

Costs and Benefits of Alternative Publishing Models: Denmark



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Introduction

A 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). Scholarly publishing plays a key role as it is central to the efficiency of research and to the dissemination of research findings and diffusion of scientific and technical knowledge. But advances in information and communication technologies are disrupting traditional publishing models, radically changing our capacity to reproduce, distribute, control and publish information. One key question is whether there are new opportunities and new models for scholarly publishing that might better serve researchers and more effectively communicate and disseminate research findings (OECD 2005, p14).

Building on previous work, this study looks at the costs and potential benefits of alternative models for scientific and scholarly publishing. The work began in Australia in 2006 with a study of *Research Communication Costs, Emerging Opportunities and Benefits* (Houghton *et al.* 2006). This was followed by a major study of the *Economic Implications of Alternative Scholarly Publishing Models* for the Joint Information Systems Committee (JISC) in the UK (Houghton *et al.* and Oppenheim *et al.* 2009). The aim of this study is to apply the same basic approach to exploring the costs and potential benefits of alternative models for scholarly publishing in Denmark.

Approach and methodology

The JISC study focused on three alternative models for scholarly publishing, namely: subscription publishing, open access publishing and self-archiving.

- *Subscription publishing* refers primarily to academic journal publishing and includes individual subscriptions and the, so called, Big Deal (*i.e.* where institutional subscribers pay for access to online aggregations of journal titles through consortial or site licensing arrangements). In a wider sense, however, subscription publishing includes any publishing business model that imposes reader access tolls and restrictions on use designed to maintain publisher control over that access in order to enable the collection of those tolls.
- *Open access publishing* refers primarily to journal publishing where access is free of charge to readers, and the authors, their employing or funding organisations pay for publication; or the publication is supported by other sponsors making publication free for both readers and authors. Use restrictions can be minimal as no access toll is imposed.
- *Open access self-archiving* refers to the situation where authors deposit their work in online open access institutional or subject-based repositories, making it freely available to anyone with internet access. Again, use restrictions can be minimal as no access toll is imposed.

As self-archiving, of itself, does not constitute formal publication our analysis focuses on two publishing models in which self-archiving is supplemented by the peer review and production activities necessary for formal publishing, namely: (i) 'Green OA' self-archiving operating in parallel with subscription publishing; and (ii) the 'deconstructed' or 'overlay journals' model in which self-archiving provides the foundation for overlay journals and services (*e.g.* peer review, branding and quality control services). Hence, each of the publishing models explored includes all of the key functions of scholarly publishing, including peer review and quality control.

Phase I: Identifying costs and benefits

The first phase of the JISC study sought to *identify* all the dimensions of cost and benefit associated with each of the models, and examine which of the main players in the scholarly communication system would be affected and how they would be affected by the adoption of alternative publishing models. In order to provide a solid foundation for analysis we developed and extended the scholarly communication life-cycle model first outlined by Bo-Christer Björk (2007).

Björk (2007) developed a formal model of the scholarly communication life-cycle, based on the IDEF0 process modelling method often used in business process re-engineering, to provide a detailed map of the scholarly publishing process. Björk's central focus was the single publication (primarily the journal article), how it is written, edited, printed, distributed, archived, retrieved and read, and how eventually its reading may affect practice. Björk's model included the activities of researchers who perform the research and write the publications, publishers who manage and carry out the actual publication process, academics who participate in the process as editors and reviewers, libraries who help in archiving and providing access to the publications, bibliographic services who facilitate the identification and retrieval of publications, readers who search for, retrieve and read publications, and practitioners who implement the research results directly or indirectly.

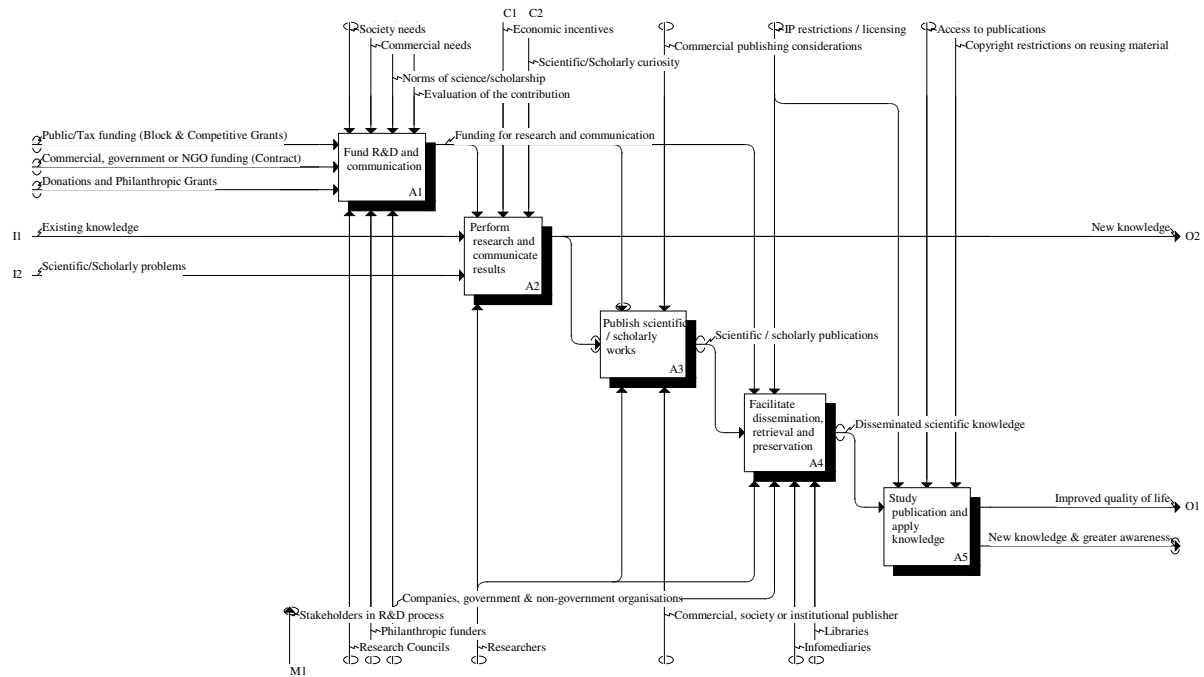
Extending the model outlined by Björk (2007), the scholarly communication process model developed for the JISC study included five core scholarly communication process activities, namely:

- (i) Fund research and research communication;
- (ii) Perform research and communicate the results;
- (iii) Publish scientific and scholarly works;
- (iv) Facilitate dissemination, retrieval and preservation; and
- (v) Study publications and apply the knowledge (Figure 1).

Each of these is further subdivided into a detailed description of the activities, inputs, outputs, controls and supporting mechanisms involved. This formal process modelling was used to identify activities and provide the foundation for activity costing.¹

¹ Details of the entire model in 'browseable' form can be found on the Web at <http://www.cfses.com/EI-ASPM/SCLCM-V7/>.

Figure 1: The scholarly communication process



Source: JISC EI-ASPM Project (<http://www.cfses.com/EI-ASPM/SCLCM-V7/>).

Phase II: Quantifying costs and benefits

The second phase of the JISC study sought to *quantify* the costs and benefits, identify and where possible quantify the cost and benefit implications for each of the main players in the scholarly communication system and, as far as possible, compare the costs and benefits of the three models.

There are three elements to our approach to quantifying costs and benefits.

- First, we explore the costs of individual process activities and then sum them to estimate system-wide costs. From this we can see cost differences and direct cost savings.
- Second, we present cases and scenarios to explore the potential cost savings resulting from alternative publishing models (*e.g.* looking at impacts on search and discovery, library handling costs, etc.). From this we can explore indirect cost differences and savings.
- Third, we approach the issue from the top down and model the impact of changes in accessibility and efficiency on returns to R&D using a Solow-Swan model, into which we introduce *accessibility* and *efficiency* as negative or friction variables to reflect the fact that there are limits and barriers to access and to the efficiency of production and usefulness of knowledge (Houghton and Sheehan 2006; 2009).

A full description of the modelling approach and details of its operationalisation can be found in the JISC Project Report (Houghton *et al.* and Oppenheim *et al.* 2009) (<http://www.cfses.com/EI-ASPM/>).

Data sources and limitations

There are two elements to the activity cost modelling, namely (i) local national variables, and (ii) more generic activity costings. While there are important structural differences between national research and scholarly communication systems, research is a global activity and many research-related and publishing activities are common across countries. Consequently, for preliminary estimations, it is possible to use international sources on research and publishing activities where no local sources exist. This section describes the major sources used and possible limitations, taking each of the five main activity areas identified in the scholarly communication process model in turn (See Annex I for details).

(i) Fund research and research communication

Major sources on research funding in Denmark include the annual reports of major funding agencies and departments (*e.g.* Ministry of Science, Technology and Development, DCIR, DCSR, etc.), national and international reporting of R&D expenditures and the number of personnel engaged in research (*e.g.* StatBank.dk, OECD, EuroStat, etc.), and reports of the activities of universities and research institutes in Denmark (*e.g.* Bibliotek og Medier, Danish Universities, etc.). Drawing on these sources provides sufficient data for preliminary estimation.

(ii) Perform research and communicate the results

Major sources on the performance of research in Denmark include a mix of local and international sources. Local sources include academic pay scales and the ratio of salaries to overheads typical in universities and research institutes, and publication counts for journal articles and other forms of output for the universities. Salaries are based on those reported by the universities, with estimated overheads based on dividing R&D expenditure by FTE researchers. The average total cost of researcher activities in the universities, including salaries and overhead costs, is estimated to be around DKK 1.3 million per FTE researcher per year, or DKK 780 per hour. This figure includes the personnel costs of research technicians and support staff as overheads.² For national totals, reported university publication counts are supplemented by counts sourced from the ISI Web of Knowledge and SCOPUS databases for the calendar year 2007, scaled to account for content not included in those sources (Björk *et al.* 2008).

For much of the researcher activity data we must rely on international sources on the activities of researchers in universities and elsewhere. The principal sources include the King and Tenopir tracking studies, which have been undertaken over many years in the US and more recently in a number of other countries (not including Denmark). Major sources include Tenopir and King (2000); Tenopir and King (2002); Tenopir and King (2007); Tenopir, King, Edwards and Wu

² To the extent that researchers work longer than their official standard hours these costs may be somewhat high and might, perhaps, be thought of as the value of the activity rather than the cost (per hour).

(2009); King, Tenopir and Clarke (2006); Rowlands and Nicholas (2005); Halliday and Oppenheim (1999); Houghton, Steele and Sheehan (2006); CEPA (2008); Björk, Roos and Lauri (2008), etc. Drawing on these sources provides sufficient data for preliminary estimation.

(iii) Publish scientific and scholarly works

Scholarly publishing is a global activity and the activities of journal and academic book publishers are similar around the world. Moreover, the aim herein is to cost activities relating to the publication of scientific and scholarly works researched and written in Denmark, and Danish research is published by international as well as local publishers. Consequently, publishing activities and costs can be sourced from the wide range of existing literature and industry consultations undertaken for the previous studies.

