

Business Process Costs of Implementing “Gold” and “Green” Open Access in Institutional and National Contexts

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As open access (OA) publication of research outputs becomes increasingly common and is mandated by institutions and research funders, it is important to understand different aspects of the costs involved. This paper provides an early review of administrative costs incurred by universities in making research outputs OA, either via publication in journals (“Gold” OA), involving payment of article-processing charges (APCs), or via deposit in repositories (“Green” OA). Using data from 29 UK institutions, it finds that the administrative time, as well as the cost incurred by universities, to make an article OA using the Gold route is over 2.5 times higher than Green. Costs are then modeled at a national level using recent UK policy initiatives from Research Councils UK and the Higher Education Funding Councils’ Research Excellence Framework as case studies. The study also demonstrates that the costs of complying with research funders’ OA policies are considerably higher than where an OA publication is left entirely to authors’ discretion. Key target areas for future efficiencies in the business processes are identified and potential cost savings calculated. The analysis is designed to inform ongoing policy development at the institutional and national levels.

Introduction

While some of the costs of open access (OA) publishing and dissemination have been explored in detail, others have received little attention. Existing studies have focused mostly on two areas. The first relates to business models for OA journal publishing (“Gold” OA), particularly the market for article-processing charges (APCs) (Björk, 2012; Björk & Solomon, 2012, 2014a; Jubb, 2011). The second concentrates on the costs associated with the set-up of repositories for OA research outputs (“Green” OA), with studies often focusing on institutional repositories (Barton & Walker, 2003; Burns, Lana, & Budd, 2013; Swan, 2008). In contrast, little work is available on the costs to academic institutions of the business processes associated with making articles OA via either the Gold or Green routes.

Estimating the administrative costs incurred by universities in this area is, however, particularly important in the context of the policies of research funders encouraging or mandating open access, which are now becoming increasingly common. As of January 2015, the SHERPA/Juliet service (SHERPA, n.d.) listed a total of 32 funders globally requiring OA publication, and 92 requiring OA archiving of publications. In the UK, policies have been introduced by government-funded agencies, such as Research Councils UK (RCUK) (RCUK, 2013) and the Higher Education Funding Councils (HEFCE, 2014b), and charity funders, such as the Wellcome Trust (Walport & Kiley, 2006; Wellcome Trust, 2012, 2014). These policies allow for both Gold and Green OA but with different preferences and

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emphases, and, therefore, different implications for institutions in terms of administrative costs. RCUK, Wellcome, and the Charities Open Access Fund policies place an emphasis on Gold OA and include the provision of block grants for institutions to pay for APCs. In contrast, the HEFCE (Higher Education Funding Council for England) policy, which will be fully operational in 2016, prioritizes Green OA, requiring that every output submitted to the next national research quality evaluation exercise (the Research Excellence Framework or REF) be deposited in an OA repository on its acceptance for publication.

As higher education institutions (HEIs) put in place systems and processes to enable more of their publications to be openly available in such a way as to ensure compliance with these policies, understanding the cost implications of making research OA becomes paramount for HEIs (in order to enable more informed planning of resource allocation). For governments and research funders, a better understanding of costs is important in order to inform future development of policy initiatives. At present, however, it is unclear precisely what the cost implications of compliance with these policies are. Cost components, such as APCs, have begun to be better understood (Björk & Solomon, 2014b; Pinfield, Salter, & Bath, 2015), but implementation costs (such as for administration, communication, and technical infrastructure) need further investigation.

This paper investigates the costs of OA implementation to institutions based on data gathered from UK HEIs. It focuses in particular on administration costs associated with making articles OA by either the Gold or Green routes while also taking into account the cost of complying with policy mandates. In doing so, this study contributes to the ongoing debate about OA implementation, helping to inform policy decisions at institutional and national levels.

