD online computer and video game study DSTI/ICCP/IE(2004)13/FINAL ((OECD 2004d, 2004e)], and piracy concerns act as a barrier for both publishers' and authors' distribution of content in digital form.

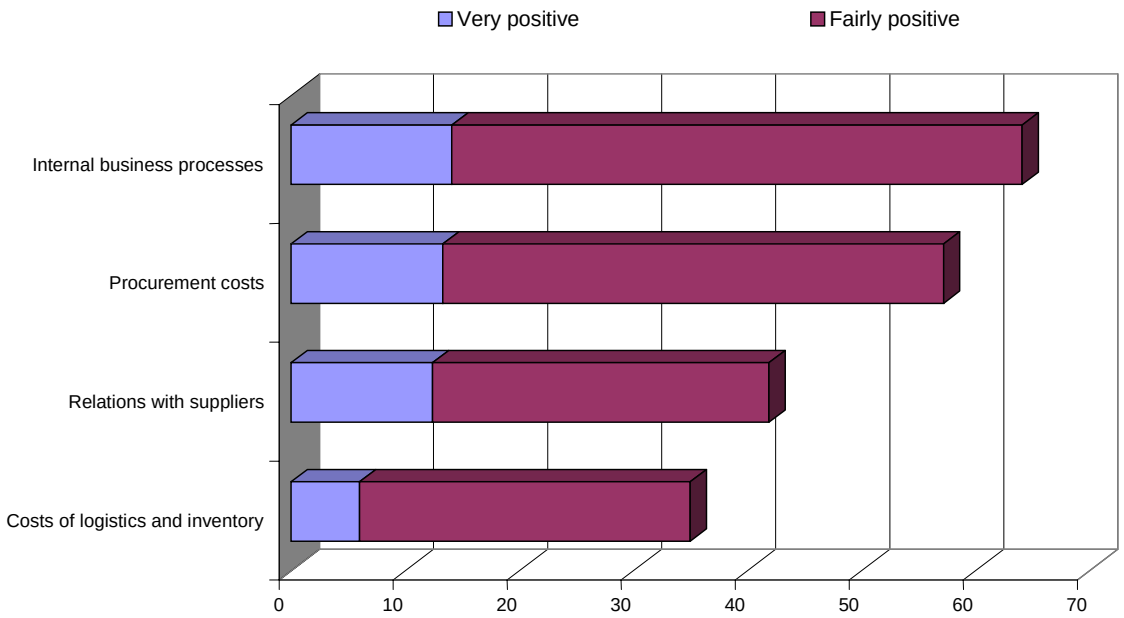
Currently, these and other factors are encouraging the maintenance of the print system in parallel with digital delivery. This dual mode publishing is adding costs, as publishers commonly produce for print, then make a digital copy available for online distribution, rather than vice versa (*e.g.* through print-on-demand) or gearing the process to digital delivery only. Importantly, while dual mode publishing persists, both publishers and their customers are facing increasing costs rather than reaping the benefits and cost savings available from an entirely digital delivery-based system.

Impacts

The impacts of e-commerce, and the adoption of e-business solutions and digital delivery on publishers include both efficiency gains and disruptions to existing business models. On the demand-side, the major impacts have been significant increases in access and the ability to use content in new ways.

The main impacts of *online procurement* noted by European (EU-7) media and publishing enterprises in mid 2002 were: improved internal processes (64% of those procuring on line), reduced procurement costs (57%) and improved relationships with suppliers (42%) (Figure 11). Improved internal business processes were felt more by enterprises in the media and publishing sector than by those in other sectors, while other impacts (particularly reduced costs of logistics and inventory) were felt less in the media and publishing sector than in others. This may reflect the digital nature of the content and the fact that inventory costs play a lesser role (with the exception of book publishers) than in many other sectors (E-business Watch 2003).

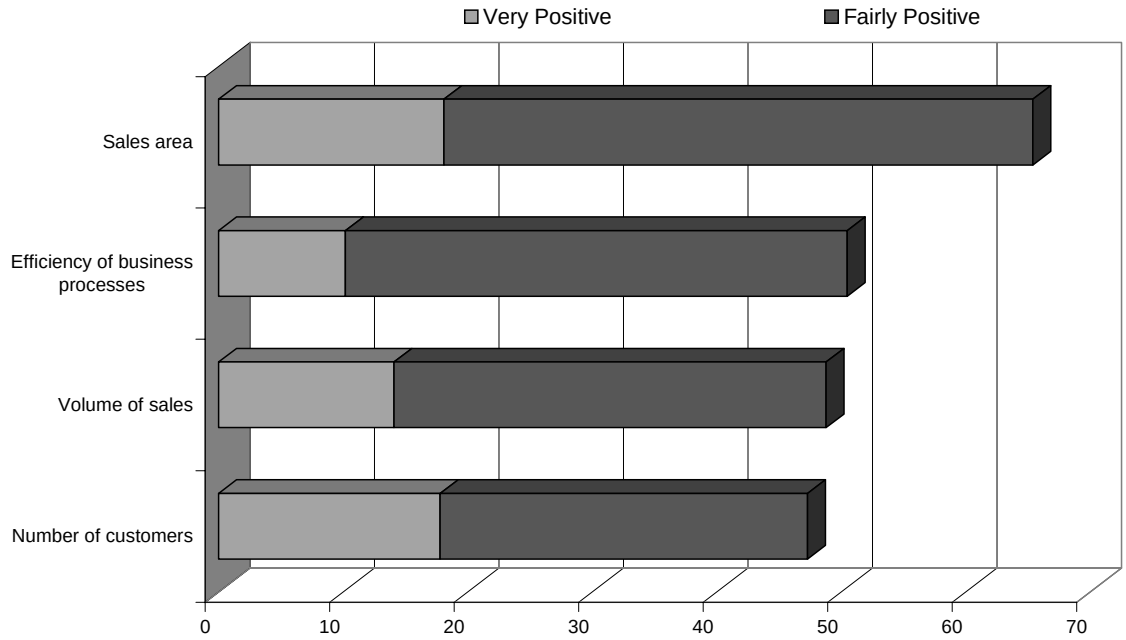
Figure 11. Impacts of procuring on line in media and publishing in Europe, 2002
(percentage of enterprises on line)



Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

The main impacts of *selling on line* for media and publishing enterprises in Europe (EU-7) in 2002 were: increased sales area (65% of those selling on line), efficiency of business processes (51%) and increased volume of sales (49%) (Figure 12). Sales area impacts were felt more in the media and publishing sector than in other sectors, perhaps reflecting the digital nature of some of the products and their transportability; while other impacts were felt somewhat less than was the case in other sectors (E-business Watch 2003).

Figure 12. Impacts of selling on line in media and publishing in Europe, 2002
(percentage of enterprises on line)



Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003) *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

In a 2002 study of UK publishers, DTI (2002a) reported their conclusions from a series of case studies which provided insights into the motivations, expectations and experiences of publishing firms in the adoption of e-commerce and digital delivery. In relation to *book publishing*, DTI (2002a, pp34-39) concluded that:

> *Electronic commerce is well established for advertising, catalogues and stock lists as well as additional information such as jackets, sample chapters, reviews, etc. Information can be provided more easily and bundled to provide a more comprehensive service... The use of electronic commerce for the ordering, billing/payment, finance and delivery is well-established and well-used by all but the smallest enterprises. The ability to link between proprietary and interlinked systems ensures the widest take-up rate. The net result has been a reduction in costs for order processing and fewer errors, [and] better tracking. Not only has this had a positive impact on logistics, but it also has improved co-ordination and integration as well as promoting a greater sense of trust.*

Similarly, EPS (2004a, p5) reported that "the rise of 'digital workflow' in book publishing had been a revolution in the process rather than the product: the final product may look the same, but the process by which it is produced has been radically transformed." E-commerce and e-business solutions have enabled book publishers to refine stock management practices and reinvent the life-cycle of the book.

In relation to *journal publishing*, DTI (2002a, p59) found that:

- Authors' files are used directly by typesetters, which reduces costs; although the cost of generating electronic files has reduced some of the benefit.

- The review process has been streamlined, as publishers have implemented online review systems, enabling a better overview of content flow to be obtained.

- Several parties have created online aggregation services. These include subscription agents, archiving agencies and new players in the market.

- Subscription agents have been squeezed by both aggregators and publishers selling directly to end-customers (*i.e.* library consortia).

- Significant investments in time and money have been made in new e-commerce transaction software and methodologies.

- The industry has had to invest heavily in training staff at all levels to create, publish, distribute, market and sell new online products.

They concluded that: "Journal publishers have been at the forefront of e-commerce developments in the publishing industry. They are the only part of the industry to have implemented products and business models that generate significant revenues from online products. It is now the exception that a journal is not available in full text online" (DTI 2002a, p59).

E-business Watch (2002, 2003) concluded that impacts on media and publishing enterprises included: changes to workflow and the value chain as a result of working with digital content, with some steps in the value chain becoming obsolete and some being taken over by other players in the value chain; increased opportunities to collaborate with suppliers, customer and competitors; changes in product and service possibilities and related changes to business models; and changes to corporate strategies to cope with the new challenges and seize new opportunities. At the industry level, impacts included: the likelihood of economies of scale and greater market reach increasing pressures for concentration; pressures arising from digital delivery encouraging cross-media ownership; and the potential for increased polarisation of the industry between very large multinational enterprises and SMEs. There are cases of both disintermediation and the emergence of new intermediaries – with publishers increasingly dealing directly with their research library customers and some subscription agents being squeezed out (Cox 2005), and the emergence of new forms of hosted distribution service (*e.g.* HighWire Press).

Citing Christensen (1997), Pira International noted the distinction between *sustaining technologies* that improve the performance of established products and business models and *disruptive technologies* that bring different value propositions and performance characteristics, enabling the introduction of alternative business models and changing the ways that industries function. ICTs, e-commerce and digital delivery in publishing bring both. "New sustaining technologies – more efficient editorial production systems, cheaper colour print technologies, the use of e-business technologies to improve production and communication between supply chain partners – lead to economies and efficiencies. However, disruptive technologies have the potential to introduce new combinations of media, erode existing revenue models, and to force content companies to develop new business models and change relationships with the consumer." (Pira International 2003, p117). There are both opportunities for disintermediation within the supply chain and opportunities to create new intermediaries, combining resources, assets, knowledge and information from a variety of sources to create new value propositions and to serve as the focal point for new relationships with the consumer. These emerging business models are analysed in the following sections.

NEW VALUE CHAINS AND BUSINESS MODELS

This section examines recent developments in scientific publishing and some of the business models that have emerged and their underlying economics and implications. Current scientific publishing practices reflect three major developments which all depend upon digital delivery. These include:

- The, so called, "Big Deal" – where institutional subscribers pay for access to an online aggregation of journal titles through consortial or site licensing arrangements.

