

Costs and benefits of alternative scholarly publishing models: Lessons and developments

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Abstract

The JISC study *Economic implications of alternative scholarly publishing models: Exploring the costs and benefits*, released early in 2009, focused on three alternative models for scholarly publishing: subscription or toll access publishing, open access publishing using the author-pays model, and self-archiving. The research approach involved a combination of process mapping, activity costing and macro-economic modelling. Since its release, there have been six follow-on studies applying elements of the same basic methodology. This paper describes the research approach and explores some of the major issues arising and lessons learned from this ongoing research. Drawing on experience from a number of studies and countries, it attempts to distil and summarise the key research issues and policy messages arising.

Keywords: Scholarly publishing; economics of publishing; cost-benefit analysis; open access.

1. Introduction

The JISC report *Economic implications of alternative scholarly publishing models: Exploring the costs and benefits*[1] was greeted with praise in some quarters and opposition from others. During 2009, there were a number of follow-on studies. These included national studies in The Netherlands and Denmark, and a three-country comparison that explored the impacts of alternative scholarly publishing models for one of the larger (United Kingdom), a mid-sized (Netherlands) and one of the smaller European countries (Denmark). During the first half of 2010, there have been three further projects, two of which are still underway. The first focuses on Germany, and brings the

German National Licensing Program (NLP) into the mix of alternative scholarly communication models. The second, conducted by Alma Swan of Key Perspectives, focuses on the United Kingdom, using the JISC EI-ASPM on-line cost model to examine the cost implications of alternative scholarly publishing models for a sample of UK universities.[2] The third significantly extends one aspect of the underlying method used in the original study to explore the possible return on investment implications of the proposed *Federal Public Research Access Act* (FRPAA) in the United States. This paper explores some of the major issues arising and lessons learned from this ongoing research. Drawing on experience from a number of studies and countries, it attempts to distil and summarise the key research issues and policy messages arising.

2. The JISC EI-ASPM study

The JISC study *Economic implications of alternative scholarly publishing models: Exploring the costs and benefits*[3] focused on three alternative models for scholarly publishing: subscription or toll access publishing, open access publishing using the author-pays model, and self-archiving. Because self-archiving, of itself, does not constitute formal publication, analysis focused on two publishing models in which self-archiving is supplemented by the peer review and production activities necessary for formal publishing, namely: 'Green OA' self-archiving operating in parallel with subscription publishing, and the 'deconstructed' or 'overlay journals' model in which self-archiving provides the foundation for overlay journals and services.[4] Hence, each of the publishing models explored includes all of the key functions of formal scholarly publishing, including peer review and quality control.

The approach taken to the JISC EI-ASPM study involved a combination of process mapping, activity costing and macro-economic modelling, and the research process involved four main steps.

Process mapping

Björk (2007) developed a formal model of the scholarly communication lifecycle, based on the IDEF0 process modelling method which is often used in business process re-engineering.[5] 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. To provide a solid foundation for our analysis, we developed

Costs and benefits of alternative scholarly publishing models:

Lessons and developments

and extended Björk's model to include five core scholarly communication lifecycle 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. Each of these activities is further subdivided into a detailed description of the activities, inputs, outputs, controls and supporting mechanisms involved, creating a lifecycle process model with some 53 diagrams and 190 activities.[6]

Activity costing

This formal process model provided the foundation for detailed activity costing, using a spreadsheet-based cost model that included all of the elements in the lifecycle model, as well as the base data necessary for the study (*i.e.* relating to the UK and UK higher education). The costings relied primarily on existing sources, and collating activity cost information from a wide-ranging literature on scholarly communication and publishing.[7] Where necessary, these sources were supplemented by informal consultation with experts in the field. For the UK national and higher education data, we relied on national and international sources on R&D expenditure and personnel by activity and sector, expenditure and employment trends. Detailed data on higher education were sourced from such agencies as SCONUL and HESA. The resulting activity cost model included more than two thousand data elements.