Research Context

Concerns about administration issues associated with both Green and Gold OA are not new. Librarians and repository managers have noted that the time taken to deposit items in repositories would act as a disincentive to authors to make their work OA (Ashworth, Mackie, & Nixon, 2004; Watson, 2007). A common solution to this problem has been for support staff (usually from the library) to carry out most of the administrative work in order to minimize academic staff time on such workflows (Afshari & Jones, 2013; Salo, 2008) and enhance the quality of the metadata in repositories (Joint, 2006). Others have emphasized the importance of “mandates” (institutional or funder) to encourage deposit (Harnad, 2009; Pinfield, 2005; Sale, 2006; Swan, 2006). Some commentators, however, have sought to de-emphasize the significance of the self-archiving effort. For example, Harnad (2011) states:

The years of experience of the 15% of authors who have been providing Green OA spontaneously, unmandated, as well as the weblog analyses done on the timing and the number of

keystrokes involved in actual deposits show that IR [institutional repository] deposit time is about 6–10 minutes per paper. (Harnad, 2011, p. 36)

Harnad also criticized repository administrators for what he sees as unnecessary administrative effort in, for example, checking for copyright compliance before making papers available (Harnad, 2014).

Concerns raised regarding Gold OA administration have often focused on the complexity of current processes, particularly the time taken to manage micro-payments for different publishers (Harris, 2013). Solutions to that problem have tended to focus on prepayment or membership schemes (Kingsley, 2014) and the role of intermediaries in handling APCs (RIN, 2012), both as a means of creating economies of scale. There is, however, acknowledgment that business processes are still immature in this area and there is room for significant efficiency gains (Jisc, n.d.).

Despite such concerns, there have been few attempts to cost systematically administrative processes for either Green or Gold OA. Studies that have done so have normally examined the costs as part of large-scale modeling exercises covering the entire scholarly communication system. For example, the Houghton report (Houghton et al., 2009) estimated the cost of depositing in repositories to be £9.35 per deposit, allowing for 10 minutes of academic staff time, calculated on the basis of average academic staff salaries and including on-costs and overheads. Scaling up this estimate, they calculated that:

If all publications produced during 2007 had been self-archived (a single deposit), we estimate that it would have cost around £1.6 million in the UK nationally and £1.3 million in higher education. The self-archiving of all journal articles alone, would have cost around £1 million nationally and £920,000 in higher education, although self-archiving journal articles is likely to involve more than one posting (e.g., pre-print, final author and/or publisher versions). Hence these self-archiving costs are likely to be lower bound estimates. (Houghton et al., 2009, p. 176)

The report was primarily produced to model the costs and benefits of different possible scholarly communication scenarios rather than provide a detailed analysis of current processes. As such, it has clear limits: first, it only includes academic staff time in its estimates; second, it does not include any breakdown of costs for Green OA; and finally, it does not provide any equivalent costing for Gold OA. It seems to have assumed more automated payment of APCs as part of future Gold OA scenarios rather than author-based payment.

A more recent attempt to estimate Green OA administration costs was carried out by the PEER (Publishing and the Ecology of European Research) project (PEER, 2011), which focused on analyzing the impact of repositories on the scholarly communication environment. Based on an investigation of a number of European repositories, they concluded:

... the reported cost of processing per document for repositories is 10 EUR maximum per reference archived and 18 EUR maximum per full text document, and 43 EUR maximum per journal article. The cost includes metadata creation. (PEER, 2011, p. 46)

These estimates focus on administrative time and effort. However, it is unclear the extent to which costs of any outsourced administrative effort and author time are included in the study.

More recently, Pinfield et al. (2015) attempted to assess the costs of Gold OA administration as part of the overall "total cost of publication" (TCP) for institutions. Following Willetts (2014), they defined the total cost of publication as consisting of journal subscriptions, OA APCs, plus any new administration costs associated with paying APCs. In their study based on data from 23 UK institutions collected in 2014 they found wide variation in administration costs:

... there was ... no clear pattern in the data resulting, for example, in a consistent [administration] cost per APC paid. Of those institutions providing sufficient data allowing such calculations, figures of administrative cost per APC varied from £66 to £665. (Pinfield et al., 2015, p. 15)

As a result, the study did not include administration costs in their total costs of publication modeling. These costs are often "hidden" and remain unfunded by research funders.