- Open access publishing supported by author charges or other forms of institutional support on the supply-side – where authors and/or their employing or funding organisations contribute some or all of the costs of publication (*e.g.* BioMed Central), and

- Open access archives and repositories – where organisations support institutional repositories and/or subject archives (*e.g.* CogPrints, eScholarship, etc.).

These three models and their hybrids (*e.g.* delayed open access – where journals allow open access after a period during which they are accessible to subscribers only; open choice – where authors can choose to pay author fees and make their works open access or not to pay and make their works subscription only; etc.) are the most significant developments. There are also coexisting alternatives and mixes, such as pay-per-use (where individual or institutional users pay for access to single articles) and advertiser supported distribution (where advertisers seeking to sell to readers contribute to cover some or all of the costs of production and distribution). This section analyses each of the three models, exploring what is happening and how it works, and the impacts in terms of the economics of publishing and publisher business models and the impacts on science, and the potential advantages and disadvantages.

The "Big Deal"

Online access and distribution change cost structures. Characteristically, content products have high first copy costs and low subsequent copy or marginal costs of production. Nevertheless, when content is printed, packaged and distributed through a wholesale-retail distribution channel there remain significant costs in the production and distribution of copies. Making the same content available on line reduces these producers' costs dramatically, with no physical (re)production and distribution activities and no inventory. New investment in the producers' technical infrastructure is frequently required, but the long-term impact of online distribution tends to be to increase first copy costs, reduce marginal cost of production to near zero and shift the distribution of costs towards fixed costs. Current and emerging content business models can be seen as responses to these changed economic characteristics of content brought about by online distribution and access.

Bakos and Brynjolfsson (2000, p117) suggested that the Internet has radically changed the economics of distribution and opened up new possibilities. Goods that were previously aggregated to save transaction or distribution costs may be disaggregated (*e.g.* newspapers), but new aggregations may emerge to exploit the potential of bundling for profit maximisation. The Big Deal is one such aggregation. Lower distribution costs tend to make unbundling more attractive for sellers, while lower marginal costs of production tend to favour bundling by producers. Unbundling involves operating mechanisms such as pay-per-view and associated payments systems, which represent unavoidable costs in the unbundling model. Near zero

marginal cost favours bundling from the producers' side, the more so where advertising and marketing costs can be significantly reduced by aggregating consumers. Some analysts have extended the logic of bundling from the content itself to subscription (*i.e.* bundling over time) and site licensing (*i.e.* bundling users) (Bakos and Brynjolfsson 1999; Bakos, Brynjolfsson and Lichtman 1999; Bakos and Brynjolfsson 2000). Different consumers may have a different willingness to pay, and the same consumer may have a different willingness to pay at different times. If provision of access over time costs very little, it may be more profitable to provide a long-term subscription than to provide for individual uses in short periods of time (*e.g.* pay-per-view) (Bakos and Brynjolfsson 2000, p131). Similarly, site and consortial licensing aggregates individual subscribers and allows the supplier to charge at the individuals' average willingness to pay.[10]

Table 8 outlines some of the advantages and disadvantages of the "Big Deal" based on a review of the recent literature. One major advantage is that it gives researchers access to many more titles than is typically the case with individual subscriptions. This can be particularly important for researchers in interdisciplinary fields and in circumstances where greater breadth of knowledge and flexibility in focus is required (Houghton *et al.* 2003). Such deals also reduce per title and per article costs to users within the overall package, and to that extent increase access. Bundling and site licensing can also increase budgetary certainty for research libraries through multi-year deals with agreed fixed price increases. This can be an attractive feature for libraries, which often operate on fixed multi-year budgets. Aggregating subscriptions and site licensing has also encouraged libraries to form purchasing consortia, which have often enabled them to obtain greater discounts than they could have obtained individually.

Table 8. Advantages and disadvantages of the "Big Deal"

Advantages	Disadvantages
Improved access, with access to more titles – which suits researchers in emerging interdisciplinary areas and tends to lead to higher use. Reduces the per title and per article costs to users of the overall package. Can increase budgetary certainty for research libraries through multi-year deals with fixed price increases agreed up-front. Can increase access through consortial deals, especially for those previously poorly served.	Tends to lock libraries into the major bundles and makes it more difficult to cancel titles. Tends to reduce substitutability, and may reduce price elasticity of demand. Tends to squeeze out smaller publishers who cannot offer access to large bundles (*i.e.* becomes competition between publishers rather than titles). May influence impact factors in favour of titles within the bundle and strengthen the position of the major publishers. Because publishers try to build up the bundle and price it, rather than individual titles, there is less pressure to axe low demand titles. As a result, aggregate fixed (first copy) costs increase. Access may sometimes be more restrictive than that for print subscriptions (*e.g.* access for walk-in library users may be cut by either publisher or library logon requirements). Concern over access to previously subscribed to back issues if subscription is terminated (*i.e.* cut off from everything, not just new issues). Concern over long-term archival integrity.

However, a number of disadvantages have been associated with the "Big Deal". For example:

- Such deals tend to lock libraries into the major bundles available and make it more difficult for them to cancel individual titles. There have, for example, been reported cases of research libraries subscribing to journals for disciplines that the institution does not support or that they do not need (Franklin 2002; Key Perspectives 2004; CESTMJP 2004; etc.).[11] Aside from questions of value for money and efficiency, such deals reduce substitutability and may reduce price elasticity of demand.

- Such deals tend to squeeze out smaller independent publishers who cannot offer access to large bundles, with research libraries taking the titles that are available from major commercial publishers as a part of the bundle and cancelling titles from the small independents to pay for them (Prosser 2004). This has encouraged independent society and institutional publishers to attempt to create their own collective subscription and licensing deals (*e.g.* ALPSP, BioOne, Project Euclid, etc.) (SQW 2003; Key Perspectives 2004).

- It has been suggested that the Big Deals may influence citation patterns and impact factors in favour of titles within the bundle because they are more easily accessible, and thereby strengthen the position of the major publishers (Guedon 2001, p46). This may increase the desirability of that publisher's titles over those of others, reduce substitutability and, thereby, enable them to increase their prices in the future.

- Because publishers price a bundle of titles rather than individual titles, there is less pressure for them to remove low demand titles from their portfolios. When subscribed to individually, journal titles must compete for research library budgets. When they are part of major aggregation deals they no longer compete individually. This may enable low demand/low use titles that would otherwise have been cancelled to continue as a part of a bundle, which remains viable because of other titles within the aggregation. As a result, the number of titles may increase, inflated by low demand/low use titles that would not otherwise have survived, and aggregate fixed costs within the system may increase (Houghton 2001; SQW 2003, p5).

- Licensing arrangements and electronic access have sometimes been more restrictive than for print subscriptions – for example walk-in library users who could access the print journal versions may not be able to access their electronic only equivalents on line,[12] and greater restrictions have sometimes being placed on the distribution of copies for inter-library loan requests, etc. (CESTMJP 2004, p4).

- With print copies, should a library cancel a subscription it retained the copies obtained during the subscription period. With the Big Deal and online access through a particular front-end system, there has been concern over how to maintain access to previously subscribed to issues when subscription was terminated. Historically, some publishers have felt reluctant to guarantee perpetual access, including updates and upgrades to the access system. This arises because the access technology and platforms have been supplied with the content, and the bundle priced according to print-based business models in which there was no access technology or platform.

- There has been some concern over responsibility for, and the integrity of, the long-term archive. This concern relates to issues of trust and practical issues of the longevity of commercial publishing firms. There have been occasions of commercial publishers deleting or blocking access to articles that had been published but later found to be fraudulent or plagiarised (*e.g.* controversy over the deletion of articles from ScienceDirect by Reed Elsevier during 2002 – see www.library.yale.edu/~llicense/ListArchives/0211/msg00013.html).

While much progress has been made, there remains concern relating to the mechanics, economic and scholarly outcomes of major bundled subscriptions and site licensing deals (Frazier 2001; Gatten and Sanville 2004; CESTMJP 2004, p22).

Open access publishing

A recent development to have gained considerable momentum is open access, principally in the forms of *open access publishing* supported by grants and donations, author charges or other kinds of cost recovery, and *open access archives and repositories*. There is an important distinction between open access publishing (*i.e.* open access to formally published work) and open access archives and repositories, which may contain both formally published work (*e.g.* e-prints) and works that may not previously have been formally published. Furthermore, open access is not synonymous with author pays and various kinds of cost-recovery apart from the author pays model are being experimented with by open access publishers. Definitions of *open access* vary. The Public Library of Science (PLoS, 2004) suggested that an Open Access Publication is one that meets the following two conditions:

- The authors and copyright holders grant to all users a free, irrevocable, worldwide, perpetual right of access to, and a license to copy, use, distribute, transmit and display the work publicly and to make and distribute derivative works, in any digital medium for any responsible purpose, subject to proper attribution of authorship, as well as the right to make small numbers of printed copies for their personal use, and

- A complete version of the work and all supplemental materials, including a copy of the permission as stated above, in a suitable standard electronic format is deposited immediately upon initial publication in at least one online repository that is supported by an academic institution, scholarly society, government agency, or other well-established organisation that seeks to enable open access, unrestricted distribution, interoperability and long-term archiving (PLoS 2004).

Box 4. The open-access approach for science

The practical advantages of true open access are already very familiar to many researchers in the life sciences through two longstanding successful open-access experiments: GenBank and the Protein Data Bank. The success of the genome project, which is generally considered to be one of the great scientific achievements of recent times, is due in no small part to the fact that the world's entire library of published DNA sequences has been an open-access public resource for the past 20 years. If the sequences could be obtained only in the way that traditionally published work can be obtained, that is, one article at a time under conditions set by the publisher, there would be no genome project. The great value of genome sequences would be enormously diminished.

More significant is the fact that open access is available for every new sequence, which can then be compared to every other sequence that has ever been published. The fact that the entire body of sequences can be downloaded, manipulated by anyone, and used as a raw material for a creative work has led thousands of individual investigators to take up the challenge of developing new data-mining tools. It is such tools and the new databases that incorporate sequences, enriched by linking them to other information, that have made the genome project the success that it is today. By adapting the genome model of open access to the publication of scientific literature, we could see a similar flowering of new, investigator-initiated research and creative, value-adding work.

Source: Brown, P., in Committee on Electronic Scientific, Technical, and Medical Journal Publishing (CESTMJP) (2004), *Electronic Scientific, Technical, and Medical Journal Publishing and Its Implications: Proceedings of a Symposium*, National Research Council, National Academies Press, Washington DC, p30.

Others argue that delayed open access through existing well-established journal access systems is sufficient. The key element of open access is that the material is made available freely and openly, without charge or usage restrictions to anyone with Internet access. And open access need not be limited to

scientific literature. It can apply to any works born digital (*e.g.* research databases and analytical objects) or to older works, like public-domain literature and cultural-heritage objects, digitalised later in life.