For the basic market data relating to STM publishing we rely on EPS/Outsell, while publishing output volumes are sourced from the ISI Web of Knowledge and SCOPUS databases, Ulrich's, The Publishers Association, Björk *et al.* (2008), etc. Detailed activity costs relating to journal publishing are sourced primarily from Tenopir and King (2000) and their subsequent tracking studies, the ALPSP, CEPA (2008), Waltham (2005; 2006), etc. Activity costs relating to scholarly book publishing are less well reported in the literature, although data can be sourced from Clark (2001; 2008), Watkinson (2001), Greco and Wharton (2008), etc. We have also obtained confidential cost data from book publishers for the previous studies. Details of author-pays fees are sourced from a sample of open access journal publishers.

These sources provide sufficient data for preliminary estimation, but more information on local publishing costs in Denmark would be helpful in informing us as to the need to adjust for local costs structures (*e.g.* due to publication in Danish and the implied shorter print runs and fewer subscribers, publication in multiple languages adding translation and additional production costs, possibly higher international distribution costs, etc.). To the extent that such factors add to the costs of publishing the scientific and scholarly content produced by researchers in Denmark, the publisher cost estimates herein should be taken as something closer to lower bound estimates. However, this is unlikely to affect the overall findings, as impacts would relate more to production cost differences between print and electronic formats than between publishing business models, which are compared as if everything was electronic only, and translation costs would be common across publishing models.

(iv) Facilitate dissemination, retrieval and preservation

The activities of dissemination, retrieval and preservation, most notably those of research and special libraries, exhibit greater variation between countries. Danish data from the university and government research libraries are very good, but in the absence of detailed local information research library activity costings can be no more than first approximations based on international activity studies (*e.g.* Schonfeld *et al.* 2004; King *et al.* 2004; etc.), with the activity times translated to local costs using average Danish university library staff salaries. Moreover, as 'Big Deal' subscriptions and electronic journals become the norm and e-book collections are emerging library handling activities are changing rapidly, making data from 2004 no more than an approximate guide to current library activities. However, library handling costs are relatively

low and play a minor part in overall systems costs and potential savings (See Figures 6, 7 and 8).

Cost and operational data relating to repositories are highly varied, but there are sufficient data for preliminary estimation from international studies (*e.g.* Swan 2008, The Driver Report 2008, Bailey 2006, Universities UK 2007, Houghton *et al.* 2006 and ROAR, etc.) as well as good local sources. It is notable that the recent case studies in the LIFE Project report very similar per article and per object repository life-cycle costs to those derived independently for the JISC study.

(v) Study publications and apply the knowledge

With limited information about the activities of researchers, research and special libraries, and research users outside higher education and specialist public sector research institutions, the analysis of costs relating to studying publications and applying knowledge is limited to the use of research by other public sector researchers. This limits the extent to which the possible costs, cost savings and benefits of alternative scholarly publishing models can be examined on a detailed case-by-case basis and has led to our reliance on a macro-modelling of the potential impacts of enhanced access on social returns to R&D using a modified Solow-Swan model. This limitation and consequent approach has been common across the previous studies.

Summary of preliminary results

Drawing on this wide range of data sources, activity surveys and tracking studies we estimate costs for activities throughout the scholarly communication process at the national level and for the eight research universities in Denmark. For ease of comparison this summary follows the structure of the JISC Project Report's Executive Summary (Houghton *et al.* and Oppenheim *et al.* 2009) and that of the recent Netherlands study (Houghton *et al.* 2009). All data are standardised on 2007 prices and levels of activity.

Scholarly communication system costs

Reading scholarly publications by Danish researchers and academic staff is a major activity, perhaps costing around DKK 16 billion annually, and reading by those actively publishing (*i.e.* approximating reading in order to write) cost around DKK 6.6 billion during 2007 (Table 1).³ We estimate that writing the core peer-reviewed scholarly publications may have cost around DKK 2.7 billion, and preparing and reviewing research grant applications for the independent and strategic research councils (DCIR and DCSR) alone may have cost around DKK 240 million.

The peer review of scholarly journal articles and books conducted by Denmark's researchers on behalf of publishers (*i.e.* external peer review activities) probably cost around DKK 390 million during 2007, and the external journal editorial and editorial board activities of researchers

³ All costs are expressed in 2007 Danish Kroner and, where necessary, have been converted to Kroner using OECD published annual average exchange rates and adjusted to 2007 using the Danish consumer price index. All publisher costs include commercial margins.

around DKK 170 million. We estimate that publisher costs relating to Denmark-authored publications probably amounted to around DKK 780 million (excluding the external costs noted above). Summing these costs suggests that core scholarly publishing system activities may have cost around DKK 11 billion in Denmark during 2007 (See Annex II for details).

Table 1: Estimated annual national scholarly communication activity costs (DKK, circa 2007)

<i>DK National</i>	<i>Estimate</i>
Reading (Published Staff)	6,590,200,000
Writing (WoK based estimate, scaled)	2,741,600,000
Peer Review (Scaled to publication counts)	390,800,000
Editorial activities (Scaled to published staff)	154,200,000
Editorial board activities (Scaled to published staff)	17,100,000
Preparing Grant Applications (DCIR & DCSR)	235,300,000
Reviewing Grant Applications (DCIR & DCSR)	7,400,000
Publisher Costs (Scaled to publication counts)	779,600,000
Total National System	10,916,300,000

Source: DK model: Author's analysis.

Table 2 summarises these same scholarly communication activity costs for the eight universities. It shows that academic staff reading probably cost around DKK 8.3 billion during 2007, and reading by those actively publishing around DKK 5 billion. We estimate that writing peer reviewed scholarly publications in universities cost around DKK 2.5 billion, and preparing and reviewing research grant applications for the independent and strategic research councils (DCIR and DCSR) alone may have cost around DKK 185 million.

Table 2: Estimated annual universities' scholarly communication activity costs (DKK, circa 2007)

<i>DK Universities</i>	<i>Estimate</i>
Reading (Published Staff)	5,020,200,000
Writing (WoK based estimate, scaled)	2,509,900,000
Peer Review (Scaled to publication counts)	356,300,000
Editorial activities (Scaled to published staff)	112,700,000
Editorial board activities (Scaled to published staff)	12,500,000
Preparing Grant Applications (DCIR & DCSR)	181,200,000
Reviewing Grant Applications (DCIR & DCSR)	5,700,000
Publisher Costs (Scaled to publication counts)	717,500,000
Total National HE System	8,915,900,000

Note: Includes the 8 universities only.

Source: DK model: Author's analysis.

The peer review of scholarly journal articles and books conducted on behalf of publishers by academic staff (*i.e.* external peer review activities) probably cost around DKK 356 million during 2007, and their external journal editorial and editorial board activities around DKK 125 million. We estimate that higher education output-related publisher costs probably amounted to

around DKK 720 million (excluding the external costs noted above). Summing these costs suggests that scholarly publishing system activities may have cost Denmark’s universities around DKK 9 billion during 2007 (See Annex II for details).

The cost of alternative models

Our analysis focuses on three alternative models for scholarly publishing, namely: subscription publishing, open access publishing and self-archiving. Table 3 summarises costs relating to each of these models.

Subscription and toll access publishing cost the university libraries DKK 94 million for acquisitions (*i.e.* for subscription or toll access payments). Negotiation of subscriptions and licensing, access control and other library handling relating to the subscription or toll access model also accounted for a substantial share of university library non-acquisition costs. Other research-related libraries spent an additional DKK 550 million, of which DKK 126 million was on acquisitions (*i.e.* purchase of materials and online resources).

Table 3: Estimated annual universities’ scholarly communication related costs (DKK, circa 2007)

<i>Denmark’s Universities</i>	<i>Estimate</i>
Library Acquisition (Universities)	94,000,000
Library non-Acquisition (Universities)	233,900,000
Author-pays fees for all journal articles (Open access publishing)	226,900,000
Repository Costs (Open access self-archiving)	8,800,000

Source: DK model: Author’s analysis.

Open access publishing all of Danish universities’ journal article output in 2007 under the ‘author-pays’ model (at DKK 16,500 per article) would have cost around DKK 230 million. Given that it is said that no more than half of open access journals actually charge author fees, perhaps DKK 115 million would have been required for author-side payments. However, if Denmark supported open access publishing in proportion to output, the remaining DKK 115 million would have been paid in other forms of institutional support.

Open access self-archiving costs are based on estimated repository costs, which are necessarily no more than approximate. Nevertheless, we estimate that a system of institutional repositories in the eight universities in which every institution had one publications-oriented repository and all publications were self-archived once might have cost around DKK 9 million per annum (at 2007 prices and levels of publication output).

Costing activities, objects and functions

The matrix approach to costing lying behind these activity costs enables their presentation in various forms, including as costs for actors, objects and functions. For example, combining activity costs to estimate object costs we find that journal articles cost an estimated average of around DKK 125,700 to produce in Denmark circa 2007, of which around DKK 74,400 related to the direct cost of writing (excluding input research activities, such as reading), DKK 31,900

related to publisher costs and DKK 19,400 to external peer review costs (per article published) (Table 4 and Figure 2).

Table 4: Estimated per item object costs (DKK, circa 2007)

	<i>Estimate</i>
Cost per journal article (per article)	
Writing	74,400
Peer review (per published)	19,400
Publisher related	31,900
Library acquisition	3.20
Library handling	2.94
<i>Per article production</i>	<i>125,700</i>
Publisher share of production costs	25%
Cost per academic book (per title)	
Writing	892,900
Peer review (per published)	29,100
Publisher related	171,800
Distribution related (print)	73,600
Library acquisition (books and pamphlets per item)	89
Library handling	538
<i>Per monograph production</i>	<i>1,167,900</i>
Publisher and distributor share of production costs	21%

Note: Writing costs include those items that are not published while all other costs are per item published. Acquisition costs are excluded from the totals to avoid double counting.

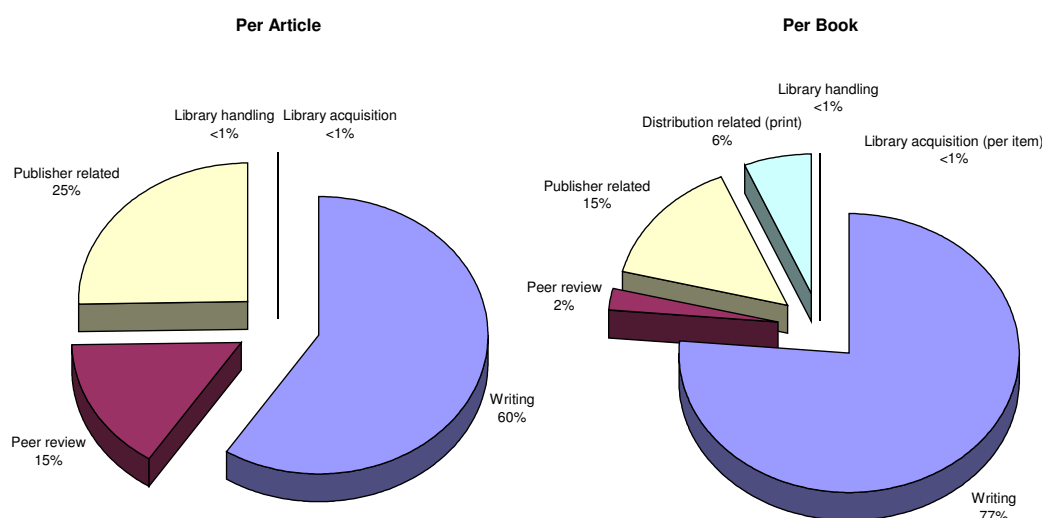
Source: DK model: Author's analysis.