Macro-economic modelling

To capture the impacts of alternative scholarly publishing models on returns to R&D expenditure, we developed a modified Solow-Swan model. The standard Solow-Swan approach makes some key simplifying assumptions, including that: all R&D generates knowledge that is useful in economic or social terms (*the efficiency of R&D*); and that all knowledge is equally accessible to all entities that could make productive use of it (*the accessibility of knowledge*). Addressing the fact that these assumptions are not realistic we introduced *accessibility* and *efficiency* into the standard model 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. Then we explored the impact on returns to R&D of changes in accessibility and efficiency.[8]

A stepwise approach

There were four main steps in the research process. In the first, we produced a detailed costing of all of the activities identified in the scholarly communication lifecycle model, focusing on areas where there were likely to be activity and, therefore, cost differences between the alternative publishing models. In the second, we summed the costs of the three publishing models through the main phases of the scholarly communication lifecycle, so we could explore potential system-wide cost differences between the alternative publishing models. In the third of the three major research steps, we used the modified Solow-Swan model to estimate the impact of changes in accessibility and efficiency on returns to R&D. The final step was to compare costs and benefits, for which we used the three elements outlined: (i) the direct costs associated with each of the models, (ii) the associated indirect system-wide costs and cost savings, and (iii) the benefits accruing from increases in returns to R&D resulting from increases in accessibility and efficiency. Because the returns to R&D lag expenditure and accrue over a number of years, the cost-benefit comparisons were made over a 20 year transitional period.

Findings and conclusions

Our analysis of the potential benefits of more open access to research findings suggested that open access could 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 overlay alternatives (*Gold OA*) and for parallel subscription publishing and self-archiving (*Green OA*).

For example, during a transitional period of 20 years we estimated that, in an all 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 the UK's universities using an author-pays system (*Gold OA*) might be around 3 times the costs;
- The combined cost savings and benefits from open access self-archiving in parallel with subscription publishing (*Green OA*) might be around 7 times the costs; and
- The combined cost savings and benefits from an alternative open access self-archiving system with overlay production and review services (*overlay journals*) might be around 4 times the costs.

While the benefits from unilateral national adoption of open access alternatives would be lower, they would be substantial – ranging from 2 to 4 times the costs.

3. Responses to the JISC EI-APSM study

Responses to the JISC report have been polarised. While recognising the inherent limitations in such modelling, academic and professional commentary has been generally positive. A detailed peer review of the report undertaken by Professor Danny Quah, Head of Economics at The London School of Economics, provides an example of the academic and professional reception of the work. He concluded:

The report addresses an important and difficult problem, and is clearly the result of a lot of very careful thinking about the issues. The methodology is sound and the analysis is extremely detailed and transparent. The multi-stage model of production that is used is complex, and does require calibration according to a large number of parameters, many of which are necessarily estimates, where possible taken from published sources or the wider literature. If demonstrably better estimates become available then these could improve that calibration still further. The report represents the best evidence so far on the questions it addresses.[9]

Initial comments from some publishers' representatives, including The Publishers' Association, the Association of Learned and Professional Society Publishers and the International Association of *stm* Publishers, focused on the modelling assumptions and calibration, while implicitly accepting the methodology and underlying analysis. Ware and Mabe (2009) summarised the critique, noting that:

"[The Houghton Report] underestimated the efficiencies of the current subscription system and the levels of access enjoyed by UK researchers. Many of the savings hypothesized would depend on the rest of the world adopting author-pays or self-archiving models. The calculated savings would remain hypothetical unless translated into job losses... Critics also argue that Houghton et al. underestimated the costs of switching to an author-pays model because they underestimated the true costs of publishing an article only, and because additional costs such as the infrastructure required to manage the many small publication charges were not included."[10]

Although referring to critics, Ware and Mabe (2009) failed to cite a single source. Nevertheless, JISC (2009) released a response addressing the

Costs and benefits of alternative scholarly publishing models:

Lessons and developments

criticisms soon after the release of the report and a response to Ware and Mabe was posted on the Liblicense-L list.[11]

Later in 2009, the International Association of *stm* Publishers commissioned Steven Hall to provide a critique of the JISC report, which resulted in a paper and presentation at the Berlin7 Conference. Hall's analysis rested on such claims as:

"The fact is, researchers today have immediate access to the vast majority of the scientific articles that they could need for their research."