In late 2014 the London Higher organization and SPARC Europe commissioned a research project aimed at identifying specific costs for Gold and Green OA processes and also other costs associated with complying with funder requirements (Research Consulting, 2014). Building on that research, this article seeks to address the following questions:

1. What does it cost institutions to make research articles OA through the Gold and Green routes?
2. How do these costs scale for an entire country, taking account of any additional costs associated with implementing policy initiatives promoting OA?
3. How might efficiencies in these processes be achieved in the future?

These questions were considered in particular for the UK, taking into account policy developments, especially those of RCUK and the Higher Education Funding Councils, but have been addressed in such a way as to make the analysis applicable to other policy initiatives outside the UK.

Methods

Approach

Data were gathered via a web-based survey open to all UK HEIs and public sector research establishments (PSREs), followed by a series of in-depth discussions with a subset of the participating institutions. Potential respondents were encouraged to respond through a range of

mailing lists and social media channels. Data were received from a total of 29 institutions (28 HEIs and one PSRE, listed in the Appendix) on a range of quantitative and qualitative aspects of OA management, and respondents tended to be mid-level managers in institutional libraries with roles often involving management of the processes concerned. These data were combined with publicly available information from sources including the Higher Education Statistics Agency (average salary data), RCUK (institutional block grant allocations and compliance targets), and HEFCE (numbers of articles submitted to the 2014 REF) to generate the findings in this report. A data set showing anonymized survey responses and the workings used to calculate the findings of this study is also available (Johnson, 2014).

The survey asked respondents to provide the following information:

- Time estimates for processing articles through the Gold and Green routes (with "best case," average and "worst case" figures in each case, and for each identified stage of the process).
- Estimates of the time spent managing and implementing the RCUK policy (in full time equivalent staff numbers, or FTEs) in 2013/14.
- Details of other costs incurred in supporting, promoting or facilitating OA.
- Spend on APCs, in total and from RCUK funds, and number of article deposits, in total and for RCUK-funded articles.
- Total number of publications and expenditure on serials per year (for contextual purposes only).
- Free text comments on a range of questions about the RCUK and REF OA policies, and institutional approaches to the management of OA.

The majority of the survey questions were optional, in recognition of the fact that many institutions would find it difficult to provide the requested information in full. Twenty-five complete submissions were received, and a large number of partial responses. Four of these were found to contain useful information, and permission was obtained from the institutions in question to include these data in the analysis. A small number of outlying results were queried with respondents, and corrected where appropriate.

In order to minimize the burden on respondents, the survey requested data on staff time and FTEs only, not salary costs. Average salaries listed by HESA (the Higher Education Statistical Agency) were used to convert the survey data into costs as follows:

- *Author time for Gold and Green routes*—HESA UK average salary for "Academic Staff."
- *Peer review time for Gold routes*—HESA UK average salary for "Professors."
- *Administrative time for Gold and Green routes, and policy implementation*—HESA UK average salary for "Professional, Technical and Clerical Staff."
- *Academic management time*—HESA UK average salary for "Academic Managers."

In each case HESA average salaries for the 2012/13 academic year were obtained from the HESA website, uplifted by 1% to reflect the 2013/14 pay award, and uplifted by between 24% and 27% to allow for employer's on-costs (National Insurance tax and superannuation).

The estimates of time for processing APCs provided by each institution for the Gold and Green process were collated, and an average figure calculated for each stage, giving best-case, worst-case, and average scenarios. Weighted averages were also calculated. These reflected the number of RCUK APC payments and the number of RCUK article deposits reported by each responding institution, as a percentage of the total across all the respondents. Time estimates in minutes were converted to hours, and then converted into costs using a standard working year of 1,650 hours and the salary costs referred to earlier.

A range of options for calculating overhead costs associated with article administration and the implementation of OA policies were considered. The accepted approach to costing research activity in UK HEIs is the full economic costing (fEC) methodology (HEFCE, 2014a). Using this methodology in this case was not considered appropriate, since the majority of the staff time relates to administrators and academic managers, who do not attract overheads under fEC. In view of this, a fixed overhead rate of 50% on all staff costs was adopted, which is considered to represent a reasonable estimate of overheads. It is important to note this approach to calculation of overheads as it has a significant impact on the costs reported in this study.