Similarly, we estimate that research monographs (*i.e.* authored and edited books) cost an average of around DKK 1 million to produce circa 2007, of which around DKK 893,000 related to the direct cost of writing (excluding input research activities, such as reading), DKK 171,800 related to publisher costs and an estimated DKK 73,600 to distribution costs, and DKK 29,100 to external peer review costs (per title published) (Table 4 and Figure 2).

Activity costs can also be combined into the cost of specific functions, such as peer review and the functions of quality control and certification.⁴ The activity cost estimates include both internal publisher peer review handling and management related costs and external, largely non-cash, peer reviewer costs. Per article published, these amounted to an estimated DKK 3,749 and DKK 19,385, respectively, or a total function cost of DKK 23,134 circa 2007. For books, these costs are estimated at DKK 18,894 per title for publisher editorial activities and DKK 29,078 for external peer review, or a total function cost of DKK 47,972.

⁴ A number of publisher activities relating to the proofing, checking and editing of manuscripts might also be included in the function of quality control, but have been excluded from this example for the sake of simplicity.

Figure 2: Estimated per item object cost shares (per cent)



Note: Writing costs include those items that are not published while all other costs are per item published.
Source: DK Model: Author's analysis.

Publisher costs per journal article

One key challenge is to separate the cost impacts of publishing models from those of publishing format, so we can explore the cost differences between subscription and open access publishing models independent of differences between print and electronic production. Our approach is to estimate costs for print, dual-mode (*i.e.* parallel print and electronic) and electronic-only formats for subscription and open access business models, and then to compare subscription and open access models as if they were all electronic or 'e-only'. All of these costings include commercial publisher margins.

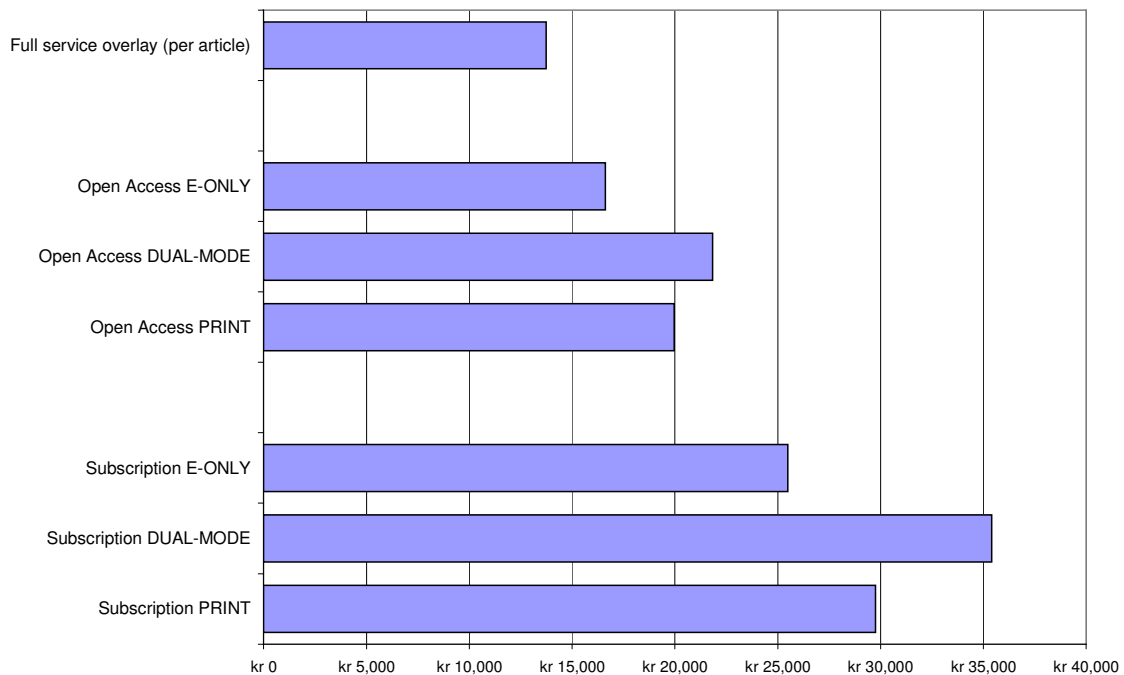
For *subscription publishing*, we estimate an average publisher cost of around DKK 35,410 per article for dual-mode production, DKK 29,750 per article for print only production and DKK 25,490 per article for e-only production (excluding the costs associated with external peer review and Value-Added Tax) (Figure 3).⁵

For *open access publishing*, we estimate average per article costs at DKK 16,625 for e-only production. Excluding the costs of copy printing and delivery, we estimate the cost of dual-mode open access publishing at around DKK 21,840 per article and print only open access publishing at DKK 19,965 per article.⁶ Indicatively, if printing and delivery costs were the same as subscription publishing, they might add around DKK 1,600 per article.

⁵ These publisher costs are derived from those reported in the UK JISC study, and are converted to Kroner at 2007 annual average exchange rates.

⁶ It is impossible to estimate the cost of printing and delivery in open access publishing as it depends on the number of copies involved, and in the absence of subscriber counts that number cannot be known.

Figure 3: Estimated average publisher costs per article by format and model (DKK, circa 2007)



Note: These costs exclude the external costs of peer review and VAT. Overlay services include operating peer review management, editing, proofing and hosting, with commercial margins. Estimates for print and dual-mode open access publishing exclude copy print and delivery related costs, assuming that the content is produced print ready and print is an add-on.

Source: DK model: Author's analysis.

We include the implied publisher costs of *overlay services to open access self-archiving* (i.e. the overlay services model), with the same commercial management, investment and profit margins applied. This suggests that operating peer review management, editing, production and proofing as an overlay service would cost around DKK 12,295 per article excluding hosting, or DKK 13,735 including hosting.

Publisher costs per book title

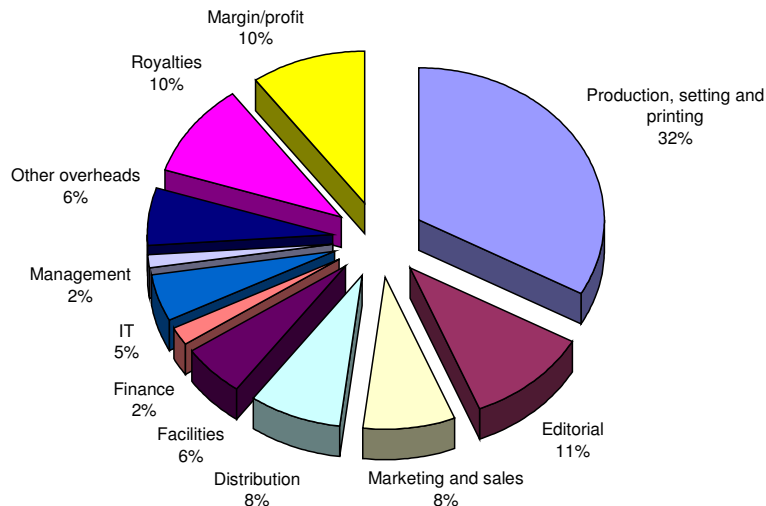
Costs relating to academic book publishing are less widely discussed in the literature, although there a number of sources on book publishing costs, publisher management and pricing issues that provide a foundation. It is clear from these sources that book publishing costs vary widely, even within scholarly or academic book publishing.

Based on proportions derived from industry consultation and those reported in the literature (Figure 4), we estimate average publisher Net Sales Revenue at DKK 100,000 to DKK 200,000 in 2007 prices (excluding external peer review costs). Average costs can be summed by format and publishing model, with the cost of toll access book publishing in print form at an estimated

Therefore, estimates for print and dual-mode open access publishing exclude actual copy print and delivery related costs, assuming that the content is produced print ready and print is an add-on.

average of DKK 172,000 per title. In electronic or e-only format, we estimate toll access publishing costs at an average of around DKK 123,500 per title, and open access publishing around DKK 80,500 per title. These average costs are no more than approximate, but differences between the modes and models are indicative.

Figure 4: Approximate academic book publisher cost shares (per cent)



Note: Cost shares of estimated Net Sales Revenue per title, print.
Sources: Industry consultation and Clark (2001). DK model: Author's analysis.

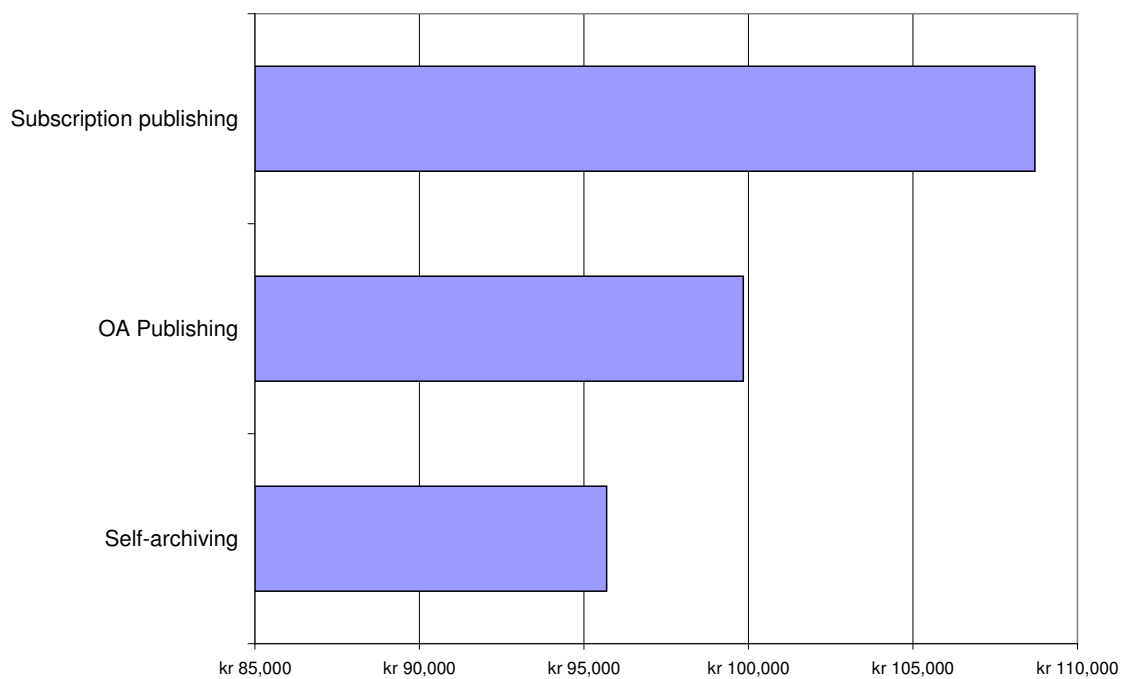
Those difference are accentuated when distributor discounts are taken into account. Academic book publisher discounts to distributors can be substantial, often ranging in the region of 30% to 40%. These discounts should not simply be included in publisher costs, but rather separately identified as distribution or channel costs. For example, if a book sold 500 copies at DKK 490 per copy, a 30% distributor's discount would be worth DKK 147 per item or an average DKK 73,615 per title. Adjusting publisher costs to include distributor discounts brings our estimated average costs per title to DKK 245,380 for print, DKK 160,495 for toll access e-books and an unchanged DKK 80,490 for open access e-books – substantially increasing the difference between publishing models.