"The fact is, the report's authors have failed to show that there is any real gap between the access that researchers have today to the scientific literature that they need and that which they might have under an open access model."[12]

Unfortunately, of course, the fact is that there is widespread evidence that such claims are baseless. Much of the evidence is cited in the JISC report, although some important studies have been published since which confirm, yet again, that access gaps remain a major concern. Ware (2009) reported that 73% of UK small firms experienced difficulties accessing articles and just 2% reported having all the access they needed.[13] As the Research Information Network recently noted:

"...access to research information content issues must be addressed if the UK research community is to operate effectively, producing high-quality research that has a wider social and economic impact."[14]

A response to Hall's critique is available from the Berlin7 Conference website.[15]

Much of the critique rests on the assertion that one should choose different variables. However, the project website has included an on-line version of the underlying cost model since the report's release, which allows anyone to experiment with alternative values for the major parameters (<http://www.cfses.com/EI-ASPM/>). Consequently, the critique rather misses the mark, as anyone could test different parameters and publish the results along with their evidence for the choice of alternative values. Moreover, our own sensitivity testing suggested that the bottom-line answer does not change for any plausible values that we have tried.

In the absence of any serious critique of the approach, subsequent studies have focused on its further development, refinement and application.

4. The three-country studies: a comparison

During 2009, the same basic approach as that used in the JISC study was applied in the Netherlands[16] and Denmark[17] with a view to exploring the potential impacts of alternative publishing models in a mid-sized and a smaller European country, as well as one of the larger European countries. For the purposes of presenting a summary of the three country studies in Brussels, Knowledge Exchange facilitated a workshop and released summary report.[18]

In exploring the potential impacts of alternative publishing models in the three countries, differences in the modelling *per se* were kept to a minimum, although some minor adjustment of the basic model to fit different national circumstances was necessary. Nevertheless, there are a number of factors that can affect the benefit/cost estimates for different countries. As modelled, these included 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; relative national and sectoral publication productivity; historical and projected growth in publication output; and the mix of publication types.

There are also inherent data limitations that varied somewhat between the countries. For example, in addition to cost differences between the countries, there were minor differences in the methods used to estimate full cost for researcher activities. In the UK, we used the official higher education costing methodology for full economic costing of research (TRAC fEC), for the Netherlands we used an averaged GERD/FTE researchers triangulating with a variation of a full cost model from the University of Amsterdam, and in Denmark we used a simple HERD/FTE researchers calculation. Minor differences between these methods relate primarily to the inclusion (exclusion) of the technicians counted among research personnel into (from) overheads. In addition, some UK R&D data related to 2006, whereas data for the Netherlands and Denmark were all from 2007.

Despite these influences, the different national studies produced very similar results and exhibited broadly similar patterns within the results. The cost-benefits of the open access 'author-pays' publishing model were similar across the three countries. In terms of estimated cost-benefits over a transitional period of 20 years – open access publishing all articles produced

Costs and benefits of alternative scholarly publishing models:

Lessons and developments

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 all open access world.

One observable difference related to scale and the impacts of unilateral national adoption of open access, with the benefits of worldwide adoption being relatively larger for smaller countries as they produce a smaller share of the world's journal articles. However, the most obvious difference between the results related to the 'Green OA' self-archiving and repositories model, which did not look quite as good in the Netherlands as in the UK and nothing like as good as it did 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 related to the number of institutions and their operational overheads were shared across the number of articles produced and archived. For example, under the modelled assumptions, for 2007 outputs, the Netherlands' 86 higher education institutional repositories might have housed around 26,000 articles (an average of 302 each from that year), the UK's 168 higher education institutional repositories might have housed around 100,000 articles (an average of 595 each from that year), and Denmark's 8 universities' repositories might have housed around 14,000 articles (an average of 1,750 each from that year). As modelled, these differences materially affected the implied per article cost of self-archiving. Of course, had we used a averaged per article lifecycle costing, these differences would not have been apparent.

Notwithstanding these differences, the modelling suggested that open access alternatives would be likely to be more cost-effective in a wide range of countries (large and small), with 'Gold OA' 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.