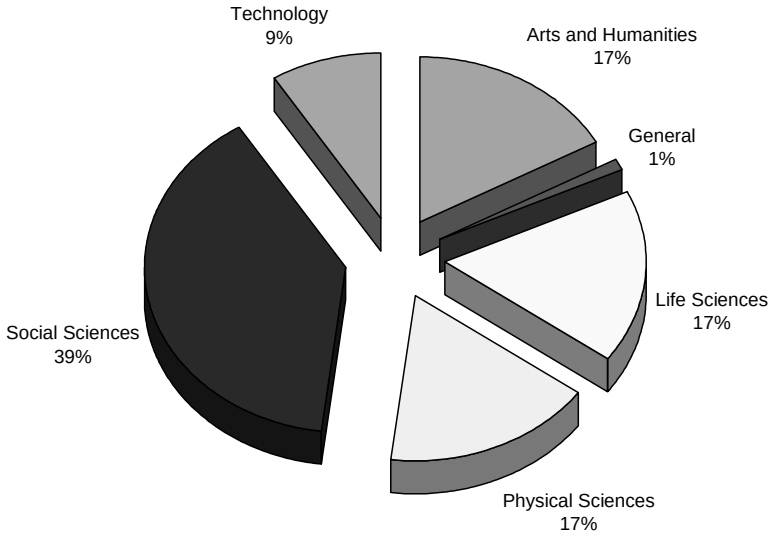
In the *open access publishing* model, the costs of peer review and the production of journals are met from donations and/or institutional support, or wholly or in part by charging authors a per article or per page fee for publication, submission or some combination of both.[13] These fees will be paid by the authors' institutions and/or funders, with publication regarded as a part of the cost of research. Currently, relatively few open access journals are author pays, with many using donations, bequests, institutional support, priced add-ons or auxiliary services to support publication. These models are still evolving and it is still relatively early to judge their role and viability with respect to other emerging and established models.

Among the major open access publishing initiatives where the author pays are:

- The Public Library of Science (PLoS) – which is a non-profit organisation of scientists and physicians that seeks to make the world's scientific and medical literature a public resource. It began in October 2000 with a call to make scientific and medical literature available, on an open access basis, after a delay (typically of six months) for material published in subscription journals. In 2001, PLoS launched its own open access journals using the author pays model. Author fees for the publication of an article in a PLoS open access journal are USD 1 500, and all articles published are deposited in an open access archive (*e.g.* PubMed Central). PLoS also operates an institutional membership scheme for author fees, in which author fees are waived for authors employed by member institutions (www.plos.org). (Recent views of Patrick Brown one of the cofounders of PLoS are presented in Box 4.)

- BioMed Central – which lists more than 100 open access journals covering all areas of biology and medicine. BioMed Central is an independent publisher that makes all the original research articles in its journals immediately and permanently available on line without charge or any other barriers to access. All research articles and most other content in BioMed Central's journals are peer-reviewed. Authors retain copyright over their work. Open access is supported by article processing charges levied on authors. The majority of BioMed Central journals charge a flat fee of USD 525 for each accepted manuscript, but the leading journals in the stable charge up to USD 1 500. A number of major institutional funders have announced their willingness to cover BioMed Central and other open access publishing charges within their research grants, and no direct article charges are levied if the submitting author's institution is a BioMed Central member. As at July 2004, BioMed Central had 451 institutional members in 40 countries who paid between USD 1 600 and USD 8 000 to join (www.biomedcentral.com).

Figure 13. Scientific refereed open access journals by subject, 2002



Note: From publisher survey (N=60).

Source: Hedlund, T., T. Gustafsson and B-C. Bjork (2004), 'The open access scientific journal: an empirical study,' *Learned Publishing*, 17(3), pp199-209.

Others adopting and/or experimenting with open access and various forms of author pays journal publishing include: the Institute of Physics Publishing, Oxford University Press, The Company of Biologists, National Academy of Science (*PNAS*), The American Physiological Society (*Physiological Genomics*), Entomological Society of America, The American Institute of Physics and the large commercial publishers Springer and Blackwells. *Ulrich's Periodicals Directory* listed 192 920 active titles in August 2004, of which 1 149 were open access. Of the 45 091 listed active academic and scholarly titles, 889 (2%) were open access (www.ulrichsweb.com). Lund University's Directory of Open Access Journals listed 1 151 titles (www.doaj.org).

A review of the literature suggests that there are a number of advantages and disadvantages to the "author pays" version of open access publishing (Table 9). Perhaps the most significant advantage is enhanced access and greater dissemination of research findings likely to bring higher social returns on investments in R&D. There is recent evidence that citation and use is higher for online and open access articles than for articles that are available on a subscription or pay-per-view basis (HCSTC 2004, p76; Lawrence 2001a; Odlyzko 2002; Prosser 2003; Kurtz 2004; Walker 2004),[14] although some others have challenged this suggestion (Richardson and Saxby 2004). It must also be remembered that citation reflects research use and does not take account of the wider use by other users of online and readily accessible research findings (*e.g.* medical practitioners, consulting engineers, etc.). There is significant potential for various evolving forms of open access to expand and facilitate the use and application of research findings to a much wider range of users well beyond core research institutions that have access to the subscription-based literature.[15]

Table 9. Advantages and disadvantages of author pays open access publishing

Advantages	Disadvantages
Increases access to the findings of research, thereby increasing social returns from investment in research.	May lead to inequality of access, with publishing based on means rather than merit.
Costs should be lower than subscription-based models, due to lack of need for licensing, subscription management, and access control.	May not work for the humanities, arts and social sciences, where research funding is more limited.
Scales publication to research funding and activity, rather than research library budgets (*i.e.* better matches demand and supply).	May make it more difficult to establish a new journal, thereby reducing the number of titles over time and making it difficult for new areas of scholarship to find an outlet.
Journals compete for authors rather than subscribers, so likely to increase substitutability between titles.	May create a disincentive to publish, thereby reducing the impact of R&D and the return on R&D spending.
	May have a detrimental impact on institutional and society publishers, who have used subscription revenues to subsidise other activities.
	May raise quality concerns due to economic pressure to lower rejection rates to control costs.
	Will shift the costs of publishing, and may lead to organisations and countries that are major producers of scientific and scholarly works paying more in author charges than they would for subscription fees in a reader pays system.
	May create a free rider problem, with open access for previously paying users in the private sector (*e.g.* pharmaceutical firms).

It has been suggested that some form of open access publishing supported by author fees may also be an appropriate and economically efficient model. There are a number of reasons, including: that it is likely to be a lower cost model, with no need for licensing, subscription management and access control, although an author payments management system will be required (PLoS 2003; SQW 2004, p2; HCSTC 2004a, p73); that the system scales to research funding and activity rather than research library budgets, which are not necessarily related to the level of research activity (PLoS 2003; HCSTC 2004a); that it bypasses some aspects of the subscription model – such as the lack of competition between journal titles and articles (being "must have" items for readers), issues of price signals, non-price sensitive research library acquisition practices, etc. (SQW 2004); and that it increases competition between journal titles as there is greater substitutability between titles for authors than there is for readers/subscribers, and thereby puts downward cost pressures on publishers as they compete (in part) for authors on article production costs (Bergstrom and Bergstrom 2004a, 2004b).

However, many analysts have questioned whether the author pays model is sustainable (Zandonella 2003; Willinsky 2003; McCabe and Synder 2004a, 2004b; HCSTC 2004a; 2004b; etc.). There are many potential disadvantages relating to an author pays system and its economic and scholarly impacts. For example:

- There are potential difficulties in moving to any system that introduces financial means as a condition of publishing. For example, where publication is supported through research grant funding there may be further accentuation of already existing inequalities, with publication dependent upon research funding and research funding dependent upon publication, which favours already successful and well-funded research over poorly funded unknown and new research. There are questions of scholarship and ease of access for young researchers entering a field who may initially have very limited financial backing although author pays models have also provided mechanisms for subsidising those who cannot pay to alleviate inequality issues.
- Author fees are likely to represent a very small fraction of research funding in many science, technical and medical fields, but an author pays system may not work in areas of the humanities, arts and social sciences, where there is often more limited research funding. Author pays will also be more difficult in fields where there are higher average article rejection rates.
- An author pays model may introduce an incentive to publish less at the individual, institutional and perhaps even national levels – because of problems of affordability and access to publishing. Obviously, such an outcome is the opposite of what most proponents of open access seek to achieve, and would undermine some of the potential social welfare benefits of open access. When author charges are levied for accepted articles, there is an economic incentive for publishers to accept a higher proportion of articles which may have negative implications for quality. However, perceptions of quality and journal impact factors should lead authors to continue to value high quality titles and seek to publish in them, thereby allowing high quality journals to compete for authors with lower-fee alternatives. Furthermore, the quality of articles and rejection rates depend on the level and rigor of peer review not the particular business model adopted and there is some evidences that rejection rates are similar for different models.[16]
- An entirely author pays system may make it more difficult to establish a new journal, which would lack the established reputation of existing titles (King and Tenopir 2004; Odlyzko 2004). Over time, this might reduce the number of titles and make it more difficult for new areas of scholarship to get a hearing and for new groups of researchers to emerge. On the other hand, there may be alternative start-up support mechanism, such as learned societies, foundations, etc. which could provide an opportunity for new streams of publication. It might also be argued that, with revenue tied to submissions rather than subscriptions and potentially lower costs, it may be easier to find support to launch open access journals. An author pays system could have a detrimental impact on institutional and society publishers, who use subscription revenues to subsidise other activities (Willinsky 2003; Worlock 2004b; Morris 2004; etc.). While this may be true and adjustments may be required, making formerly hidden cross-subsidies more transparent has been widely acknowledged as being beneficial.[17]
- Moreover, societies provide a range of services that are valued by their communities and membership is not solely dependent upon ‘free’ journals – which could, in any event, be replaced by waiver of submission/publication fees in the society journal as an alternative incentive.
- There are also questions regarding whether an author pays system will favour some forms of research funding over others, to the extent that they support financing of the costs of publishing. However this balance will depend on the extent to which different sources of research funds (public or private sources) can be used to support the costs of author pays systems and whether there are anti-competitive restrictions built into such funding which unnecessarily favours different forms of publishing and hence sources of research funding.
- An author pays system shifts the costs of publishing, and may lead to organisations and countries that are major producers of scientific and technical knowledge paying more in author charges than they would for subscription fees in a reader pays system. In its submission to the UK House

of Commons Science and Technology Committee Inquiry into Scientific Publications, for example, Elsevier (2004) suggested that:

> *…while Britain's spending on journal subscriptions currently amounts to 3.3% of the world's total, UK researchers contribute a much higher 5% of all articles published globally. As a result, we estimate that the UK Government, foundations, universities and researchers could together pay 30-50% more for STM journals in an Open Access [publishing] system than they do today (Elsevier 2004, p2).*

- Similar concerns have been expressed by some leading research schools (Okerson 2004; Davis, *et al.* 2004, p20; etc.). Davis *et al.* (2004) suggested that author charges would need to be "very low" for Cornell to see any cost savings and that if average author publication charges were USD 1 500 per article, the library would require an infusion of almost USD 1.5 million per year. Such calculations depend upon the level of author fees assumed necessary to support the journals concerned – about which there is little agreement. Others have suggested that for leading US universities author pays would cost less. For example, Velterop (2003) suggested that, based on 2001 publications and serials budgets, and with articles charges of USD 500 per article, Cornell could save USD 3.65 million, Dartmouth USD 2.6 million, Princeton USD 3.4 million and Yale USD 4.6 million.