The impact of alternative scholarly publishing models

Summing the costs of production, publishing and dissemination *per article* in electronic-only format suggests that average subscription publishing system costs would amount to around DKK 108,709 per article (excluding VAT), average open access publishing costs would amount to DKK 99,844 per article and average open access self-archiving costs DKK 95,689 per article (including overlay review and production services with commercial margins). At these costs, open access publishing would be around DKK 8,865 per article cheaper than subscription

publishing, and open access self-archiving with overlay services around DKK 13,020 per article cheaper (Figure 5).

Figure 5: Scholarly communication system costs per article (DKK, circa 2007)



Note: Includes the direct costs of writing, peer review, publishing and disseminating in e-only format, and excludes VAT. Self-archiving includes publisher production and review costs, including commercial margins (*i.e.* overlay services).

Source: DK model: Author's analysis.

For higher education (*i.e.* the universities), these journal article cost differences would have amounted to savings of around DKK 122 million per annum circa 2007 from a shift from subscription to open access publishing, and DKK 180 million from a shift to open access self-archiving with overlay services. While alternative publishing models for scholarly books are much less developed and costings more speculative as a result, substantial savings would also appear to be available from shifting to open access book publishing.

In addition to direct cost differences there are potential system cost savings. In a highly simplified form, the following figures summarise the estimated impacts for Denmark nationally and for the universities in Denmark of unilateral national and worldwide adoption of alternative open access journal/article publishing models, including: (i) 'Green OA' self-archiving in parallel with subscription publishing; (ii) 'Gold OA' or author-pays journal publishing; and (iii) the 'deconstructed' or 'overlay journals' model of self-archiving with overlay services. Reported increased returns arising from enhanced access are from public sector and higher education R&D spending expressed as annual increases in current values (Box 1).⁷

⁷ Increased returns are recurring gains from one year's R&D expenditure. Such returns can be expressed in Net Present Value (NPV), lagged and recurring over the useful life of the knowledge. For

Box 1: Estimating the impacts of enhanced access on returns to R&D

To explore the impacts of enhanced access on social returns to R&D we modified a basic Solow-Swan model, by introducing *accessibility* and *efficiency* as negative or friction variables, and then calculating the impact on returns to R&D of reducing the friction by increasing accessibility and efficiency.

We find that with a 20% return to publicly funded R&D, for the major categories of research expenditure in Denmark in 2007, a 5% increase in accessibility and efficiency⁸ would have been worth:

- DKK 304 million per annum in increased returns to public sector R&D (*i.e.* government and higher education);
- DKK 243 million per annum in increased returns to Higher Education R&D (HERD); and
- DKK 61 million per annum in increased returns to Government R&D (GovERD).

These are recurring annual gains from the effect of one year's R&D expenditure, so if the change that brings the increases in accessibility and efficiency is permanent they can be converted to growth rate effects.

Note: Estimates of the social returns to R&D are based on aggregates, such as national or public sector expenditure, for which they can be reasonably accurate. Their use for specific fields of research and smaller aggregations, perhaps even smaller countries, will be subject to greater uncertainty and should be treated with caution.

As many of the potential cost savings cannot be fully realised unless there is worldwide adoption of open access, in the unilateral national open access scenarios funder, research, library handling and subscription cost savings are scaled to Denmark's article output (*i.e.* are in proportion to the share of worldwide journal literature that would be open access as a result of the unilateral adoption of alternative open access models by Denmark). In the 'Green OA' model self-archiving operates in parallel with subscription publishing, so there are no publisher, library handling or subscription cost savings. As increased returns to R&D are diffuse and occur throughout the economy they cannot be considered a part of the internal scholarly communication system cost-benefits, so we separate modelled increases in returns to R&D resulting from enhanced access from the cost impacts and present the net scholarly publishing system cost impacts of the alternative publishing models. Where net cost is negative it represents a saving, and where positive it represents a cost (*i.e.* effectively, the investment required to obtain the increased returns and realise the benefits).

We estimate that *open access publishing* for journal articles using the 'author-pays' model might bring system savings of around DKK 520 million per annum nationally in Denmark in a worldwide open access system (at 2007 prices and levels of publishing activity), of which

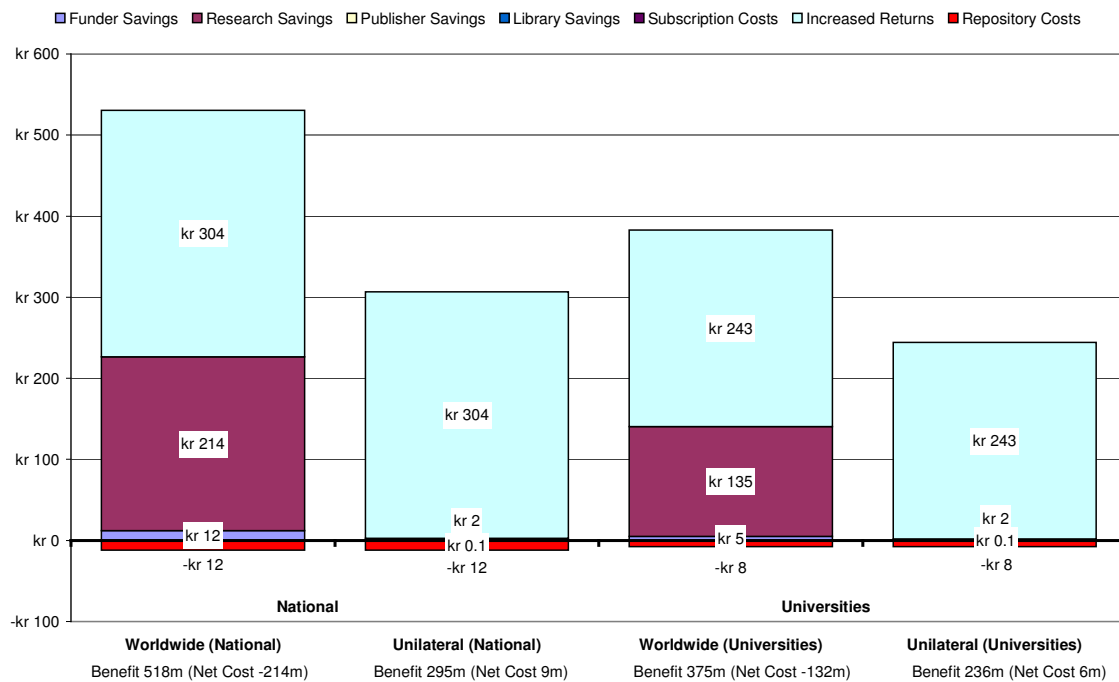
the sake of simplicity and transparency in these charts we have simply taken the original value of annual returns as indicative. In the cost-benefit comparisons below, returns are presented in Net Present Value and lagged.

⁸ The rationale behind the use of a 20% return to R&D and a 5% increase in accessibility and efficiency is discussed in detail in the JISC EI-ASPM Report (Houghton *et al.* and Oppenheim *et al.* 2009, pp193-208). See <http://www.cfses.com/EI-ASPM/>

around DKK 340 million would accrue in the universities. *Open access self-archiving without subscription cancellations* (i.e. ‘Green OA’) might save around DKK 215 million per annum nationally in a worldwide Green OA system, of which around DKK 130 million would accrue in the universities. The *open access self-archiving with overlay services* model explored is necessarily speculative, but might save around DKK 570 million per annum nationally in a worldwide ‘overlay journals’ system, of which around DKK 390 million might accrue in the universities.

These savings can be set against the cost of open access publishing, which if all journal articles produced encountered author fees of DKK 16,500 would have been around DKK 250 million nationally in 2007, of which DKK 225 million would have been faced by the universities. Similarly, with estimated repository costs at around DKK 12 million nationally and DKK 8 million for the universities, the potential net benefits from ‘Green OA’ self-archiving or from self-archiving with overlay production and review services would be substantial.

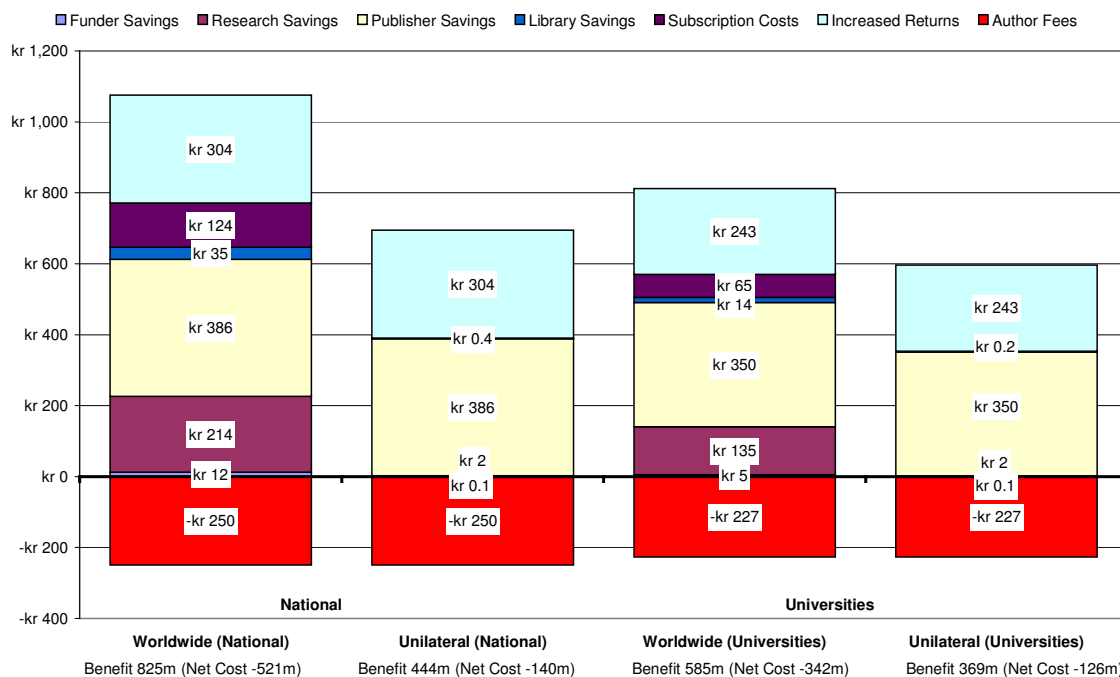
Figure 6: Estimated impact of ‘Green OA’ self-archiving (DKK millions per annum, circa 2007)



Source: DK model: Author’s analysis.