5. Germany: incorporating the NLP

As a part of a much larger ongoing project, funded by DfG in Germany, we have been working with colleagues at Goethe Universität in Frankfurt on a study that brings the German National Licensing Program (NLP) into the mix of alternative models, and compares the NLP with the subscription and open access alternatives.

Costs and benefits of alternative scholarly publishing models:

Lessons and developments

The German NLP provides enhanced access for researchers in Germany through an extended form of consortial purchasing and licensing. While it centralises a number of activities in the lifecycle process relating to facilitating dissemination, retrieval and preservation (e.g. negotiation and licensing), the NLP does not fundamentally change the activities performed. Since the scholarly communication lifecycle process model focuses on activities without pre-judging which actors undertake them, incorporating the NLP has not necessitated changes to the underlying process model.

Nevertheless, the German NLP does impact a number of the five main activity areas in the scholarly communication lifecycle.

- ***Fund research and research communication:*** The NLP has little or no impact on the activities performed by research funders, with the exception of DfG which funds it, so no impacts were included in the modelling.
- ***Perform research and communicate the results:*** With the exception of time saving related to permissions and research reporting, the NLP facilitates much the same potential time saving as open access alternatives for German researchers, but scaled to the share of worldwide journal articles/titles that are encompassed by the NLP.
- ***Publish scientific and scholarly works:*** While it could be seen as a new sales strategy for publishers, the NLP has little or no impact on publisher costs except for possible minor savings on marketing, the operation of servers and user support. As these activities are still performed for content lying outside the NLP and the rest of the world outside Germany these impacts were excluded.
- ***Facilitate dissemination, retrieval and preservation:*** The NLP leads to research library savings in handling, support and purchasing and negotiation activities, scaled to the number of titles in the NLP. The counter-factual to the NLP is not readily knowable as we cannot know if the NLP content would have been subscribed to without the NLP. Hence we explored per title impacts, then multiplied by the number of titles accessible through subscriptions and through the NLP (combined). It is assumed that the NLP reduces non-negotiation and licensing subscription-related library activities by 50% (i.e. 50% of the non-negotiation and licensing subscription-related activity is handled centrally under the NLP and 50% is still done by the institutional research library).
- ***Study publications and apply the knowledge:*** The impacts of the NLP on accessibility and efficiency were modelled as follows:

Costs and benefits of alternative scholarly publishing models:

Lessons and developments

- In relation to accessibility, the NLP leads to (i) a marginal increase in returns to German R&D through an increase in German access, which would be very small and was not included; and (ii) no increase in access to German research outside Germany, as it is published in the same way; and
- In relation to efficiency, the NLP's impacts are less than those of open access as it has no impact on the speed of publication and facilitates domestic collaboration only. Hence the efficiency impacts were scaled.

There is one important difference between the comparisons undertaken in the German study and those that preceded it. Subscription and open access publishing perform very different roles. To the limits of affordability, subscription access seeks to provide an institution's or country's researchers with access to the worldwide research literature; whereas open access seeks to provide worldwide access to an institution's or country's research output. These are very different things, but to compare cost-effectiveness it is necessary to compare like with like. Consequently, the JISC EI-ASPM study compared the costs associated with publishing, handling and accessing UK article output under different models. In contrast, the German study compares the costs of operating within alternative models. This does not compare the cost of using alternative models to achieve a comparable task, rather it compares the cost implications of the alternative models for a particular actor or actors (in this case for Germany).

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 found that the benefits of open access publishing models were likely to substantially outweigh the costs. The German National Licensing Program (NLP) returned the highest benefit/cost ratio during a transitional period and the second highest (to 'Green OA' self-archiving) in a simulated steady state alternative scenario. Whether 'Green OA' self-archiving in parallel with subscriptions is a sustainable model over the longer term is uncertain. So too is the potential for developments in open access or other scholarly publishing business models to significantly change the relative cost-benefit of the NLP over time.

Currently, the project focus is on ascertaining what impact the NLP may have on: (i) the take up of open access alternatives in Germany (*e.g.* by improving access for German researchers, does it reduce awareness of and pressures for open access, or does it enhance awareness of the importance of access?), and (ii) levels and patterns of use of the content available (*e.g.* does

the NLP materially affect usage patterns, perhaps increasing usage, and, if so, how does usage under the NLP compare with that under open access?).