- Moreover, while there are major advantages with any open access system in terms of access to the journal literature for readers in developing countries, the concern shifts to their potential exclusion as authors. Obviously, access for authors from developing countries and less well funded organisations must be considered, with schemes required to facilitate participation which mirror those that have been established to enable reader access to the subscription literature (*e.g.* HINARI, INASP, etc.) (SQW 2004, p21; HCSTC 2004a).

- Another issue is that of the "free rider" (HCSTC 2004a). In fields where there is extensive application of research – such as medicine, engineering, computer science, management, etc. – many of the users (*i.e.* readers) do not contribute as authors. With a shift from reader pays subscriptions to author pays open access, these readers become free-riders. BioMed Central is one example where university-based researchers pay to be published, while their readers, many of whom are in the private sector (*e.g.* pharmaceutical firms), access the work free of charge, and apply its findings in their business and professional practices. This can adversely affect members of any group that is more highly represented among research authors than among research users. The reverse side of this argument relates to the public good nature of research findings and the maximisation of benefits through wide dissemination and commercialisation – with the "free-rider" a mechanism for the realisation of benefits.

Open access archives and repositories

Open access archives and repositories are the third major recent development in scholarly communication. Open access archives are typically subject or discipline based, offering open and free access to pre-print and/or post-print papers in a particular discipline or subject area. Open access repositories are typically institutionally based, offering the same level of open and free access to the work and outputs of particular institutions (*e.g.* universities or research institutes). Both rely upon authors and/or their employing institutions posting material to the archive/repository (*i.e.* "self-archiving").[18]

Subject-based open access archives have been available for a number of years.[19] Archives operate by authors submitting their work for inclusion, and may involve various levels of access control depending upon the particular archive. Some archives are subject to oversight by a group of experts associated with the establishment and operation of the archive (*e.g.* ArXiv). Archives can cater for both pre-prints

(*i.e.* articles that have been submitted for publication but not yet accepted) and post-prints (*i.e.* articles that have been accepted for publication and/or published), with the balance between pre-prints and post-prints depending upon the focus and policy of the individual archive.

Table 10. Examples of subject archives

Archive
AMS Directory of Mathematics Preprint and e-Print Servers
ArXiv.org (formerly the Los Alamos Physics Preprint Archive, now at Cornell)
ClinMedNetPrints (British Medical Journal)
CogPrints
Computing Research Repository (CoRR), Los Alamos
E-BioSci (EMBO)
E-LIS
Eprint
EUCLID (Cornell/SPARC - Mathematics)
PubMed Central
Social Science Research Network (SSRN)
RePEc (Research Papers in Economics)

Source: ALPSP (http://www.alpsp.org/htp_openarc.htm). Accessed June 2004.

Perhaps the leading and best known example is the Ginsparg Archive (arXiv.org), which is a pre-print and post-print service in the fields of physics, mathematics, non-linear science, computer science and quantitative biology. The contents of arXiv conform to Cornell University's academic standards, with an advisory board and subject experts overseeing its operation. arXiv was established in August 1991 and had received 283 513 submissions by 26 July 2004 (arXiv.org). Other examples include: CogPrints (cogprints.ecs.soton.ac.uk), E-BioSci (www.e-biosci.org), RePEC (repec.org), etc. (Table 10). In July 2004, there were 208 open access archives listed by eprints.org (http://archives.eprints.org/).

Institutional repositories are a somewhat more recent development. They operate in much the same way as subject archives, but they are associated with an organisation – such as a university or research institute, rather than a subject area or discipline. The UK House of Commons enquiry concluded that:

> *"institutional repositories have the potential greatly to increase the speed, reach and effectiveness of the dissemination of research findings: the Wellcome Trust noted that "the existence of a central archive could transform the market. Access to all UK publications would be possible and would act as a brake on excessive pricing". They would benefit authors, readers and institutions: authors would see their articles made available to a wider audience; readers would be able to access articles free of charge over the Internet; and institutions would benefit from having an online platform on which to display their funded research." (HCSTC 2004a, p58).*

Examples include the CERN Document Server (http://cds.cern.ch/), which late-2004 had over 650 000 bibliographic records, including 320 000 full text documents of interest to people working in particle physics and related areas. It covers pre-prints, articles, books, journals, photographs etc. (http://cds.cern.ch/) (Table 11). In the United Kingdom, around 60% of higher education institutions (*i.e.* SCONUL members) had or were developing institutional repositories in June 2004 (HCSTC 2004, p57). According to the 2004 PALS report there are over 200 Institutional Repositories in the world, mainly populated with unpublished material (HCSTC 2004b, p27).

Table 11. Examples of institutional repositories

Repositories
ANRO (Academic Research in the Netherlands Online)
Archive Electronique (Institut Jean Nicod)
Archivio E-prints (Università degli studi di Firenze)
ANU E-prints (Australian National University)
CERN Document Server
DARE Net (Netherlands – network of 17 institutional repositories)
CODA (Caltech)
Digital Library and Archives (Virginia Polytechnic Institute)
DSpace (MIT)
DSpace@Cambridge
Elderado (University of Dortmund)
Electronic Library (Aalborg University)
Electronic Documents (University of Maastricht)
Electronic Research Archive (Blekinge Institute of Technology)
ePrints@Bath (University of Bath)
eprint@iisc (Indian Institute of Science)
Eprint Archive (NUI Maynooth)
eScholarship (California Digital Library)
Glasgow ePrints Service
HofPrints (Hofstra University)
Knowledge Bank (Ohio State University)
KOPS-Datenbank (University of Konstanz)
LUFT (Lunds Universitet)
MILESS (University of Essen)
Nottingham ePrints (University of Nottingham)
Online Publications (University of Stuttgart)
Papyrus (University of Montreal)
Publications (Luleå University of Technology)
SHERPA (University of Nottingham, UK)

Sources: ALPSP http://www.alpsp.org/htp_openarc.htm and ARL http://www.arl.org/sparc/core/index.asp. Accessed June 2004.

Institutional repositories operate by voluntary or mandated deposit of the works of institutional employees either before publication (pre-print) or, more commonly, afterwards (post-print). While the population of repositories is problematic, their use is increasing. In a small survey, as many as 32% of physics researchers surveyed posted material to pre-print archives or repositories and 16% of physics, engineering and maths researchers posted material to post-print archives or repositories (Table 7 above, reported by Swan, 2003). The OAI searcher, OAIster, listed 3.4 million records from 327 institutions in early August 2004 (http://oaister.umdl.umich.edu/o/oaister/).

A crucial element for the success of repositories is the existence of metadata management and access standards ensuring harvestability, and the widespread availability of open source software systems for their operation and management. The Open Archives Initiative (OAI), which was developed to promote the use of standards that facilitate the dissemination of content, has played a major role.[20] There are now a number of OAI-compliant software systems available as freeware that enable open access through author and/or institutional archiving (*e.g.* EPrints, DSpace, CDSware, Fedora, etc.) (Buckholtz *et al*. 2003, p2; OSI 2004).

One important feature of institutional repositories is that they can host a range of objects, including pre-print and post-print articles *and* a range of other digital objects (*e.g.* monographs, reports, laboratory and field notes, data, analytical software, audio, video and image files, etc.). As the nature and practice of research evolves, with greater capabilities for automated data collection and increased emphasis on data manipulation, mining and analysis, the flexibility that institutional repositories provide in hosting and enabling the use of such digital objects is an important strength and is one of the ways in which they go

beyond traditional scientific publishing in the facilitation of both research and its dissemination. The UK government noted in its response to the House of Commons Science and Technology Committee Report on Scientific Publishing that "institutional or thematic repositories should provide a useful environment for disseminating such information and linking it to research results" (HCSTC 2004b, pp. 12-13). Open access repositories may also be better adapted to the needs of inter-disciplinary and collaborative research (Lynch 2003), and have the potential to readily integrate with e-science data repositories, thereby allowing dissemination to be built into the e-science infrastructure.

Open access archives and repositories (self-archiving) have the advantages of open access, maximising the dissemination of research findings and the economic and social benefits from R&D spending.[21] The posting of pre-prints increases the speed of dissemination over and above that achieved through either subscription-based or open access publishing models which are subject to the delays of the traditional journal peer review process. At the same time, various forms and levels of quality control and quality tagging can be implemented, ensuring that readers are aware of the quality criteria applied and the quality accreditation of particular digital objects in the archive.

Where there is institutional support or mandates, repositories can become a more complete record of science than traditional scientific publishing. There is a natural tendency for both researchers and editors to publish "success stories" rather than focus on a record of failed or inconclusive experiments. Were funders and/or institutions to require it, repositories could become a source of information about the findings from *all* projects and experiments undertaken. Such information could be valuable in the prevention of duplicative work and pursuit of "blind alleys" contributing to increasing efficiency of research, provided that there are efficient means of filing such information without overloading researchers and repositories.

Because of the availability of OAI standards and guidelines and a number of open source and/or freeware software systems for the establishment and operation of archives and repositories they may represent a relatively low cost alternative for providing access to research – although not for its accreditation. One submission to the UK House of Commons Inquiry into scientific publication suggested that the establishment of higher education institutional repositories in the UK could cost GBP 3 900 (USD 5 900) per institution, with annual operating costs of around GBP 31 300 (USD 47 000) (HCSTC 2004, p65).

Table 12. Advantages and disadvantages of open access archives and repositories

Advantages	Disadvantages
Access free and open to all, maximising the dissemination of research findings and thereby social welfare benefits from R&D spending. Speed of dissemination is greater than subscription-based or open access publishing. May help to overcome the publishing bias towards publication of successful findings. May contribute to the creation of a more complete record of scholarship (*e.g.* institutional repositories recording the institutions' entire output). Because of the availability of OAI standards and guidelines and a number of open source / freeware software systems archives and repositories could be a relatively low-cost alternative. Potential for repositories to integrate with e-science data repositories and a range of other forms of digital objects, and thereby provide enhanced support for collaborative and inter-disciplinary research. Potential to contribute to enhanced measurement, and greater quality and ease of research assessment at both institutional and/or individual levels.	Control over quality and posting may vary from archive to archive and institution to institution. Concern over the handling of copyright for archives/repositories and publishing (*e.g.* possible limitations on posting published material and potential IP conflicts). Potential lack of market segmentation for authors and access control over their works. Relatively low rates of posting to most institutional repositories to date (*i.e.* population issue).