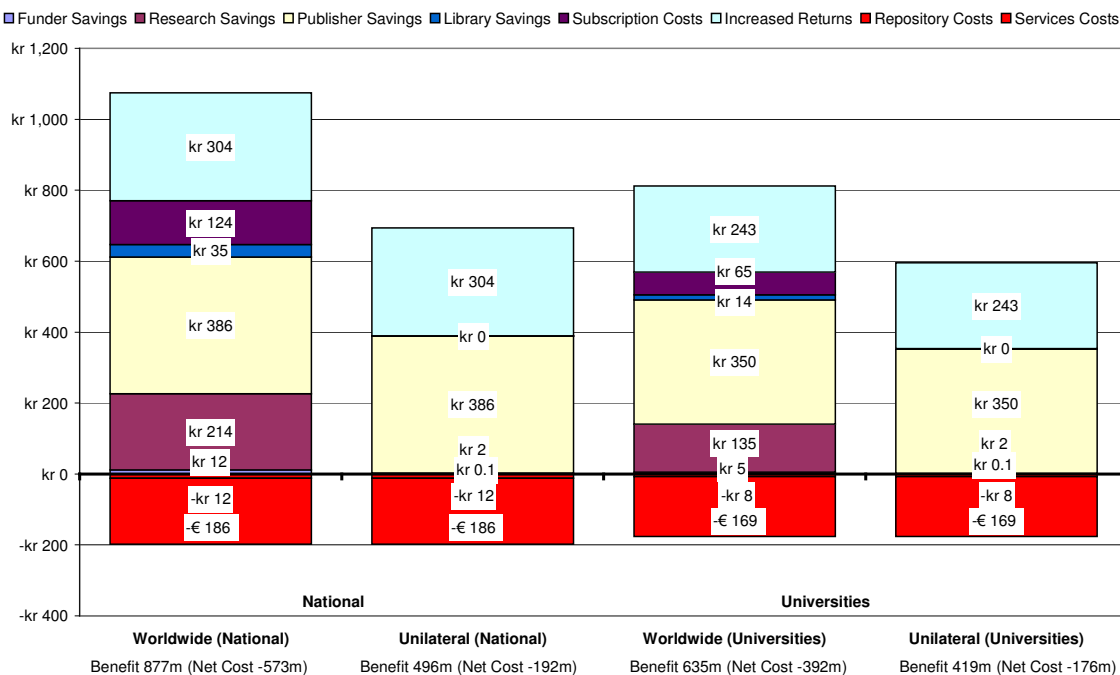
Figure 6 summarises the potential cost impacts of ‘Green OA’ self-archiving in parallel with subscription publishing circa 2007. Indicatively, it suggests that in an all open access world, ‘Green OA’ to all journal articles produced in Denmark during 2007 might have generated an approximate net benefit of around DKK 518 million (per annum), including a net cost saving of around DKK 214 million. Whereas, the unilateral national adoption of ‘Green OA’ in Denmark may have generated little more than half the net benefit while incurring a net cost of around DKK 9 million (i.e. effectively the investment required to realise the benefit).

Figure 7: Estimated impact of 'Gold OA' publishing (DKK millions per annum, circa 2007)



Source: DK model: Author's analysis.

Figure 8: Estimated impact of OA self-archiving with overlay production and peer review services (DKK millions per annum, circa 2007)



Source: DK model: Author's analysis.

Figure 7 summarises the potential cost impacts of ‘Gold OA’ publishing through the author-pays model, and Figure 8 the cost impacts of self-archiving with overlay production and review services (*i.e.* the deconstructed or overlay journals model). Each includes indicative net benefit and net cost implications.

Comparing costs and benefits

Modelling the impacts of an increase in *accessibility* and *efficiency* resulting from more open access on returns to R&D over a 20 year period and then comparing costs and benefits, we find that the benefits of open access publishing models are likely to substantially outweigh the costs.

First, we explore the cost-benefit implications of simply adding open access publishing and self-archiving to current activities, all other things remaining the same (*i.e.* *ceteris paribus* scenarios). Then we explore the implications of open access publishing and self-archiving as alternatives to current activities, by adding the estimated system savings to the estimated increases in returns (*i.e.* net cost scenarios).⁹

These cost-benefit comparisons suggest that the additional returns to R&D resulting from enhanced accessibility and efficiency alone would be sufficient to cover the costs of parallel open access self-archiving without subscription cancellations (*i.e.* ‘Green OA’). When estimated savings are added to generate net costs there is a substantial increase in the benefit/cost ratios, and for both open access publishing and self-archiving alternatives (*i.e.* ‘Gold OA’ and ‘Green OA’) the benefits exceed the costs, even in transition. Indicative modelling of post-transition ‘steady-state’ alternative systems (Box 2) suggests that, once established, alternative open access publishing and/or self-archiving systems would produce substantially greater net benefits.

For example, during a transitional period we estimate that, in an Open Access world:

- The combined cost savings and benefits from increased returns to R&D resulting from open access publishing all journal articles produced in Denmark’s universities using an ‘author-pays’ system would be around 3 times the costs;
- The combined cost savings and benefits from open access self-archiving in parallel with subscription publishing (*i.e.* ‘Green OA’) would be around 27 times the costs; and
- The combined cost savings and benefits from an alternative open access self-archiving system with overlay production and review services (*i.e.* ‘overlay journals’) would be around 4 times the costs (Table 5).

Indicative modelling of post-transition ‘steady-state’ alternative systems returns benefits of around 7 to 10 times costs for open access publishing and self-archiving with overlay services, more than 100 times the costs for the ‘Green OA’ self-archiving.

⁹ Of course, the scenario adding open access publishing to current activities is ‘unrealistic’, as parallel publishing all articles in open access and subscription journals simultaneously would not be possible given the copyright demands of subscription publishing.

Box 2: A brief description of the returns to R&D model

Main characteristics: A spreadsheet model to estimate the impacts of increases in ‘accessibility’ and ‘efficiency’ on returns to R&D over 20 years in a 20 by 20 matrix, with three data inputs: (i) R&D expenditure, (ii) annual costs associated with the publishing model, and (iii) annual savings resulting from the publishing model (in the net cost scenarios only).

Assumptions and parameters: All the parameters can be changed in order to explore various scenarios and test sensitivities. Key parameters include: (i) the rate of social return to R&D, (ii) the rate of depreciation of the underlying stock of knowledge, (iii) the discount rate applied to costs and benefits to estimate net present value, (iv) the rate of growth of R&D expenditure, (v) the rate of growth of costs associated with the alternative publishing scenario being explored, (vi) the average lag between publication or self-archiving and returns to R&D in years, and (vii) the average lag between R&D expenditure and publication in years (See Annex I for details).

Transition versus ‘steady-state’ alternative: Because of the lag between research expenditure and the realisation of economic and social returns to that research, the impact on returns to R&D is lagged (by 10 years in the transitional scenario) and the value of those returns discounted accordingly. This reflects that fact that a shift to OA publishing or self-archiving would be prospective and not retrospective, and the economic value of impacts of enhanced accessibility and efficiency would not be reflected in returns to R&D until those returns are realised.

An alternative approach would be to model a hypothetical alternative ‘steady-state’ system for alternative publishing models in which the benefits of historical increases in *accessibility* and *efficiency* enter the model in year one. This would reflect the situation in an alternative system, after the transition had worked through and was no longer affecting returns to R&D.

The model used herein focuses on the transition and explores alternative models through a series of scenarios over a 20 year transitional period. However, the possible impacts in a hypothetical ‘steady-state’ alternative system are explored indicatively by introducing the estimated annual increase in returns into year one. This effectively removes the lag, but is no more than indicative because it does not include the recurring gains from historical expenditures occurring before year one.

Source: Houghton, J.W., Rasmussen, B., Sheehan, P.J., Oppenheim, C., Morris, A., Creaser, C., Greenwood, H., Summers, M. and Gourlay, A. (2009) *Economic Implications of Alternative Scholarly Publishing Models: Exploring the Costs and Benefits*, London & Bristol: The Joint Information Systems Committee (JISC), p211.

Table 5: Summary of benefit/cost comparisons by scenario and model (DKK millions and benefit/cost ratio)

Scenario	Costs	Benefits		Benefit/Cost Ratio
		Savings	Returns	
Ceteris Paribus Scenarios				
Transitional Model:				
OA Publishing in HE (unrealistic)	2,748	..	1,200	0.4
OA Publishing Nationally (unrealistic)	3,024	..	1,504	0.5
OA Self-archiving in HE	106	..	1,200	11.3
OA Self-archiving Nationally	160	..	1,504	9.4
Simulated Steady State Model:				
OA Publishing in HE (unrealistic)	2,748	..	13,424	4.9
OA Publishing Nationally (unrealistic)	3,024	..	16,824	5.6
OA Self-archiving in HE	106	..	13,424	126.3
OA Self-archiving Nationally	160	..	16,824	105.0
Net Cost Scenarios				
Scenario (Denmark Unilateral OA)				
Transitional Model:				
OA Publishing in HE	2,748	4,275	1,200	2.0
OA Self-archiving in HE (Green OA)	106	19	1,200	11.5
OA Self-archiving in HE (Overlay Services)	2,142	4,275	1,200	2.6
OA Publishing Nationally	3,024	4,724	1,504	2.1
OA Self-archiving Nationally (Green OA)	160	31	1,504	9.6
OA Self-archiving Nationally (Overlay Services)	2,398	4,724	1,504	2.6
Simulated Steady State Model:				
OA Publishing in HE	2,748	4,275	13,424	6.4
OA Self-archiving in HE (Green OA)	106	19	13,424	126.4
OA Self-archiving in HE (Overlay Services)	2,142	4,275	13,424	8.3
OA Publishing Nationally	3,024	4,724	16,824	7.1
OA Self-archiving Nationally (Green OA)	160	31	16,824	105.2
OA Self-archiving Nationally (Overlay Services)	2,398	4,724	16,824	9.0
Scenario (Worldwide OA)				
Transitional Model:				
OA Publishing in HE	2,748	6,896	1,200	2.9
OA Self-archiving in HE (Green OA)	106	1,699	1,200	27.3
OA Self-archiving in HE (Overlay Services)	2,142	6,896	1,200	3.8
OA Publishing Nationally	3,024	9,337	1,504	3.6
OA Self-archiving Nationally (Green OA)	160	2,741	1,504	26.5
OA Self-archiving Nationally (Overlay Services)	2,398	9,337	1,504	4.5
Simulated Steady State Model:				
OA Publishing in HE	2,748	6,896	13,424	7.4
OA Self-archiving in HE (Green OA)	106	1,699	13,424	142.2
OA Self-archiving in HE (Overlay Services)	2,142	6,896	13,424	9.5
OA Publishing Nationally	3,024	9,337	16,824	8.7
OA Self-archiving Nationally (Green OA)	160	2,741	16,824	122.1
OA Self-archiving Nationally (Overlay Services)	2,398	9,337	16,824	10.9

Note: Compares open access alternatives against subscription access, with costs, savings and benefits expressed in Net Present Value over 20 years (DKK millions). Increased returns to R&D relate to higher education R&D expenditure (HERD) and national public expenditure on R&D (PUBRD).

Source: DK model: Author's analysis.

This preliminary analysis of the potential benefits of more open access to research findings suggests that different publishing models can make a material difference to the benefits realised, as well as the costs faced. It seems likely that more open access would have substantial net benefits in the longer term and, while net benefits may be lower during a transitional period they are likely to be positive for both open access publishing and self-archiving alternatives (*i.e.* Gold OA) and for parallel subscription publishing and self-archiving (*i.e.* Green OA).