Institutions were asked to estimate the amount of time, in FTEs, spent responding to and implementing RCUK's OA policy in 2013/14. Institutions also provided details on other costs incurred in support of OA during the 2013/14 year, which were aggregated into two general headings of "Systems and software" and "Other costs." Each institution's results were allocated to one of four groups based on the level of block grant funding for APCs received in the 2013/14 academic year, and an average set of costs for that group was determined. This average was then multiplied by the total number of UK institutions in the group in order to calculate an estimated cost for the UK sector as a whole.

Limitations

OA remains a rapidly evolving area, with little stability in the arrangements for its management within HEIs and PSREs. Inevitably, this means the findings of this study are subject to a number of limitations. The information collected relates only to identifiable costs associated with the implementation of the RCUK OA policy. In many cases institutions will have incurred other OA costs, which may be met by other funders (such as the Wellcome Trust) or from their own resources. Previous work in this area has established that institutions cannot provide reliable data on the value of APCs met directly from research project grants or departmental funds (Woodward & Henderson, 2014). Such costs

were considered to be outside the scope of this study, but may nonetheless be significant.

The data collected on time spent on the Gold and Green routes to OA are based on estimates provided by survey respondents. In many cases, these represent the estimates of a single member of staff, but relate to activities completed by academic and administrative staff located across the organization. Furthermore, the findings are based on the responses of 29 organizations, which collectively were in receipt of £7.7m of RCUK block grant funding for OA in 2013/14 (or 46% of the total). While this represents a good overall response rate for a survey of this type, lower response rates to some questions and from some institutional groups mean the results may not be wholly representative. A full list of respondents can be found in the Appendix.

More generally, the study focuses on costs and makes no attempt to identify benefits of these aspects of OA. This is not intended to create a negative impression of OA, merely to gain a fuller understanding of implementation issues. The benefits of OA in general have been discussed in detail elsewhere (e.g., Suber, 2012; Willinsky, 2006). This study also considers the administrative implications of a move to OA for one group of stakeholders in the scholarly communications process, academic institutions. However, OA also places an additional administrative burden on publishers and funders, which was not within the scope of this study to assess.

Results

Article-Level Time Costs

Gold OA. The data collected as part of this study have allowed the typical cost to institutions of administering an APC to be estimated. In order to gain specific cost estimates, the process was divided into a number of stages, with time estimates requested for each. These stages were identified and agreed through initial consultation with a subset of the survey participants and were as follows:

- **Author:** Identify requirement or option to make article Gold OA, direct request to appropriate point in the institution, provide relevant information to administrative staff.
- **Administrator—Triage:** Receive and review a request, confirm whether Gold is appropriate, identify steps required to make article Gold OA.
- **Administrator—Payment:** Request and pay invoice/use purchase card to pay invoice/advise author on use of prepayment account, liaise with publisher.
- **Administrator—Closure:** Confirm payment is made correctly, reconciliation of prepayment accounts to finance system, check article is made OA and correct license applied.

Institutional responses varied from as little as 40 minutes to over 5 hours, although these extreme examples come from smaller institutions handling a relatively low volume of articles. The full range of institutional responses is shown in Figure 1 (sorted in ascending order).

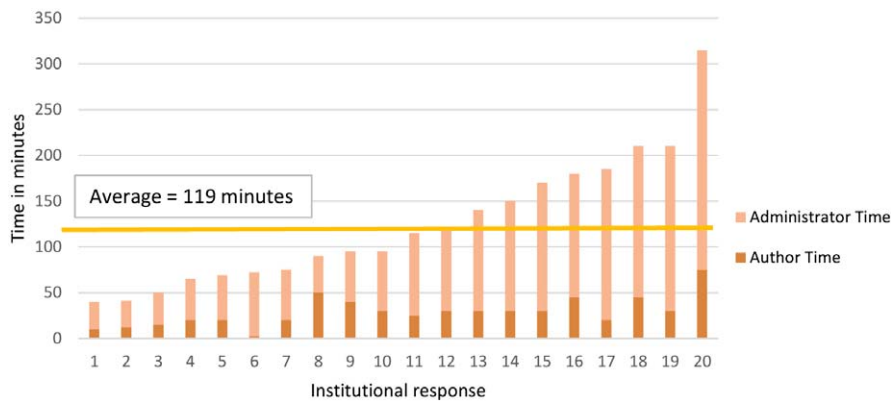


FIG. 1. Average time in minutes (per Gold OA article). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