Potential disadvantages and challenges remaining for the development and widespread adoption of open access archives and repositories have been discussed in the literature (Table 12). These include:

- Control over quality and posting, which is essential for the development of trust among readers and, perhaps, among authors. While neither archives nor repositories are typically peer-reviewed in the same way as scholarly journals, there are a variety of measures that can be taken to ensure a level of quality is maintained. Examples include the oversight of archive operations by an expert advisory board and control over institutional repository postings equivalent to that exercised over institutional presses and/or institutional working paper series, and various levels of internal and external peer review. This issue will also be addressed in the follow-up to the 2004 OECD Ministerial declaration on access to digital research data from public funding.
- The handling of copyright for archive/repository publishing, with freedom to post into an open access archive potentially limited by copyright agreements with some publishers – although it was recently reported that more than 80% of publishers currently allow self-archiving after publication (HCSTC 2004, p57).[22] A major issue is clarification of the respective intellectual property rights of researchers and their employers, and the development of standard licensing contracts by institutions or sectors (*e.g.* universities) in support of researcher interactions with publishers, archives and repositories (*e.g.* creative commons licensing).
- The level of posting to institutional repositories has been somewhat limited. This may simply be a matter of awareness and opportunity, critical mass and/or incentives for authors. Authors may be concerned about the possibility of pre-posting jeopardising their chances of publication, although this too may be more a matter of awareness. However authors have little incentive to

undertake extensive and time-consuming self-archiving while research evaluation remains linked almost exclusively to traditional publishing forms.

Databases and open access

One of the drivers for change has been the increasing collection of data and use of research databases. Such databases are having a profound effect on research practices and this issue in the context of publicly funded research is the focus of the follow-up to the 2004 OECD Science Ministerial "Declaration on Access to Research Data from Public Funding" (see Box 5). The US National Research Council (2001, p5) noted that:

> *The rapidly expanding availability of primary sources of data in digital form may be shifting the balance of research away from working with secondary sources such as scholarly publications. Researchers today struggle to extract meaning from these masses of data, because our techniques of searching, analyzing, interpreting, and certifying information remain primitive. New automated systems, and perhaps new intermediary institutions for searching and authenticating information, will develop to provide these services, much as libraries and scholarly publications served these roles in the past.*

There is widespread use of databases by researchers in many research fields (*e.g.* Education for Change *et al.* 2002; Friedlander 2002; Key Perspectives 2002; Houghton *et al.* 2003; Atkins *et al.* 2003; etc.). Research databases have also raised awareness of the substantial benefits generated by placing information in publicly available open access repositories (PLoS 2003, p3). As a result there have been a number of announcements focusing upon research databases and/or explicitly including them in open access initiatives (*e.g.* OECD in Box 5, US House of Representatives Committee on Appropriations/NIH, UK House of Commons Science and Technology Committee, Max Planck Institutes, etc.).

E-science and grid computing developments are leading to a "data deluge", as more sources of large-scale observational data emerge and the volume of scientific data collected is rapidly dwarfing anything in the past. Hey and Trefethen (2002, p3) noted that:

> *There are a relatively small number of centres around the world that act as major repositories of a variety of scientific data. Bioinformatics, with its development of gene and protein archives, is an obvious example. The Sanger Centre at Hinxton near Cambridge currently hosts 20 Terabytes of key genomic data and has a cumulative installed processing power... of around ½ Teraflop/s. Sanger estimate that genome sequence data is increasing at a rate of 4 times each year and that the associated computer power required to analyse this data will 'only' increase at a rate of 2 times per year... A different data/computing paradigm is apparent for the particle physics and astronomy communities. In the next decade we will see new experimental facilities coming online that will generate data sets ranging in size from 100's of Terabytes to 10's of Petabytes per year. Such enormous volumes of data exceed the largest commercial databases currently available by one or two orders of magnitude. Particle physicists are energetically assisting in building Grid middleware that will not only allow them to distribute this data amongst the 100 or so sites and 1 000 or so physicists collaborating in each experiment, but also will allow them to perform sophisticated distributed analysis, computation and visualisation on all or subsets of the data. Particle physicists envisage a data/computing model with a hierarchy of data centers with associated computing resources distributed around the global collaboration.*

This sort of e-science requires a network of data repositories to house, make available and provide a permanent archive of these mass of data. To date, digital libraries have focused upon the storage of text, audio and video. The scientific digital libraries that are being created by global, collaborative e-science

experiments will need the same sort of facilities as conventional digital libraries (*i.e.* a set of services for manipulation, management, discovery and presentation) (Hey and Trefethen 2002, p11).

Box 5. 2004 OECD Science Ministerial "Declaration on Access to Research Data from Public Funding"

On 30 January 2004, 34 governments[23] declared their commitment to:

"work towards the establishment of access regimes for digital research data from public funding in accordance with the following objectives and principles:

Openness: balancing the interests of open access to data to increase the quality and efficiency of research and innovation with the need for restriction of access in some instances to protect social, scientific and economic interests.

Transparency: making information on data-producing organisations, documentation on the data they produce and specifications of conditions attached to the use of these data, available and accessible internationally.

Legal conformity: paying due attention, in the design of access regimes for digital research data, to national legal requirements concerning national security, privacy and trade secrets.

Formal responsibility: promoting explicit, formal institutional rules on the responsibilities of the various parties involved in data-related activities pertaining to authorship, producer credits, ownership, usage restrictions, financial arrangements, ethical rules, licensing terms, and liability.

Professionalism: building institutional rules for the management of digital research data based on the relevant professional standards and values embodied in the codes of conduct of the scientific communities involved.

Protection of intellectual property: describing ways to obtain open access under the different legal regimes of copyright or other intellectual property law applicable to databases as well as trade secrets.

Interoperability: paying due attention to the relevant international standard requirements for use in multiple ways, in co-operation with other international organisations.

Quality and security: describing good practices for methods, techniques and instruments employed in the collection, dissemination and accessible archiving of data to enable quality control by peer review and other means of safeguarding authenticity, originality, integrity, security and establishing liability.

Efficiency: promoting further cost effectiveness within the global science system by describing good practices in data management and specialised support services.

Accountability: evaluating the performance of data access regimes to maximise the support for open access among the scientific community and society at large.

Seek transparency in regulations and policies related to information, computer and communications services affecting international flows of data for research, and reducing unnecessary barriers to the international exchange of these data;
Take the necessary steps to strengthen existing instruments and – where appropriate – create within the framework of international and national law, new mechanisms and practices supporting international collaboration in access to digital research data;
Support OECD initiatives to promote the development and harmonisation of approaches by governments adhering to this Declaration aimed at maximising the accessibility of digital research data;
Consider the possible implications for other countries, including developing countries and economies in transition, when dealing with issues of access to digital research data.
Invite the OECD: To develop a set of OECD guidelines based on commonly agreed principles to facilitate optimal cost-effective access to digital research data from public funding"

Source: Meeting of the OECD Committee for Scientific and Technological Policy at Ministerial Level, 29-30 January 2004, Final Communiqué, Annex 1. Available at: http://www.oecd.org/document/15/0,2340,en_2649_33703_25998799_1_1_1_1,00.html

There is a great deal of activity in relation to access to scientific data and making the data and materials relating to publications accessible to others, in order to enable confirmation of findings and

others to build upon those findings, mine data and create new knowledge – rather than waste time duplicating and replicating. Many initiatives seek to establish standards of practice and then implement supporting infrastructures. For example, a recent US National Academy of Sciences committee suggested that: "standards for sharing publication-related data and materials should flow from the general principle that the publication of scientific data is intended to move science forward." (Board of Life Sciences, 2003, p4). The committee went on to say that:

> *The purpose of using publicly accessible data repositories is a practical one – to expedite scientific progress and provide access to data in a manner that allows others to build on it. By their nature, these repositories help define consistent policies of data format and content, as well as accessibility to the scientific community. The pooling of data into a common format is not only for the purpose of consistency and accessibility. It also allows investigators to manipulate and compare datasets, synthesize new datasets, and gain novel insights that advance science* (Board of Life Sciences, 2003, p6).

There is clear potential, and a need, to integrate these with subject archives and institutional repositories in such a way as to maximise the benefits of digital content and make the whole seamlessly available to all researchers that can benefit from its access and use.

Work on access regimes to digital research data is being pursued by OECD countries and at the OECD and detailed discussion of these issues is not undertaken here (Box 5). However issues of access to data and other research outputs are parallel and related to access to scientific publications.

Discussion

Going online changes the distribution and form of costs – reducing distribution costs to near zero and increasing the share of fixed costs in total costs. Such radical changes in cost structures may affect business models, who should pay and how, and in the current period of experimentation multiple publishing models operate simultaneously. This raises such questions as whether one model will prove superior, will alternative models (including current models) survive together, will the future involve a greater variety of mixed models, and will developing hybrid models prove to be better? The remainder of this section examines these questions.

Alternative publishing business models are continuing to compete for content and readers. Many commercial and society publishers are maintaining the subscription-based model of journal publication, while others are moving partially or wholly to open access publishing including models supported by author charges, delayed open access, authors' choice and/or open access archives and repositories.

Will authors prefer to submit papers to subscription journals without author fees, rather than pay for publication in author pays journals? This depends upon:

- Author perceptions about quality and the relative merits and reputations of the respective journals – with competition between them based on quality *and* price.
- Possible differences between citation and impact factors of subscription and open access journals – with some evidence that open access may increase citation and may, over time, increase the impact factor standing of open access journals over their subscription-based rivals.
- Whether authors' employers and/or funders will provide funding support for author pays publishing, and how readily publishers will waive fees in cases of hardship.
- The transparency of price signals to authors and how author charges are paid – with funding agencies and institutional employers masking the price from authors, and some open access

publishers adopting price masking strategies that reduce the impact of author charges upon authors (*e.g.* BioMed Central's institutional membership scheme).

- Author perceptions about alternatives – with separation of publication and dissemination, authors may prefer to post material to open access archives and repositories for dissemination purposes and treat publication as evaluation, making journal reputation and quality peer review more important than whether the journal is open access or subscription-based.

Are publishers of open access journals in the variant that is supported by author charges vulnerable to competition from open access archives and repositories? This will depend primarily upon the importance of quality control through peer review, both for readers and in evaluation. Peer reviewed journals will survive until there are viable and respected alternatives – be they quality controlled archives and repositories, reader commentary and feedback or other alternatives. Are publishers of subscription-based journals vulnerable to competition from open access archives and repositories? This will also depend primarily upon the importance of quality control through peer review, and it would appear that peer reviewed journals of any type can survive until there are viable and respected alternatives. Hence, in the short-term, a mix of business models may persist.