International comparisons

In exploring the potential impacts of alternative publishing models in the UK, Netherlands and Denmark differences in the modelling *per se* have been kept to a minimum, although some minor adjustment of the basic model to fit different national circumstances has been necessary. Nevertheless, there are a number of factors that can affect the benefit/cost ratio estimates for different countries and, thereby, the overall findings. As modelled, these include such things as: the number and size of universities and research institutions; the implied number of institutional and other repositories, each with substantial fixed costs and relatively low variable costs; the ratios of publicly funded and higher education research spending to gross national expenditure on R&D; historical and projected rates of growth of R&D spending by sector and overall; relative national and sectoral publication productivity; historical and projected growth in publication output; the mix of publication types; etc. There are also inherent data limitations that vary somewhat between the countries.

Despite these influences, the different national studies produce very similar results and exhibit broadly similar patterns within the results. The cost-benefits of the open access or ‘author-pays’ publishing model are very similar across the three countries. In terms of estimated cost-benefits over a transitional period of 20 years, open access publishing all articles produced in universities in 2007 would have produced benefits of 2 to 3 times the costs in all cases, but showed benefits of 5 to 6 times costs in the simulated alternative ‘steady state’ model for unilateral national open access, and benefits of around 7 times the costs in an open access world.

The most obvious difference between the results relates to the ‘Green OA’ self-archiving and repositories model, which does not look quite as good in the Netherlands as in the UK and nothing like as good as it does in Denmark. This is due to the implied number of repositories, each with operational overheads. As modelled, the number of institutional repositories required in each country relates to the number of institutions and their operational overheads are shared across the number of articles produced and self-archived. For example, under the modelled assumptions for 2007, the Netherlands’ 86 higher education institutions’ repositories might have housed around 26,000 articles (302 each), the UK’s 168 higher education institutions’ repositories might have housed around 100,000 articles (595 each), and Denmark’s 8 universities’ repositories might have housed around 14,000 articles (1,750 each). These differences materially affect the implied per article cost of self-archiving.

Notwithstanding this difference, the modelling suggests that more open access alternatives are likely to be more cost-effective mechanisms for scholarly publishing in a wide range of

countries (large and small), with ‘Gold OA’ open access or author-pays publishing, the deconstructed or overlay journals model of self-archiving with overlay production and review services, and ‘Green OA’ self-archiving in parallel with subscription publishing progressively more cost-effective.

Conclusions and implications

The analysis summarised in this report compares three scholarly publishing models as if they were alternatives. In reality, of course, there are a number of variations and hybrids (*e.g.* delayed open access, open choice/author choice, etc.) and the models co-exist in various mixes in different fields of research. Nevertheless, these three models do have some key defining characteristics, and these characteristics have cost implications for producers, intermediaries and the users and consumers of content. They also have implications for the efficiency of research, the accessibility of research findings and their impacts, and, thereby, for returns to investment in R&D.

The potential cost implications for stakeholders throughout the scholarly communication system are summarised in Figures 6, 7 and 8 (above), which outline the cost implications of the three alternative models for funders, researchers and research institutions, publishers, research and special libraries. The estimated cost-benefit of the alternative models over 20 years are summarised in Table 5 (above).

Implications for funders

The operational costs of funding agencies are unlikely to change very much as a result of alternative publishing models, but there is likely to be an impact on the implied effective level of research funding – primarily through the diversion of research funding into author-side fees.

Noting that only around half of all open access journals actually charge author fees but that support for open access publishing would nevertheless be coming from the producer-side, we estimate that had all Denmark-authored journal articles been published in an entirely producer-pays open access publishing model in 2007, at DKK 16,500 per article published it would have cost around DKK 250 million nationally, of which around DKK 230 million would have been from the universities.

Balancing the negative impacts of such a diversion of research funding on the level of research activity against the positive impacts of enhanced accessibility and efficiency on returns to that R&D still conducted and system cost savings, we find that the benefits of enhanced accessibility and efficiency and potential system cost savings would be likely to outweigh the costs of diverting research funds to author-side open access publishing fees. However, the increased returns would be lagged and diffuse and the potential system savings would be realised primarily by research institutions and research users. Consequently, a policy decision to fund open access alternatives through the producer-side is required.

Implications for researchers

In addition to possible costs and cost savings, impacts on funding flows within research activities would be likely to revolve around possible differences in the use of researcher time and funding (*e.g.* in applying for and obtaining permissions versus self-archiving to a subject or institutional repository, etc.). Time and cost savings are likely to arise in such areas as: reduced search, discovery and access time through enhanced discoverability, greater accessibility and less use of authentication and access control and of proprietary silo access systems; and less time spent on seeking and obtaining permissions to reproduce copyrighted material in publications, text mine, etc. In addition to these savings, there are opportunities for new forms of analysis when the findings and record of research are openly available, due to both their accessibility and usability (*e.g.* permission to use for any purpose subject only to attribution). Independent scholars working outside mainstream institutions, as well as those from poorer institutions and poorer countries, could also benefit from more open access to scholarly publications.

Open access publishing may require author-side payments, and researchers in fields that are relatively poorly funded, those working without specific project funding, and independent scholars may find it difficult to pay unless there are specific funds made available to support publishing fees. Self-archiving also takes some additional time, but for the researcher the potential benefits from enhanced accessibility, broader readership and, potentially, increased citation are likely to make the effort worthwhile. Moreover, the act of self-archiving could be centrally organised and performed by specialist staff with more experience of metadata requirements and at a lower time/cost (*e.g.* through research libraries).

Implications for the universities and research institutions

From the perspective of universities and research institutions, research library acquisition and handling cost savings should also be factored in. Because research intensive institutions are both major producers and users of scholarly publications, research and library cost savings would offset additional producer-side costs. Nevertheless, research intensive institutions might pay relatively more in a producer-pays system, and it would be preferable to cover the direct costs of producer-side open access publishing fees from competitive and block grant funding. This might be scaled to outputs in the previous year, and would be likely to cost of the order of DKK 250 million per annum to publish journal article output in open access journals.

Similar support mechanisms could be offered for the operation of institutional repositories and, perhaps, open access book publishing. Enabling and supporting self-archiving through the operation of institutional repositories offers a number of potential benefits for universities and research institutions, not only through providing greater support to research, but also in providing a platform for hosting and showcasing the institutions research and maintaining a more complete record of it, which can assist the institution in research management and reporting functions. There are also potential benefits in hosting teaching and learning materials alongside research materials in integrated institutional repositories. Consequently, research institutions may see the operation of institutional repositories as an integral part of their

operations, and given relatively modest costs, it is unlikely that anything more than ‘facilitational’ central funding support would be required.

Implications for publishers and the publishing industry

Savings relating to publishing are captured in the publisher cost differences between the publishing models. Clearly, reduced costs imply reduced revenue flows from research users to publishers, although these reductions may be offset by revenue gains from selling value-adding services to a larger number of readers and/or authors and from alternative revenue streams (*e.g.* advertising).

For governments, there are taxation differences between alternative publishing models. Obviously, with no access charges levied in open access models there would be no Value-Added Tax (VAT) collected on subscriptions. However, VAT would be collected on the (domestic) provision of publisher services, including author-pays fees and fees for overlay services, depending on the domicile of content producers *vis-à-vis* publishers, and the VAT registration status of institutions. Consequently, while one might expect lower publisher production costs to imply somewhat lower taxation revenue in open access publishing and self-archiving models, the net impact is unlikely to be significant and will depend on the methods of payment and level of international publishing (*e.g.* whether or not authors publish with domestic or overseas publishers).

A reduction of revenue to the publishing industry, should such a reduction arise, would imply a reduction of activity and employment in the industry. Such adjustments are difficult for those concerned, but an economy is a dynamic system and, over the business cycle, is likely to achieve something close to ‘full employment’. As a result, the capital and labour no longer employed in publishing would be employed in an alternative activity. Given the relative size of the publishing industry and the rate at which alternative publishing models are being adopted, it is unlikely that Denmark’s economy would have difficulty adjusting to such a change.

The publishing industry in Denmark is an exporter, contributing as all exporters do to the balance of payments. However, scholarly publishing is a global activity with payments for scholarly content and services flowing both in and out. While it is impossible to predict how alternative publishing models would affect these payment flows, there is no obvious reason to expect the net effect to be large. For example, possible losses from reduced subscription payments inflows would be offset by reduced subscriptions payments outflows and increased author-pays fees and overlay services payments inflows to open access publishers.

Implications for research libraries

Savings relating to facilitating dissemination, retrieval and preservation are largely captured in the research library acquisition and handling cost differences between the publishing models. There are also library-related savings in such areas as operating and supporting access and authentication systems, permissions and copyright fees, etc.

It is difficult to say exactly how open access publications will be treated by research libraries and what role libraries would play in dissemination and preservation in these alternative

publishing models. Nevertheless, we suggest that research libraries will continue to play a key role in providing access to open access journals and self-archived content and have costed library handling activities accordingly.

With little evidence to date that open access self-archiving in parallel with subscription publishing (*i.e.* Green OA) leads to subscription cancellations, acquisition cost savings have not been included in that model. However, should they arise in the future, there would be potential for significant additional savings – as is indicated by the open access self-archiving with overlay services model.

As elsewhere, the potential cost savings are seen as efficiency gains. Such gains can be realised in two ways: (*i*) by producing the same output with fewer input resources, or (*ii*) by producing more output with the same resources. European countries, including Denmark, have set and are committed to ambitious R&D spending targets. In such an environment, there is little suggestion that there would be substitution at the margin. Savings realised would release resources to more research and research support activities, rather than being clawed back in funding cuts and result in job losses. Indeed, the savings suggested indicate the level of resources that could become available to libraries – as well as researchers, publishers and users of the scholarly content – to address the challenges of the digital age.

Implications for government and central agencies

Given the potential benefits, government and agency initiatives might focus on reducing the barriers to innovation in scholarly publishing models. This might involve:

- Ensuring that research evaluation is not a barrier to innovation (*e.g.* by developing and using metrics that support innovation in scholarly publishing, rather than relying on traditional evaluation metrics that reinforce and reward traditional publishing models and behaviours);
- Ensuring that there is funding for author or producer side fees (*e.g.* encouraging all research funders to make explicit provision for publication charges, and encouraging higher education and research institutions to establish funds to support publishing fees);
- Encouraging and funding the further development of institutional and/or subject repositories to enable author self-archiving; and
- Supporting advocacy initiatives to inform and educate funders, researchers and research managers about the potential impacts of alternative publishing models.

There is likely to be uncertainty during the coming years as to the direction and speed of a transition towards more open access to research findings through open access publishing and/or self-archiving, if there is such a transition, and there will be difficulties in shifting budgetary allocations around the system in such a context. Moreover, some of the savings and benefits resulting from alternative publishing models cannot be realised until some time after the costs have been met. Consequently, it seems inevitable that central allocations will be required at the funder, institutional and, perhaps, national levels.

However, estimated annual author-pays costs of around DKK 250 million for Denmark nationally and perhaps DKK 13 million nationally for a basic system of publications-oriented institutional repositories are relatively modest in comparison to Denmark's gross expenditure on R&D of more than DKK 40 billion per annum and higher education R&D expenditure of almost DKK 12 billion per annum. All the more so when system-wide cost savings as well as potential increases in the social returns to R&D resulting from more open access to research findings are likely to outweigh those costs. Nevertheless, however modest, the costs would have to be met, as would the costs associated with facilitating the structural, behavioural and cultural changes that would be necessary throughout the scholarly communication system.