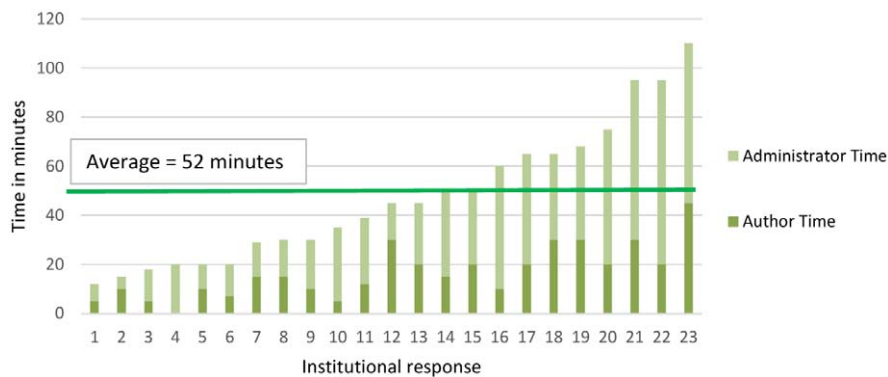


FIG. 2. Average time in minutes (per Green OA article). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

On average, it took an institution around 2 hours to process each APC. Weighting responses by number of RCUK articles made Gold OA results in a time of 134 minutes, with an unweighted figure of 119 minutes. This is estimated to represent £88 (US\$133) per article (the unweighted cost is £80, \$121). The average weighted costs for each of the stages of the process were calculated as follows:

- *Author and internal peer review, where applicable:* 31 minutes at a cost of £29 (\$44).
- *Administrator—Triage:* 43 minutes at a cost of £25 (\$38).
- *Administrator—Payment:* 30 minutes at a cost of £17 (\$26).
- *Administrator—Closure:* 30 minutes at a cost of £17 (\$26).

The increased time and cost where figures are weighted by article volumes reflects the fact that those institutions processing the largest numbers of APCs gave slightly higher estimates of time per APC than average. These results indicate that at present there are few, if any, economies of scale in the process, with most APCs being processed individually and still requiring multiple interactions with the author and publisher. The results may also reflect a more established and rigorous approach to compliance checking at the largest

institutions, several of whom had appointed dedicated staff to support the management of Gold OA.

Green OA. The costs of depositing an article in an institutional repository were also calculated, with the Green OA process broken down into the following stages:

- **Author:** Identify and provide the appropriate version of the article to administrative staff, or undertake deposit where this is the author's responsibility.
- **Administrator—Triage:** Receive and review article or request, ensure correct version is supplied, check funder and journal policies, and obtain any other information required.
- **Administrator—Deposit:** Update repository with article, notify author, create any associations required to other systems or records, for example, PubMed or links to research data.

As with Gold OA, estimated costs varied considerably. They are presented in Figure 2. Responses have been sorted in ascending order, and so do not relate to the same institutions as in Figure 1.

On average, the overall cost was calculated to be £33 (\$50) per article when weighted by article numbers, while the

TABLE 1. Time and costs averaged across all institutions, both as a simple (unweighted) average, and a weighted average to reflect article volumes at the responding institutions.