6. Impacts on UK universities

Alma Swan, of Key Perspectives, has recently completed another follow-on study for JISC in which she applied the on-line cost model produced as a part of the original JISC EI-ASPM study to an examination of the cost and benefit implications of alternative publishing models for a small sample of UK universities.[19] As in the German study, Swan compared the costs of operating within alternative models, in this case for a sample of universities, by setting the cost of publishing UK articles under alternative publishing models against the costs of subscription to that share of worldwide articles currently subscribed to. Again, this does not compare the cost of using alternative models to achieve a comparable task, rather it compares the cost implications of the alternative models for a particular actor or actors (in this case a sample of UK universities).

Swan found that:

- There are potential economic savings for universities from open access. Economic savings accrue to universities according to the detail of how each operates its library services and its repository, and the level of research intensiveness of the institution.
- Moving to open access as the basis for disseminating research outputs can bring economic and academic benefits for all universities, though the most research-intensive universities may face additional costs under some conditions.
- If universities continue to pay for subscription-based journals while simultaneously making their outputs freely available through their repositories, as they currently do, they are likely to make savings. Savings accrue from increased efficiencies in the research and library handling processes.
- If universities switch from the current subscription-based system to publishing all their articles in open access journals that charge an article-processing fee, there would be savings for all universities with the article-processing fee at GBP 700 per article or less.

Swan showed how universities can compare the impacts of alternative publishing models for themselves, and that by looking at whole-of-system costs we can start to question the simplistic arguments that suggest that in research-intensive universities author-pays fees may be higher than current

subscription expenditures. While that may be true in some cases, it is apparent from this study that the potential savings in research time, library handling costs, etc. that could arise from more open access would also be greatest in the more research-intensive universities.

7. The United States: incorporating the FRPAA

Early in 2010, the Scholarly Publishing and Academic Resources Coalition (SPARC) supported a feasibility study that sought to outline one possible approach to measuring the impacts of the proposed US *Federal Research Public Access Act* (FRPAA) on returns to public investment in R&D.[20] The aim of the study was to define and scope the data collection requirements and further model developments necessary for a robust estimate of the likely impacts of the proposed FRPAA archiving mandate.

The project involved a major shift from previous studies in that its focus was on the modified Solow-Swan model, rather than the scholarly communication lifecycle model or the associated activity cost model. That focus enabled further development and refinement of the modified model, particularly in relation to the most appropriate lag and distribution over time of returns to R&D, the most appropriate depreciation rate for the underlying stock of R&D knowledge arising from federally funded R&D, and metrics to measure potential changes in accessibility and efficiency.

As noted, the standard approach makes some key simplifying assumptions, including that all R&D generates knowledge that is useful in economic or social terms (*the efficiency of R&D*), and that all knowledge is equally accessible to all entities that could make productive use of it (*the accessibility of knowledge*). These assumptions are not realistic. In the real world, there are limits and barriers to access and limits to the usefulness of knowledge. So, we introduced *accessibility* and *efficiency* into the standard model as negative or friction variables, and then looked at the impact on returns to R&D of reducing the friction by increasing *accessibility* and *efficiency*.

To operationalise the model it was necessary to establish values for the *accessibility* and *efficiency* parameters, as well as a number of other parameters, such as rates of return to R&D and of depreciation of the underlying stock of research knowledge. To establish plausible base case values for these parameters we drew on the extensive literature on returns to R&D.[21]

Costs and benefits of alternative scholarly publishing models:

Lessons and developments

The other piece of the puzzle is the input data required for the modelling. These include the implied archiving costs, the volume of federally funded research outputs (journal articles), and the levels of federal research funding and expenditure trends. For the purposes of preliminary analysis we used publicly available sources and published estimates. Data relating to federal research funding, activities and outputs were taken from the National Science Board *Science and Engineering Indicators 2010*,[22] and we explored three sources for archiving costs: the LIFE² Project lifecycle costs,[23] and submission equivalent costings from arXiv[24] and NIH.[25] In order to enable anyone to use alternative values for the various parameters, test sensitivities and explore the issues for themselves, we created a simplified model in MS Excel format.[26]

Preliminary modelling suggests that over a transitional period of 30 years, the potential *incremental* benefits of the proposed FRPAA archiving mandate for all federally funded R&D might be worth around 3 times the estimated cost using the higher end LIFE² lifecycle costing, 6 times the cost using the NIH costing and 17 times the cost using the arXiv costing. Perhaps two-thirds of these benefits would accrue within the US, with the remainder spilling over to other countries. Hence, the US national benefits might be of the order of 2 to 11 times the costs.