Annex I Model parameters

Data for preliminary estimations are drawn from a range of local and international sources. The following tables describe the main parameters used and their sources.

Cost estimation parameters

Parameter	Basis	Value
FUND RESEARCH		
R&D expenditure	EuroStat, OECD & StatBank	GERD 43 bn, HERD 11.8 bn
Grant applications, grants and reviews	DCIR & DCSR	3,162 applications, 963 grants, 3,162 reviews
Review of grant applications	Agency consultation	Average 3 hours
Reviews per grant application	Agency consultation	1 per application
Peer review costs, per hour	Academic salaries including on-costs and overheads	Average DKK 783 per hour
PERFORM RESEARCH		
Researchers (FTE) (Excludes technicians & support)	EuroStat & OECD	29,573 (11,988 publication active researchers in universities)
Articles (peer reviewed)	WoK, SCOPUS & local counts, scaled (Björk <i>et al.</i> 2008)	Approx. 15,150 of which 13,750 in universities
Time to write a journal article	Tenopir and King (2000), King (2004)	90 to 100 hours, average 95
Time to peer review an article	Tenopir and King (2000), King (2004)	3 to 6 hours, average 4.5 hours
Number of peer reviewers per article	Tenopir and King (2000)	2 to 3 reviewers, average 2.5
Rejection and resubmission (article)	Author's estimate based on a consensus from the literature	50% rejected of which 60% are sent for external review and 40% rejected without review, and of which 75% are resubmitted once
Number of peer reviewers per monograph	Industry consultation	2 to 3 reviewers, average 2
Rejection and resubmission (monograph)	Author's estimate based on a consensus from the literature	20% rejected of which 50% are resubmitted once
Time spent on editorial activities	Industry consultation	10 to 30 days per annum, average 20
Time spent on editorial board activities	Industry consultation	½ to 1 day per year, average ¾
Percentage of authors who are editors and/or on editorial boards	Rowlands and Nicholas (2005)	8% and 24%, respectively
Number of readings per researcher per year	Tenopir and King (2000), subsequent tracking studies and Tenopir <i>et al.</i> (2008)	Industry/higher education: <ul style="list-style-type: none"> • Articles 130/270 rising to 280 • Books 53/48 • Reports 65/46 • Trade literature 51/74 • Other items 22/14
Time spent reading an article	Tenopir and King (2007) and Tenopir <i>et al.</i> (2008)	34 minutes falling to 31, but slightly higher for research, estimate 31

Parameter	Basis	Value
Time spent searching for and accessing an article	Tenopir and King (2007), CEPA (2008) and Tenopir <i>et al.</i> (2008)	8 to 17 minutes, average 12.5 but falling, estimate 12.5
Article requests per reading	Tenopir and King (2000), CEPA (2008)	1.3 to 1.4
Time spent by author obtaining permissions per article	Halliday and Oppenheim (1999)	1 to 4 hours, average 2
Percentage of articles photocopied or printed	CEPA (2008) and Tenopir <i>et al.</i> (2008)	20% print, 69% electronic
Cost of printing and copying per page	Author's estimate	0.55 Kr per page
Time spent printing or copying an article	Author's estimate	1 to 5 minutes, average 3
PUBLISH JOURNALS		
Pages per article	Tenopir and King (2000) and tracking studies, CEPA (2008), King <i>et al.</i> (2008)	11.7 to 14.3, estimate 12.4
Articles per issue	Tenopir and King (2000), CEPA (2008)	10 to 20, estimate 10
Issue per year	Tenopir and King (2000) and tracking studies, CEPA (2008)	8 to 16, estimate 12
Articles per title per year (location of average article)	Tenopir and King (2000) and tracking studies, Björk <i>et al.</i> (2008)	50 to 150, estimate 120
Non-article content pages	King (2007), King <i>et al.</i> (2008)	10% to 20%, estimate 14%
Article rejection rate	Consensus from literature	40% to 60%, estimate 50% (20% rejected without review)
Subscriptions per title	Tenopir and King (2000), CEPA (2008)	300 to 3,000, estimate 1,200
Management and investment margin	CEPA (2008)	20% to 25%, estimate 20%
Surplus / profit margin	CEPA (2008) adjusted	10% to 30%, estimate 20%
E-only delivery and fulfilment (relative to print)	CEPA (2008), Waltham (2005), etc. adjusted	25%
E-only content processing (relative to print)	CEPA (2008), Waltham (2005), etc. adjusted	25%
OA rights management (relative to toll)	Author's estimate	20%
OA user support (relative to toll)	Author's estimate	20%
'Author-pays' marketing and support costs (relative to toll)	Author's estimate	33%
OA hosting (relative to toll)	Author's estimate	50%
OA management and Investment (relative to toll)	Author's estimate	75%
OA surplus/profit (relative to toll)	Author's estimate	75%
PUBLISH MONOGRAPHS		
Pages per title	Watkinson (2001) and industry consultation	250 to 300, estimate 275

Parameter	Basis	Value
Print run per title	Watkinson (2001) and industry consultation	400 to 1,000, estimate 700
Sales per title	Watkinson (2001) and industry consultation	350 to 500, estimate 500
Average prices	Watkinson (2001), industry consultation and LISU	Kr 440 to 550, Average Kr 490
Publisher discounts (print)	Industry consultation	20% to 40%, estimate 30%
Peer reviewers per manuscript	Industry consultation	2 perhaps 3, estimate 2.25
E-only production, setting and printing (relative to print)	CEPA (2008), Waltham (2005), etc. adjusted	25%
E-only IT facilities (relative to print)	Author's estimate	200%
Toll access e-only facilities (relative to print)	Author's estimate	50%
OA e-only facilities (relative to toll and print)	Author's estimate	33%
OA rights management (relative to toll)	Author's estimate	20%
OA marketing and support costs (relative to toll)	Author's estimate	33%
OA management and overhead costs (relative to toll print)	Author's estimate	75%
DISSEMINATION		
University library expenditure, acquisitions and stocks	Danish Libraries	Acquisitions 94m, other costs 234m
Librarian salaries	Annual reports	DKK 369/hour (incl. overheads)
Author fees	Sample of OA journals	DKK 16,500 per article published
Repository counts	http://archives.eprints.org/	Current & estimated system

Source: Author's analysis.

Scenario parameters

Parameter	Basis	Value
FUND RESEARCH		
Funding, evaluation and reporting as a share of operational costs	Author's estimate	50%
Potential savings in these costs from enhanced access	Author's estimate	5% to 10%, estimate 5%
Returns to publicly funded R&D	Literature review (conservative consensus from the literature)	20% to 60%, estimate 20%
Improved allocations increase returns to R&D	Author's estimate	1% to 5%, estimate 2.5%
Increase in allocations to R&D	Author's estimate	1% to 5%, estimate 2.5%
PERFORM RESEARCH		
Search, discovery and access time saving through more open access	Author's estimate	5% to 10%, estimate 5%
Permissions time saving through more open access	Author's estimate	40% to 60%, estimate 50%
Peer review time saving through more open access	Author's estimate	5% to 20%, estimate 10%
Writing and preparation time saving through more open access	Author's estimate	5% to 10%, estimate 5%
PUBLISH		
Share of worldwide scholarly publishing output (articles)	Web of Knowledge, SCOPUS and Björk <i>et al.</i> (2008)	1.1%
Competition reduces publisher costs and margins	Author's estimate	5% to 10%, estimate 5%
DISSEMINATE		
Time for self-archiving per item	Harnad, Swan (2008), etc. adjusted	10 minutes
Self-archiving performance	Done by researcher at average cost per hour	Kr 130

Source: Author's analysis.

Modelling parameters

Parameter	Basis	Value
CHANGE IN ACCESSIBILITY		
Percentage change in accessibility (access)	(i) 50% of the 20% of the stock of knowledge that is journals (ii) 50% of the 40% of the stock of knowledge that is publications	10% to 20%
Percentage change in accessibility (OA citation)	(i) 25% of the 20% of the stock of knowledge that is journals (ii) 25% of the 40% of the stock of knowledge that is publications	5% to 10%
<i>Combined estimate of the percentage change in accessibility to be modelled</i>	<i>Conservative consensus of the above</i>	<i>5% to 10%, estimate 5%</i>
CHANGE IN EFFICIENCY		
Percentage change in efficiency (wasteful expenditure: duplicative research and blind alleys)	Author's estimate, for illustrative purposes	1% to 5%, estimate 2%
Percentage change in efficiency (new opportunities: collaborative opportunities)	Author's estimate, for illustrative purposes	1% to 5%, estimate 2%
Percentage change in efficiency (speeding up the process)	Author's estimate, for illustrative purposes	1% to 5%, estimate 2%
<i>Combined estimate of the percentage change in efficiency to be modelled</i>		<i>5%</i>
R&D ASSUMPTIONS		
Social returns to R&D	Conservative consensus from literature (Arundel and Geuna 2004)	20% to 60%, estimate 20%
Rate of growth in R&D spending	Statistics Denmark (Yearbook)	5% per annum (current prices)
Lag between R&D spending and impacts	Mansfield (1991, 1998)	3 years to publication plus 7 years to impact, 10 years
Discount rate (risk premium)	Conservative consensus from literature	10% per annum
Rate of cost increases	Scaled to growth in R&D spending	5% per annum

Source: Author's analysis.

Annex II Additional data tables

The following tables report detailed cost estimates for various scholarly communication related activities at 2007 prices and levels of activity.

Perform research and communicate the results

Table A1: Estimated annual costs: Perform research and communicate results – research related activities (DKK, circa 2007)

<i>Activity / Item</i>	<i>Estimate</i>
READING	
<i>Reading per year (National)</i>	16,346,400,000
Papers (journal)	3,548,000,000
Books (monographs + edited books)	9,172,400,000
Other (Conference papers, Reports, etc.)	3,626,000,000
Cost of reading by authors (National)	6,590,200,000
<i>Reading per year (Universities)</i>	8,261,200,000
Papers (journal)	2,235,300,000
Books (monographs + edited books)	4,449,900,000
Other (Conference papers, Reports, etc.)	1,576,000,000
Cost of reading by authors (Universities)	5,020,200,000
WRITING	
<i>Writing per year (National)</i>	2,741,600,000
Papers (journal & conference)	1,275,400,000
Books (monographs + edited books)	1,188,800,000
Chapters	277,400,000
<i>Writing per year (Universities)</i>	2,509,900,000
Papers (journal & conference)	1,146,500,000
Books (monographs + edited books)	1,105,400,000
Chapters	258,000,000
SEARCH & DISCOVERY	
Search and Discovery (National researchers)	3,121,200,000
Search and Discovery (University researchers)	949,300,000
PRINTING & COPYING (Universities)	
Print and copying	33,200,000
Total including time spent	174,300,000
PERMISSIONS	
Cost to authors (National researchers)	42,600,000
Cost to authors (University researchers)	39,300,000
Source: DK model: Author's analysis.	

Table A2: Estimated annual costs: Perform research and communicate results – publisher related activities (DKK, circa 2007)

<i>Activity / Item</i>	<i>Estimate</i>
PEER REVIEW	
Peer review per year (National)	390,800,000
Papers (journal & conference)	316,200,000
Books (monographs + edited books)	38,600,000
Chapters	36,000,000
Peer review per year (Universities)	356,300,000
Papers (journal & conference)	286,700,000
Books (monographs + edited books)	36,000,000
Chapters	33,600,000
JOURNAL EDITORIAL	
Editorial activities (National)	171,300,000
Editor activities	154,200,000
Editorial board activities	17,100,000
Editorial activities (Universities)	125,100,000
Editor activities	112,700,000
Editorial board activities	12,500,000

Source: DK model: Author's analysis.