What is the future for hybrid models? There are various hybrid forms that have and may emerge, in which costs are recouped through various charges, *e.g*. a multi-part tariff. A multi-part tariff model has advantages, but its complexity and likely consumer resistance must also be considered. In a multi-part tariff model, journal and/or article production costs could be distributed across:

- Submission charges on a per article or per page basis – to cover the costs of peer review.
- Publication charges on a per article or per page basis – to cover the costs of copy-editing, manuscript processing and mounting in an electronic database.
- Subscription charges levied on readers – for access to the content and/or the supporting infrastructure.
- Pay-per-view charges levied for downloads – for access to the content actually downloaded.
- Pay-per-use charges – based on citation tracking or an honesty system, such as that used for shareware software.
- Advertising revenue – which may increase with greater dissemination through open access, or decrease due to increased disassociation of articles from journal titles.
- Institutional support – such as support by learned societies for dissemination, which might be derived from membership fees and might support either lower subscription charges or lower author charges for members.

Economically, a two-part tariff for author fees may make sense,[24] with fees levied for submission *and* publication serving to reduce the tendency for multiple and speculative submission of papers for publication, and enabling journals to cover the cost of quality through support for higher rejection rates. Such a model might also serve to increase revenue certainty for publishers of open access author pays variant journals and, by reducing the cost of publication in them, enable them better to compete for authors with subscription-based journals. However, user resistance would be a strong possibility compared with simpler author pays models.

Another hybrid model involves segmentation of a journal into subscription and open access on an article-by-article basis, according to the author's preference and willingness/ability to pay. Such a model has been adopted by a number of journals (*e.g. Physiological Genomics*, published by the American

Physiological Society, *Development*, *Journal of Cell Science* and the *Journal of Experimental Biology* published by the Company of Biologists, and *Pediatrics* published by the American Academy of Pediatrics (PLoS 2003, p7; Prosser 2003)). Such a model may be a useful way for a journal title to migrate from a subscription model to an open access model over time, with the pace and direction of change dictated by author preferences. A variation on this theme is the Springer "Open Choice" policy covering all Springer journals, with subscription charges based on the proportion of open access author pays content in the previous year (www.springeronline.com).[25] A similar "Open Choice" policy was introduced for *TheScientificWorldJOURNAL* by Infotrieve (Allen and Lees 2004). Time-delayed open access mixed with an author pays option is being tried by *PNAS* (Cozzarelli 2004), while perhaps the simplest and to date most common hybrid is that of delayed open access, with subscribers getting a privileged access period (*e.g.* six months or a year) before the issue becomes open access. Such a system has the advantages of building on existing publisher and hosting infrastructure, but introduces an access delay.

FUTURE VALUE CHAINS AND BUSINESS MODELS

This section analyses possible longer-term futures, emerging activities and tools. It focuses on future publishing value chains and business models, disintermediation and the possible roles of new intermediaries.

A recent US National Research Council symposium identified a number of trends in commercial STM journal publishing, including: bundling of publications by major publishers in "Big Deals"; the consolidation of publishers and the targeting of downstream and vulnerable competitors (secondary publishers and subscription agencies); diversification of the customer base to more business clients (and a concomitant emphasis on applied research and engineering journals); and market responses to open-access trends, including the creation of meta-content (*e.g.* documentation and search engines for the open-content resources) and a shift to Web services (*e.g.* substitutes for the publication of fixed content in print by providing online software, processing, and services for users) (CESTMJP 2004, p2).

It concluded that: "on the one hand, commercial (and professional society) publishers clearly add considerable value to the process of formal scientific communication, and the viability of the author-pays, PLoS type of open-access model is still untested and its future success uncertain. On the other hand, the restricted, subscription-based model clearly has great inherent social costs in comparison with the immediate, free access by any and all users of the information worldwide that the open-access publishing model makes possible." (CESTMJP 2004, p3).

Open access archives and repositories, particularly institutional repositories, may have some advantages over more traditional forms of scholarly communication. The capacity of institutional repositories to: cater for a greater range of digital objects; link into and integrate with e-science databases and data repositories, thereby offering greater support for collaborative, interdisciplinary research; provide a showcase for the intellectual output of the institution; support institutional e-learning and the needs of lifelong learners; and support open access to research findings, offer significant advantages. However, they cannot replace journal and monograph publishing at present, because of the central role it plays in peer review quality control and research evaluation.

In the immediate future there is likely to be a period of experimentation around the various versions of open access publishing, with the emergence of a range of hybrids based around mixes of open and subscription-based access. There is likely to be an unbundling of the elements, new combinations and more transparency in relation to the costs involved, potentially facilitating increased economic efficiency through a better matching of costs and benefits. In the longer term, emerging possibilities may gradually replace some of the objects and activities that have been central to scientific publishing. There are many developments in scholarly communication and research practice emerging from increased use of ICTs and the Internet for research, research communication and publishing that may enhance and/or eventually replace current practices, current objects and activities. The following short examples demonstrate some emerging possibilities.

The most central object in scholarly publishing has been the *journal*. For authors the journal title is a brand, built upon quality control, prestige of editorial affiliations, citation and impact factors. For readers, however, the availability of online journal databases and the tendency to search on line for authors or by keywords mean that readers are now accessing articles independently of journal titles and the journal may

become somewhat less important as a result. The journal has also played non-publishing roles by forming the basis for networks of scholars where the editor forms a focal point around which the editorial board, regular reviewers, contributors and readers orbit. Such networks have been extremely important (Houghton *et al*. 2003). Journals have also provided fora for ongoing discussion of particular topics (SQW 2003). However, there are now alternatives developing based upon emerging ICT applications – such as discussion groups, Web logs, etc. Friedlander and Bessette (2003, p9) observed that the nature and role of scholarly journals are changing, and Smith (2000) suggested that with the development of the Web, journals no longer form the primary communication medium. For most of the roles traditionally played by the journal alternatives are emerging and are being used, albeit, to date, in rather experimental ways.

Few activities in scholarly publishing are more central than *peer review*, but here too there are changes underway. There is some concern that peer review is not working well, especially for multi-disciplinary or trans-disciplinary research (Odlyzko 2002; Jefferson *et al.* 2003; Peek 2003). More importantly, in the increasingly multi-disciplinary, multi-site, collaborative world of research both the value of, and necessity for, peer review may decline. Whereas in the past an individual scholar might report findings, it is now increasingly the case that reports of research findings reflect the collaborative work of a number of scholars, institutional and stakeholder interests. By implication at least, they have all seen, vetted and, in some senses, peer reviewed the material. Moreover, as primary data are more widely available via open access databases and papers more commonly include direct links to accessible data elements, reported findings are more readily replicable and checkable. There are also new, technology-based alternatives to peer review emerging, such as online commentary and reader reviews, threaded discussion (Nadasdy 1997; Varian 1998; Singer 2000), as well as procedures for, and controls over posting to archives and repositories – such as institutional affiliation and status, or what Kling *et al.* (2002) referred to as Guild Publishing and the substitution of peer review by "career review".

Box 6. The relationship between research practice and research evaluation

Most researchers want the ability to cite across any and all scholarly domains and link from any citation found on the Web to the full article or the full data set on the open Web. That is what open access is all about; we would like to be able to use the Web as one large open library for us to share with one another. Open-access electronic journals are not likely to completely replace the commercial scientific literature, but open-access literature has a potential major role to play. Most researchers realize the benefits of having access and freely available access to one another's works.

The secret to open access, according to Peter Suber, is to keep control in the hands of those who most want open access—the authoring scholars. How do we keep control in the hands of the authoring scholars? How do we affect the decision making of individual scholars so that they retain power over their articles? There are several practical actions that can be taken to change the reward system. We should, for instance, consider changing the policies of funding agencies. These policies should encourage researchers to report in their grant applications only those articles and data sets that are in open-access archives. It does little good for a reviewer to assess another scholar's work or research proposals unless the reviewer has access to all the relevant significant works created by that other scientist. The current system of limited access for scientists in other than the wealthiest of institutions supports lost opportunities in advancing the progress of science.

We should be changing promotion and tenure policies. Peer-reviewed data sets and articles placed in open archives are much more valuable to society, and therefore ought to be recognized as such. The work of university scientists should be available to the world and not just to a small population of economically privileged scientists. We should also change university intellectual property policies. Formal university policies should encourage professors and researchers to use open-access licenses and should give them full authority to use such licenses for their intellectual property. Finally, we should identify within each of our disciplinary domains those journals willing to accept open access licenses and those that are not. We should identify those journals allowing authors to post final journal articles on the Web and those that are not. The goal is that the reward system will eventually benefit economically those that follow open-access approaches.

Source: Onsrud, H. (2004), 'Overview of Open-Access and Public-Commons Initiatives in the United States,' in Esanu, J.M. and P.F. Uhlir (eds.) (2004), *Open Access and the Public Domain in Digital Data and Information for Science: Proceedings of an International Symposium*, U.S. National Committee for CODATA, National Research Council, National Academy Press, Washington DC, p118.

This suggests that roles may be changing and the evolution of the scholarly communication and publishing system may involve the dissolution of existing and emergence of new combinations of objects, activities and responsibilities. This could involve for example, the rise of open access subject archives and institutional repositories populated by free-standing digital objects of all kinds, with quality control based around career review, online user commentary and more formalised but diffuse review processes, and impacts measured as hits, downloads, citations and links, which reflect use by both readers and other authors and the impact of the work more fully than do citations alone (for one view on developments see Onsrud in Box 6). Such a reconfiguration of objects and activities would likely provoke adjustment of stakeholder responsibilities (Owen 2002) – such as, for example, large commercial publishing firms shifting their emphasis from content/copyright-based publishing to value adding activities built around open access objects (*e.g.* harvesting content from open access archives and repositories, packaging and adding value through the addition of abstracting and indexing and a range of powerful searching, linking, interrogation, access and usage reporting functions). For publishers, this may also involve the development of products and services that increase value for targeted vertical markets (Akie, *et al*. 2004).

Whatever the future holds, any new system must take account of: the roles of existing stakeholders, objects and activities; the emerging and changing needs of researchers and the impacts of e-science and the related "data deluge"; the emerging opportunities afforded by rapidly developing information and communication technologies and applications; and the underlying economic characteristics of information in its various forms.

CHALLENGES AND POLICY CONSIDERATIONS

Developments in digitisation and digital delivery in scientific publishing are shaping new policy considerations and directions, and there is widespread interest in realising the benefits of digital delivery and maximising returns on investments in R&D through enhanced access to research findings. The many recent government and institutional initiatives to increase access to the scientific literature and research databases are examples of this heightened interest (see Annex I for a brief review of recent initiatives).

There is a wide range of commercial, not-for-profit and public sector organisations involved in the production, dissemination and use of scientific publications. There are established practices, businesses and business models, and publishers have been quick to adopt digital delivery and adapt their business models as ICT related developments have opened new opportunities. However, the issues are broader. They involve new expectations of research, increased focus on accountability for R&D expenditures, increased awareness of the importance of knowledge creation and distribution, and the emergence of broader ICT related opportunities (*e.g.* e-science). Research and innovation are undergoing radical reassessment and becoming central to public policy in knowledge-based economies, increasingly focusing on improving knowledge transfer and supporting innovation and commercialisation. The key issue is not reform of scientific publishing *per se*, but whether there are new opportunities to develop systems that better serve research, its funders and users, better integrate all the actors and activities within innovation systems and, thereby, increase returns to investment in R&D and enhance the innovative capacity of our economies.