Exploring sensitivities in the model in order to identify major sensitivities and, thereby, prioritise areas for further data collection and model development, we found that the benefits exceed the costs over a wide range of values. Indeed, it is difficult to imagine any plausible values for the input data and model parameters that would lead to a fundamentally different answer.

8. Summary and conclusions

With the exception of the US project, the studies have combined three main approaches: a scholarly communication lifecycle or process re-engineering model; a spreadsheet-based activity cost model; and a modified macro-economic model into which we introduced accessibility and efficiency as negative variables. The studies sought to map activities throughout the scholarly communication lifecycle, then attach costs to each of the activities to explore the direct activity cost differences and indirect system-wide cost differences between publishing models. The modified Solow-Swan model was used to explore the impact of increased accessibility on returns to R&D. In the final step, the costs are set against system-wide cost savings and

benefits in the form of increases in returns to R&D to estimate cost-benefits. While there are many limitations to such modeling, the results were not particularly sensitive. We found that the benefits of more open access exceeded the costs across a wide range of values, and it is difficult to imagine any plausible values for the main variables that would result in a fundamentally different answer.

Given the sometimes heated debate on open access and the detail and complexity of the research methods used, it is perhaps not surprising that reactions have been polarized and somewhat piecemeal. While recognising the inherent limitations in such modelling, academic and professional commentary has been generally positive. Comments from some publishers' representatives have been critical, focusing on the details of the modelling assumptions and calibration. Much of the critical comment has been based on unsubstantiated claims, misunderstandings and falsehoods, and we have provided a response to each of the commentators. We have also provided on-line versions of the models to enable anyone to explore the impacts of using their own preferred values for the main variables.

Given that there has been no substantive critique of the work and that the results appear to hold across a wide range of values and a range of countries, the evidence would seem to suggest that more open access could have substantial net benefits in the longer term, and while net benefits may be smaller during a transitional period, they are likely to be positive for both open access publishing and overlay alternatives (*Gold OA*) and for parallel subscription publishing and self-archiving (*Green OA*). At the institutional level, Swan (2010) has shown that the benefits would be likely to outweigh the costs for all but the most research-intensive of universities.[27]

Given the capacity to enhance access at very little cost, self-archiving alternatives appear to be the more cost-effective – although whether self-archiving in parallel with subscriptions is a sustainable model over the longer term is debateable. Similarly, the German NLP provides enhanced access for researchers in Germany through an extended form of consortial purchasing and licensing, which by centralising certain library subscription-related activities is effectively negative cost (*i.e.* the centralised costs are less than the de-centralised cost savings). Hence, it too provides a highly cost-effective avenue for enhanced access. The downside risks of such a program include the potential for developments in open access or other scholarly publishing business models to significantly erode the relative cost-benefit of the NLP over time, and the potential impact the NLP may have on slowing the take up of open access alternatives in Germany (*e.g.* by improving access for German

*Costs and benefits of alternative scholarly publishing models:
Lessons and developments*

researchers, does it reduce awareness of and pressures for open access, or does it enhance awareness of the importance of access?).

Nevertheless, the evidence would suggest that archiving policies and mandates, be they at the national, sectoral, funder or institutional levels, can enhance accessibility and improve efficiency at relatively little cost and with no immediate disruptive change to scholarly publishing practices and traditions. As such, archiving mandates provide an obvious focus for policy and implementation activities in the immediate term, while more fundamental changes to scholarly communication practices evolve over time.

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Costs and benefits of alternative scholarly publishing models:

Lessons and developments

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Costs and benefits of alternative scholarly publishing models:

Lessons and developments

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Lessons and developments

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