Table A3: Estimated annual costs: Perform research and communicate results – research grants related activities (DKK, circa 2007)

<i>Activity / Item</i>	<i>Estimate</i>
RESEARCH GRANTS	
Grant applications (National)	272,730,000
Preparation of grant applications (National)	235,300,000
Review of grant applications (National)	7,400,000
Reporting grant project (National)	22,600,000
Administering grant projects (National)	7,430,000
Grant applications (Universities)	210,020,000
Preparation of grant applications (Universities)	181,200,000
Review of grant applications (Universities)	5,700,000
Reporting grant project (Universities)	17,400,000
Administering grant projects (Universities)	5,720,000

Note: Includes grants relating to DCIR and DCSR only.

Source: DK model: Author's analysis.

Publish scientific and scholarly works

Table A4: Estimated average publisher costs per article by format and model (DKK, circa 2007)

	<i>Estimate</i>
Subscription Journal Publishing	
Per article costs PRINT	29,753
Per article costs DUAL-MODE	35,407
Per article costs E-ONLY	25,487
OA Journal Publishing	
Per article costs PRINT	19,964
Per article costs DUAL-MODE	21,839
Per article costs E-ONLY	16,623
OA Self-archiving (Publisher overlay services)	
Peer review management as an overlay service	4,958
Editing and proofing as an overlay service	7,336
Hosting as an overlay service	1,442
<i>'Full service' overlay (per article)</i>	<i>13,736</i>

Note: These costs exclude the external costs of peer review and VAT. Overlay services include operating peer review management, editing, proofing and hosting, with commercial margins. Estimates for print and dual-mode OA publishing exclude print or subscriber related costs, assuming that the content is produced print ready and print is an add-on.

Source: DK model: Author's analysis.

Table A5: Estimated publisher costs of Denmark's research output (DKK, circa 2007)

<i>Source & type of publication</i>	<i>Estimate</i>
Universities (Published Outputs)	717,500,000
Journal articles	438,300,000
Conference papers	9,900,000
Books	212,600,000
Chapters	49,600,000
Other	7,000,000
National Research (Published Outputs)	779,600,000
Journal articles	482,300,000
Conference papers	10,600,000
Books	226,400,000
Chapters	52,800,000
Other*	7,500,000
Book distribution	
Total Universities authored and edited	91,130,000
Total National authored and edited	97,040,000

Notes: Book publisher costs are based on research monographs costs, but a small percentage of the books produced will be textbooks which have very different costs. Hence, these costs are no more than indicative.

Source: DK model: Author's analysis.

Table A6: OA versus toll access for journals: cost estimates by mode and model (DKK, circa 2007)

	<i>Estimate</i>
Costs per article	
Current mix of formats and models	31,870
All print subscription	29,750
All e-only subscription	25,490
All e-only OA publishing	16,620
All e-only OA self-archiving and overlay services	12,290
E-only impacts	4,270
OA publishing impacts	8,860
OA self-archiving and overlay impacts	13,190
OA publishing impact from current position	15,250
Costs of articles published (Universities)	
Current mix of formats and models	438,300,000
All print subscription	409,200,000
All e-only subscription	350,500,000
All e-only OA publishing	228,600,000
All e-only OA self-archiving and overlay services	169,100,000
E-only impacts	58,700,000
OA publishing impacts	121,900,000
OA publishing impact from current position	209,700,000
Costs of articles published (National)	
Current mix of formats and models	482,300,000
All print subscription	450,200,000
All e-only subscription	385,700,000
All e-only OA publishing	251,500,000
All e-only OA self-archiving and overlay services	186,000,000
E-only impacts	64,600,000
OA publishing impacts	134,100,000
OA publishing impact from current position	230,800,000

Note: These estimates were derived entirely from the bottom up, but they triangulate well with simple top down checks.

Source: DK model: Author's analysis.

Table A7: OA versus toll access for books: cost estimates by mode and model (DKK, circa 2007)

	<i>Estimate</i>
Costs per title	
Current mix (assuming all print toll)	171,770
All print toll access	171,770
All e-only toll access	123,460
All e-only OA	80,490
E-only impacts	48,310
OA impacts	42,970
OA impact from current position	91,280
 Costs of titles published (Universities)	
Current mix of formats and models	212,600,000
All print toll access	212,600,000
All e-only toll access	152,800,000
All e-only OA	99,600,000
E-only impacts	59,800,000
OA impacts	53,200,000
OA impact from current position	113,000,000
 Costs of titles published (National)	
Current mix of formats and models	226,400,000
All print toll access	226,400,000
All e-only toll access	162,800,000
All e-only OA	106,100,000
E-only impacts	63,700,000
OA impacts	56,600,000
OA impact from current position	120,300,000

Note: Includes authored and edited books, but excludes book chapters. These costings are based on research monographs, but outputs will include textbooks which have very different costs. Hence, they are no more than indicative.

Source: DK model: Author's analysis.

Facilitate dissemination, retrieval and preservation

Table A8: Estimated journal related university library activity costs per title (DKK, 2007)

<i>Activity</i>	<i>Open Access (e-only)</i>	<i>Electronic</i>	<i>Print</i>
Collection development	..	28.26	49.15
Negotiation & licensing	..	14.13	1.54
Subscription processing	..	38.86	110.58
Receipt & Check in	...	1.41	165.87
Routing	..	..	6.14
Cataloguing	35.32	35.32	135.15
Linking	5.30	5.30	6.14
Physical processing	..	0.71	154.81
Stacks maintenance	..	0.00	90.62
Circulation	14.13	14.13	165.87
Reference	91.84	91.84	165.87
User instruction	24.73	24.73	18.43
Preservation	0.71	0.71	12.29
Other	31.79	31.79	61.43
Total	204	287	1,144

Note: Approximate activity times reported by Schonfeld *et al.* (2004) and King *et al.* (2004) converted to 2007 Kroner based on university library staff costs, with electronic staff costs 15% higher than print to reflect different skill levels (as per the studies mentioned).

Source: DK model: Author's analysis.

Table A9: Estimated journal related university library activity costs (DKK, 2007)

<i>Activity</i>	<i>Electronic</i>	<i>Print</i>
Collection development	4,380,000	640,000
Negotiation & licensing	2,190,000	20,000
Subscription processing	6,020,000	1,430,000
Receipt & Check-in	220,000	2,140,000
Routing	..	80,000
Cataloguing	5,470,000	1,750,000
Linking	820,000	80,000
Physical processing	110,000	2,000,000
Stacks maintenance	..	1,170,000
Circulation	2,190,000	2,140,000
Reference	14,230,000	2,140,000
User instruction	3,830,000	240,000
Preservation	110,000	160,000
Other	4,930,000	790,000
Total	44,510,000	14,790,000

Note: Approximate activity times reported by Schonfeld *et al.* (2004) and King *et al.* (2004) converted to 2007 Kroner based on university library staff costs with electronic staff costs 15% higher than print to reflect different skill levels, and scaled to library acquisitions.

Source: DK model: Author's analysis.

Table A10: Estimated OA self-archiving costs (DKK, circa 2007)

	<i>Estimate</i>
Cost per year per repository	750,000
Operational costs of current repos per year (National)	9,750,000
Operational costs of current repos per year (Universities)	6,000,000
Cost of depositing per article	131
Cost of posting counted publications (National)	3,483,500
Cost of posting counted publications per year (Universities)	2,778,300
Cost of posting journal articles (National)	2,184,100
Cost of posting journal articles (Universities)	1,795,200
National system of OA repositories:	
Total cost of OARs per year (National)	13,233,500
Total cost of OARs per year if all HEIs had one	8,778,300

Note: National system costs include the cost of a single deposit of all published outputs.
Source: DK model: Author's analysis.

System costs and cost savings

Table A11: Estimated costs by publishing model per item (DKK, circa 2007)

	Journal: Per article			Book: Per title		
	<i>Toll Access</i>	<i>OA Publishing</i>	<i>OA Self-archiving</i>	<i>Toll Access</i>	<i>OA Publishing</i>	<i>OA Self-archiving</i>
<i>FUND</i>	..	..	..	..	..	..
<i>PERFORM</i>						
Write	74,408	74,408	74,408	892,893	892,893	892,893
Review	8,811	8,811	8,811	21,147	21,147	21,147
<i>PUBLISH</i>						
Publish e-only	25,487	16,623	12,294	123,457	80,489	73,102
Distribute	..	..	..	37,037	..	..
<i>DISSEMINATE</i>						
Handle e-only	2.39	1.70	1.70	287	204	204
IR operation	..	..	44	..	..	44
Deposit	..	..	131	..	..	131
<i>USE</i>	..	..	..	..	..	..
Total	108,709	99,844	95,689	1,074,822	994,734	987,520

Note: Includes e-only average estimated costs for each publishing model, and excludes toll access acquisition costs to avoid double counting (*i.e.* assuming that acquisition costs recoup publisher and distribution costs). VAT is also excluded. The costs of writing and reviewing are per manuscript written and reviewed, whereas other costs are per manuscript published and disseminated. The OA self-archiving with overlay services models are necessarily rather speculative, especially for books.
Source: DK model: Author's analysis.

Table A12: Estimated savings by publishing model: Journals only (DKK millions, circa 2007)

	<i>National</i>			<i>Higher Ed.</i>		
	<i>Toll</i>	<i>OAP</i>	<i>OASA</i>	<i>Toll</i>	<i>OAP</i>	<i>OASA</i>
FUND	..	12	12	..	5	5
PERFORM	..	214	214	..	135	135
PUBLISH	..	134	200	..	122	181
DISSEMINATE						
Handling	..	35	35	..	14	14
Acquisition
USE
Partial Total	..	395	461	..	276	336

Note: Includes e-only estimated cost savings for each publishing model, and excludes acquisition costs. Additional returns exclude the impacts of accessibility and efficiency on returns to R&D. National handling savings relate to public research libraries only.

Source: DK model: Author's analysis.

Annex III Major Danish Sources

CIRIUS (Information about Higher Education in Denmark).

Copenhagen University Library and Information Service (CULIS).

Danish Agency for Libraries and Media (Bibliotek og Medier).

Danish Agency for Science, Technology and Innovation (Danish Ministry of Science, Technology and Innovation).

Danish Council for Independent Research (<http://en.fi.dk/councils-commissions/the-danish-council-for-independent-research>).

Danish Council for Strategic Research (<http://en.fi.dk/councils-commissions/the-danish-council-for-strategic-research>).

Danish Library Agency (Danish Library Statistics).

Danish Research Agency (Figures for Research).

Danish Statistical Agency (DST StatBank).

Danish Statistical Agency (Statistical Yearbook 2008).

Danish Technical Information Centre.

Danmarks Forskningsbiblioteksforenings.

EuroStat (Science Indicators).

OECD (Main Science Indicators).

The Danish Rectors' Conference (The Danish University Sector in Figures).

Universities Denmark (Danske Universiteter).

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