Areas where governments and other stakeholders can contribute to improve access and dissemination of research findings cover the general framework for research, diffusion of research results and skills development. More specifically for scientific publishing and publications, they cover development of infrastructures, improved information and analysis, removal of specific barriers to digital content supply and use and standards and interoperability issues.

- *Research funding*. Public funding and funding agencies (including private agencies) are very important in R&D and related activities that generate research data, databases and scientific publications. Access to public and government-funded research content is a crucial issue, and there is considerable potential for governments to provide a lead in enabling digital delivery and enhanced access to publicly funded scientific and technical information. The principle is to enable maximum access to findings from publicly funded research to maximise social returns on public investments. This general approach is captured in the "Declaration on Access to Research Data from Public Funding" by the OECD Science Ministers in January 2004, which recognised "that open access to, and unrestricted use of, data promotes scientific progress and facilitates the training of researchers" and "will maximise the value derived from public investments in data collection efforts", and entrusted the OECD to work towards the establishment of access regimes for digital research data from public funding.[2]

[2] Meeting of the OECD Committee for Scientific and Technological Policy at Ministerial Level, 29-30 January 2004 Final Communiqué. Ministers "emphasised the importance of ensuring the long term sustainability of the research enterprise and the need to involve civil society and business more effectively in the governance of public research". They concluded that "Coordinated efforts at national and international levels are needed to broaden access to data from publicly funded research and contribute to the advancement of scientific research and innovation. To this effect Ministers adopted a Declaration entrusting the OECD to work towards commonly agreed Principles and Guidelines on Access to Research Data from Public Funding". Final Communiqué available at: http://www.oecd.org/document/15/0,2340,en_2649_33703_25998799_1_1_1_1,00.html

- *Research evaluation*. Funding agencies (public and private) set ground rules for research evaluation as well as being major funders of research. They can play important roles in digital research content development and dissemination by: encouraging research evaluation that is neutral across different forms of publishing, while maintaining or raising quality; developing new ways of measuring the significance and use of open access archives and repositories to improve research evaluation by funding organisations, research suppliers and users; working with other institutions and researchers to respond to new challenges in disseminating research results in new media (SQW 2003; p30); and contributing to a climate that promotes diversity of public and private sector sources for information, in order to enhance access to scientific and technical information.

- *Skills*. Governments play a role in ensuring that there are the necessary education and training programmes for basic ICT skills and advanced skills, although full-time education is not currently the main source of specialist ICT skills. Given rapid changes in technologies and skill needs new strategies, partnerships and programmes may be needed focusing on the ICT and related business skills necessary to support sustainable digital delivery and the development of new business models that enhance access.

- *Infrastructure*. Various publicly funded programmes support the development of hard and soft infrastructures that enable digital delivery and enhance access, including data bases, archive and preservation initiatives, and various kinds of legal deposit requirements.

- *Information*. High quality, independent information and analysis are crucial in rapidly evolving digital content applications. Industry associations, learned societies and publicly funded specialised research and dissemination agencies can provide information on new developments in scientific digital content publishing, and the supply, purchase and use of online content (*e.g.* support for case studies, research into emerging business models, and dissemination of information to the providers of research results and the purchasers and users of this information).

- *Technology neutrality*. Digital delivery and access can be enhanced by removing barriers and disincentives to use by minimising regulatory differences between digital content and other forms of content. These include regulatory impediments or differences in treatment of physical/print and online/digital alternatives (*e.g.* different taxation treatment of print and electronic content to the extent that the products are the same). Similarly, research evaluation systems may need to ensure that there is equal treatment of equivalent research outputs in various forms.

- *Standards and interoperability*. Standard-setting bodies play an important role in ensuring the framework for dialogue and co-operation in setting new standards and ensuring interoperability to the extent possible among new technologies. Governments help set the supportive frameworks necessary for cross-industry co-operation among standards developers and users. Specifically they can encourage co-operation within the publishing industry on interoperability across access systems and platforms; encourage co-operation among publishers, research libraries and users more generally to facilitate development of business models that suit all parties; and work with industry and professional associations to ensure that all stakeholders are appropriately involved in new developments.

A combination of these informing, enabling and facilitating initiatives can support continued development of sustainable digital delivery business models that enhance access to scientific and technical information, improve the efficiency of research and increase returns on the very substantial public investments in R&D.

ANNEX TABLES

Table A1. Number of book publishers by country, June 2004

Country	Publishers
Australia	489
Austria	202
Belgium	178
Canada	281
Czech Republic	100
Denmark	104
Finland	56
France	629
Germany	1 487
Greece	132
Hungary	69
Iceland	28
Ireland	86
Italy	587
Japan	243
Luxembourg	26
Mexico	151
Netherlands	204
New Zealand	118
Norway	49
Poland	84
Portugal	134
Korea	117
Slovakia	31
Spain	518
Sweden	125
Switzerland	359
Turkey	52
United Kingdom	1 147
United States	2 989
OECD Total	10 775
Worldwide	13 574

Source: Literary Marketplace (literarymarketplace.com).

Table A2. ICT adoption in media and publishing in Europe, mid-2002
(percentage of enterprises)

	Computer usage	Internet access	E-mail usage	WWW usage	Intranet usage	Extranet usage	EDI usage	Web site
	all enterprises	*all enterprises*	*all enterprises*	*all enterprises*	*all enterprises*	*all enterprises*	*all enterprises*	*all enterprises*
Total	98.9	95.2	93.7	87.6	34.6	10.1	13.2	59.6
0-49	98.8	95.1	93.6	87.4	33.8	9.6	12.8	58.9
50-249	100.0	98.7	98.7	98.2	63.8	29.4	28.2	87.7
250+	100.0	100.0	98.8	99.3	88.9	43.1	36.7	95.5
EU-4	98.7	94.7	93.6	88.1	34.4	8.8	12.4	61.0
Germany	98.4	98.4	96.8	92.1	38.2	7.6	9.3	66.5
Greece	97.0	90.9	90.9	67.3	30.9	4.4	20.1	49.2
Spain	100.0	98.4	95.1	85.2	40.3	21.8	18.6	48.7
France	98.4	95.1	90.2	85.4	34.3	15.8	20.3	50.9
Italy	100.0	97.1	97.1	81.6	39.0	7.6	5.8	61.8
Netherlands	100.0	97.1	94.1	95.6	23.3	5.3	9.9	68.7
UK	98.4	91.8	91.8	90.1	30.6	7.1	13.7	62.0

Source: E-Business Watch (2002), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/I, October 2002, European Commission, Brussels; and E-Business Watch (2003), *ICT & e-business in the Media and Printing Industries*, Sector Report 8/II, May 2003, European Commission, Brussels.

Table A3. Production costs: for published research articles
(USD)

	Per page costs USD	Per article costs USD (11-page article)	Per issue costs (110-page book)
Pre-editing macro	0.90	10.00	100.00
Copy editing	20.00	220.00	2 200.00
Figure preparation	13.65	150.00	1 500.00
Layout	16.00 (text)	176.00	1 760.00
	+12.50 (per graphics)	+138.00 (per article)	+1 380.00 (per issue)
Proofs/correction	4.75	52.25	522.50
XML Mark-Up	3.25	35.75	357.50
PDF creation	1.50	16.50	165.00
Figure conversion to JPEG	1.60	17.50	175.00
XML upload/QC	3.75	41.25	412.50
Deposit to CrossRef/PMC	1.15	12.50	125.00
TOTAL	74.05	869.75	8 697.50
TOTAL (including electronic manuscript processing)		1 069.75	10 697.50

Source: PLoS (2004), *Publishing Open-Access Journals*, Public Library of Science, White Paper February 2004, p12. Available at: http://www.plos.org/downloads/oa_whitepaper.pdf accessed June 2004.

Table A4. Top 20 countries by journal paper publication
(ranked by number of papers published January 1992 to 30 June 2002)

Country	Papers	Citations	Citations per paper
USA	2 618 154	30 765 049	11.75
Japan	672 308	4 591 831	6.83
Germany	619 323	5 186 228	8.37
England	570 667	5 628 105	9.86
France	459 963	3 777 753	8.21
Canada	346 126	3 259 935	9.42
Italy	288 763	2 245 050	7.77
Russia	255 548	665 442	2.6
Australia	198 006	1 523 844	7.7
China	193 691	494 157	2.55
Spain	191 422	1 200 295	6.27
Netherlands	184 526	1 908 540	10.34
India	168 561	471 413	2.8
Sweden	144 425	1 446 651	10.02
Switzerland	129 785	1 585 691	12.22
Belgium	92 266	825 768	8.95
Korea	90 907	308 063	3.39
Israel	90 514	749 527	8.28
Scotland	88 836	873 438	9.83
Poland	85 445	359 420	4.21

Source: ISI Essential Science Indicators℠ Web product. Accessed June 2004.

ANNEX I. RECENT ACCESS INITIATIVES

Scientific publishing has seen rapid development in recent years as a result of the opportunities offered by digital delivery and online access to scholarly literature and scientific databases. Changes in the underlying economics of publishing, new business models and access possibilities and their interaction with changing research practices and information needs are analysed in the body of the text above. In parallel, there have been a large number of studies and statements describing and fostering new access initiatives designed to widen access to research results. Recent initiatives in chronological order include:

- In 2001, Canada's National Research Council began offering open access to 14 journals published through the NRC Research Press, supported by government funds (http://dsp-psd.pwgsc.gc.ca/INFODEP/Avis/00/0107-e.html).

- In late 2001, the Open Society Institute held a meeting in Budapest seeking to accelerate progress in the international effort to make research articles in all academic fields freely available on the Internet. The *Budapest Open Access Initiative* was released in February 2002, and by mid-2004 had gained 3 669 signatories supporting open access and endorsing author self-archiving of pre-prints and/or post-prints in open access archives and repositories, and the founding of new open access journals supported by author charges or other methods (http://www.soros.org/openaccess/index.shtml).

- In December 2002, the Howard Hughes Medical Institute made a commitment to cover open-access publication fees for its researchers as a part of their research funding (www.plos.org/news/PLoS_Moore_PressRelease_17Dec2002.pdf).

- In mid 2003, the *Bethesda Statement on Open Access Publishing* emerged from meetings of relevant parties – including the organisations that foster and support scientific research, the scientists that generate the research results, the publishers who facilitate the peer-review and distribution of the results of research, and the scientists, librarians and others who depend upon access to this knowledge. It endorsed the principles of open access and sought to promote the rapid and efficient transition to open access publishing (http://www.earlham.edu/~peters/fos/bethesda.htm).

- In June 2003, the *Public Access to Science Act* was introduced in the US House of Representatives with the aim of amending US copyright law so that research substantially funded by the US federal government cannot also be copyrighted, thereby ensuring its free availability to the public (http://www.biomedcentral.com/openaccess/archive/?page=features&issue=3).

- In October 2003, the Wellcome Trust issued a statement in support of open access in which researchers funded by the Wellcome Trust were encouraged to use open access dissemination, with any associated costs met by the Trust (http://www.wellcome.ac.uk/en/1/awtvispolpub.html).

- Late in October 2003, Germany's Max Planck Society, France's *Centre National de la Recherché Scientifique*, and other major European research institutes and funders endorsed open access in the *Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities*, by: encouraging researchers/grant recipients to publish their work according to the principles of the

open access paradigm; encouraging the holders of cultural heritage to support open access by providing their resources on the Internet; developing means and ways to evaluate open access contributions and online journals in order to maintain the standards of quality assurance and good scientific practice; advocating that open access publication be recognised in promotion and tenure evaluation; and advocating the intrinsic merit of contributions to an open access infrastructure by software tool development, content provision, metadata creation, or the publication of individual articles (http://www.zim.mpg.de/openaccess-berlin/berlindeclaration.html).

- In December 2003, the UK's Joint Information Systems Committee (JISC) announced its support for open access and the provision of funding to help journal publishers make the transition to open access (http://www.jisc.ac.uk/index.cfm?name=pr_open_access_news_051203).

- In December 2003, the United Nations' World Summit on the Information Society (WSIS) Declaration included, *inter alia*, support for both open source and open access initiatives. It committed to promoting universal access with equal opportunities for all to scientific knowledge and the creation and dissemination of scientific and technical information, including open access initiatives for scientific publishing (http://www.itu.int/wsis/documents/doc_single-en-1161.asp).

- In January 2004, the Meeting of the OECD Committee for Scientific and Technological Policy at Ministerial Level issued a statement saying that: Ministers recognised that fostering broader, open access to and wide use of research data would enhance the quality and productivity of science systems worldwide. They adopted a "Declaration on Access to Research Data from Public Funding" (see Box 5 and http://www.oecd.org/document/ 0,2340,en_2649_34487_25998799_1_1_1_1,00.html).

- In February 2004, the Governing Board of the International Federation of Library Associations (IFLA) adopted a *Statement on Open Access to Scholarly Literature and Research Documentation*, in which it supported collaborative initiatives to develop sustainable open access publishing models (http://www.ifla.org/V/cdoc/open-access04.html).

- In June 2004, the European Commission launched a study on the economic and technical evolution of the scientific publication markets in Europe, with the objective of determining the conditions required for optimum operation of the sector and assessing the extent to which the Commission can help to meet those conditions. The study was planned to deal with the current public debate, such as the future of printed scientific reviews, the risks associated with increases in the price of publications for access to information for researchers, open access to research findings for all and the need to reconcile authors' rights and the economic interests of publishers (http://europa.eu.int/rapid/pressReleasesAction.do?reference=IP/04/747&format=HTML&aged=0&language=EN&guiLanguage=en).

- In July 2004, a US House of Representatives committee recommended that the National Institutes of Health (NIH) provide free access to all funded research and asked the NIH to submit a plan by 1 December 2004 for the implementation of this new policy in fiscal year 2005. The committee's report recommended that NIH deposit the final manuscript and any supplemental materials from NIH-funded research with PubMed Central six months after publication, or if publishing costs are covered by NIH funds the research should be available immediately upon publication. In February 2005 the NIH issued its policy on enhancing public access to archived publications resulting from NIH-funded research. Beginning 2 May 2005, NIH-funded investigators are requested to submit to the NIH National Library of Medicine's (NLM) PubMed Central (PMC) an electronic version of the author's final manuscript upon acceptance for publication, resulting from

research supported, in whole or in part, with direct costs from the NIH (http://www.nih.gov/about/publicaccess/index.htm).

- In July 2004, the UK House of Commons Science and Technology Committee recommended that: all UK higher education institutions establish institutional repositories on which their published output can be stored and from which it can be read, free of charge, on line; and that Research Councils and other Government funders mandate their funded researchers to deposit a copy of all their articles in this way (http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/399/39903).

- In October 2004, the Scottish Science Information Strategy Working Group launched the *Scottish Declaration on Open Access*, and endorsed the general principles of open access (http://scurl.ac.uk/WG/SSISWGOA/declaration.htm).[26]

Funding agencies that explicitly allow the direct use of their grants to cover article processing charges to enable open access include: Canadian Institutes of Health Research, Cancer Research UK, Deutsche Forschungsgemeinschaft (German Academic Research Council), Fonds zur Forderung der wissenschaftlichen Forschung (Austrian Science Foundation), Health Research Board, Howard Hughes Medical Institute, International Human Frontier Science Program Organization, Israel Science Foundation, National Health Service (UK), National Institutes of Health (US), National Science Foundation (US), Rockefeller Foundation, Swiss National Science Foundation, and the Wellcome Trust. The UK Medical Research Council expects article processing charges to be payable via institutional funds to which it contributes (Key Perspectives 2004, pp14-15).

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NOTES

1 The June 2004 panel is summarised in OECD (2004), *Digital Broadband Content, Panel and government session*, DSTI/ICCP/IE(2004)15/FINAL, www.oecd.org/dataoecd/53/39/34579763.pdf.

2 This study was researched and written in 2004 and was up-to-date as of November 2004. It was revised and updated in February and May 2005 to take comments into account, but has not been comprehensively updated.

3 Some of the content and underlying materials in scientific publishing are in the public domain, limiting the scope for authors or publishers to enforce exclusions.

4 The 25 countries were: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, India, Ireland, Italy, Japan, Netherlands, Norway, Poland, Portugal, Russia, Slovak Republic, South Africa, Spain, Sweden, Switzerland, the United Kingdom, and the United States. See Accenture (2001) *The Unexpected eEurope: The surprising success of European eCommerce*, Accenture. Available www.accenture.com/eEurope2001 accessed January 2003. The survey was conducted June and July 2001.

5 The *Global E-commerce Survey 2002* covered 10 countries: the United States, Mexico, Brazil, Denmark, France, Germany, Taiwan, Singapore, China and Japan, and involved 2 139 companies. Sector coverage included manufacturing, wholesale and retail, and banking and finance. Wholesale and retail distribution included SICs 50-54, 56-57 and 59. See http://www.crito.uci.edu/2/prGEC3.asp accessed May 2004.

6 Includes North American online book sales by Barnes & Noble / B. Dalton, Borders / Waldenbooks, Amazon and BN.com.

7 In July 2004, EBSCO's e-journals list included 10 624 online journals from 862 publishers (http://ejournals.ebsco.com/info/ejsTitles.asp); Elektronische Zeitschriftenbibliothek (Electronic Journals Library) listed 19 573 titles, including 2 197 online-only journals (http://rzblx1.uni-regensburg.de/ezeit/); and NewJour listed 14 442 e-journals (http://gort.ucsd.edu/newjour/). ISSN included 1 125 507 registered serials publications in 2003, of which a reported 22 916 (2%) were on line (www.issn.org). These lists vary in coverage and in their treatment of print journals also available online versus online-only journals.

8 It is notable, however, that Swan and Brown (2004) reported that 39% of researchers surveyed in early 2004 self-archived in some form, including to personal and institutional Web sites.

9 Although it could, perhaps, be argued that such diversity may encourage technological innovation.

10 It is also notable that the emerging business model for the digital delivery of books (*i.e.* e-books) appears to be a blurring of the distinction between books and journals and the delivery of e-books through the major online journal access systems (*e.g.* Elsevier ScienceDirect, Springer LINK, Wiley Interscience, Blackwell Synergy, etc.) on a subscription or pay-per-view basis (EPS 2004a). With the blurring of boundaries, however, it may be more accurate to view these developments as the digital delivery of book content rather than books, as their content is often being fragmented.

11 Leo Waaijers of Delft Technical University Library noted that: "Consortia are only good for publishers, not for libraries. We now have to buy 1 100 titles from Elsevier while we really only need 68" (Waaijers, L. 'A new role for the Scientific Publisher in the electronic age,' ISOPress www.iospress.nl). (Franklin 2002). Similarly, CESTMJP (2004, p25) cite the example of the University of Minnesota library which worked with Elsevier Science to back out of its Big Deal only to find that reducing its subscription from 750 titles to 650 and moving to electronic only would result in a higher per title cost.

[12] Due to either license or institutional controls over electronic access.

[13] An overview of the development of open access (both author-pays and self-archiving) can be found at http://www.earlham.edu/~peters/fos/timeline.htm with related explanation of open access at http://www.earlham.edu/~peters/fos/overview.htm (Suber 2004a; 2004b).

[14] BioMed Central report that during the first half of 2004, open access articles in *Nucleic Acids Research* were downloaded 52% more frequently, on average, than were subscription articles in the same journal.

[15] While "public" access to the subscription journal literature may now be possible through university and public libraries, on a pay-per-view basis or via inter-library loan requests, unrestricted Web-based access from the desktop is possible with open access.

[16] In a small survey of publishers of open access journals, Hedlund, et al. (2004) found an average 50% rejection rate which is comparable to the print journal average.

[17] In its response to the House of Commons Science and Technology Committee Report on Scientific Publishing, the UK Government stated: "The Government agrees that cost transparency will help the academic world to understand the pricing regime and the products they are receiving." (HCSTC 2004b, p20).

[18] A parallel, complementary development is that of institutional e-presses, which replicate the activity of institutional presses (*e.g.* University Presses) in online only form.

[19] Subject archives are also sometime known as "thematic" archives or repositories.

[20] For an overview of OAI see the Open Access Initiative (www.openarchives.org) and the introductory tutorial at the Open Access Forum (http://www.oaforum.org/tutorial/english/intro.htm).

[21] Open access is particularly important for developing countries and for those from less well funded research and user institutions, for whom the traditional subscription-based system tends to be prohibitively expensive. (International access schemes are discussed below).

[22] One checklist of publisher policies is that at http://www.sherpa.ac.uk/romeo.php.

[23] The Declaration and commitments were agreed by all OECD Member governments plus governments of four observer countries. The complete list of countries making this Declaration and commitments is: Australia, Austria, Belgium, Canada, China, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Russian Federation, the Slovak Republic, the Republic of South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. See: http://www.oecd.org/document/0,2340,en_2649_34487_25998799_1_1_1_1,00.html.

[24] SQW (2004: 20) suggested that likely charges with a two-part tariff might be a median of USD 175 for submission fees and publication fees in the range USD 250 - 750.

[25] Although such a model is less effective in terms of price signals.

[26] For summaries of these and other developments see: http://www.plos.org/about/openaccess.html and http://www.earlham.edu/~peters/fos/timeline.htm.