	Gold OA			Green OA			Increase—Gold versus Green		
	Best case	Average	Worst case	Best case	Average	Worst case	Best case	Average	Worst case
Academic Time in mins (Unweighted)	14	29	95	9	17	52	146%	165%	183%
Academic Time in mins (Weighted)	12	31	174	8	16	50	155%	197%	345%
Admin Time in mins (Unweighted)	40	90	265	16	34	86	252%	264%	308%
Admin Time in mins (Weighted)	42	103	340	14	32	82	294%	323%	415%
Total Time in mins (Unweighted)	53	119	360	25	52	138	212%	230%	261%
Total Time in mins (Weighted)	54	134	514	22	48	132	245%	282%	389%
Salary cost in £ (Unweighted)	24	53	164	12	24	65	204%	223%	251%
Salary cost in £ (Weighted)	24	59	240	10	22	64	229%	269%	383%
Salary + overhead cost in £ (Unweighted)	36	80	246	8	36	98	204%	223%	251%
Salary + overhead cost in £ (Weighted)	36	88	359	16	33	95	292%	269%	383%

unweighted figure was £36 (\$54). The weighted costs were divided between the following different stages:

- *Author*: 16 minutes at a cost of £14 (\$21).
- *Administrator—Triage*: 20 minutes at a cost of £12 (\$18).
- *Administrator—Deposit*: 12 minutes at a cost of £7 (\$11).

Across the responding institutions, it took 48 minutes (weighted average) or 52 minutes (unweighted) to deposit an article. The slight reduction when weighting figures for article volumes indicates institutions may be achieving some economies of scale in the deposit process.

These estimates are not dissimilar to the estimates given by Houghton et al. (2009) and PEER (2011). The Houghton report estimated £9.35 (\$14.12) for academic staff time (based on 2007 prices), compared with £14 (\$21) in this study, and the PEER report overall administrative costs of 43 EUR (approximately £34, \$51), compared with £33 (\$50). For the period under review, there was no equivalent “closure” process in place for Green OA as there was for Gold, but many institutions anticipate that such a process is likely to be required in future in order to demonstrate compliance with the REF policy and would obviously increase costs. It is worth noting that the absence of such a process from these figures does contribute in part to the disparity in time taken for the Gold and Green processes.

Comparing Gold and Green Costs. Table 1 compares Gold and Green costs. All results are averaged across all responding institutions, both as a simple (unweighted) average, and a weighted average to reflect article volumes at the responding institutions. It shows the averages of Gold OA administration taking over 2 hours per article (134 minutes), at a cost of £88 (\$133); and Green OA taking just 45 minutes, at a cost of £33 (\$50). Gold costs are then on average a 269% increase on Green costs. There is, however, considerable variation in the data, with best- and worst-case costs given for both Green and Gold in Table 1. The range of costs for Gold OA of £36 (\$24) best case and £359 (\$542) worst case is at a lower level than Pinfield et al. (2015) of £66 (\$100 to £665 [\$1,004]). The current study may have been helped by

the greater degree of specificity required in the approach taken to data collection.

The variation in the data is perhaps indicative of the immaturity of such processes and therefore of variation of approach between institutions. At an individual level, there may have been a tendency among respondents to either downplay or overstate times because of the availability bias, where an individual’s most recent experience influences their perceptions of the whole (Tversky & Kahneman, 1973). It is also possible an individual’s personal views about OA and its different routes may have influenced their responses, prompting them to either overestimate or underestimate time taken. However, it is reasonable to assume that the data in the aggregate provide a fair representation of the current situation.

One notable area of consistency in responses is the relative difference between Gold and Green times. A total of 17 institutions were able to provide estimates of both academic and administrative time for the Gold and Green OA processes. These estimates are shown in Figure 3. A Pearson product-moment correlation coefficient (a statistical measure specifically designed to calculate the strength of the linear relationship between two variables) was computed to assess the relationship between the estimates of total time for the two processes. This identified a significant positive relationship between time estimates for Gold and those for Green, $r = 0.64$, $N = 17$, $p < .01$. This indicates that respondents who provided time estimates for the Gold process that were either below or above average were likely to provide similarly low or high estimates for the Green process. Despite the variation in absolute estimates of time between institutions, in all but 2 of the 17 cases the estimates provided for Gold OA were longer than those for Green OA.

Scaling Up

Having ascertained average costs per article for both Gold and Green OA, it is possible to model these costs against various scaling-up scenarios. Costs have been calculated for the following:

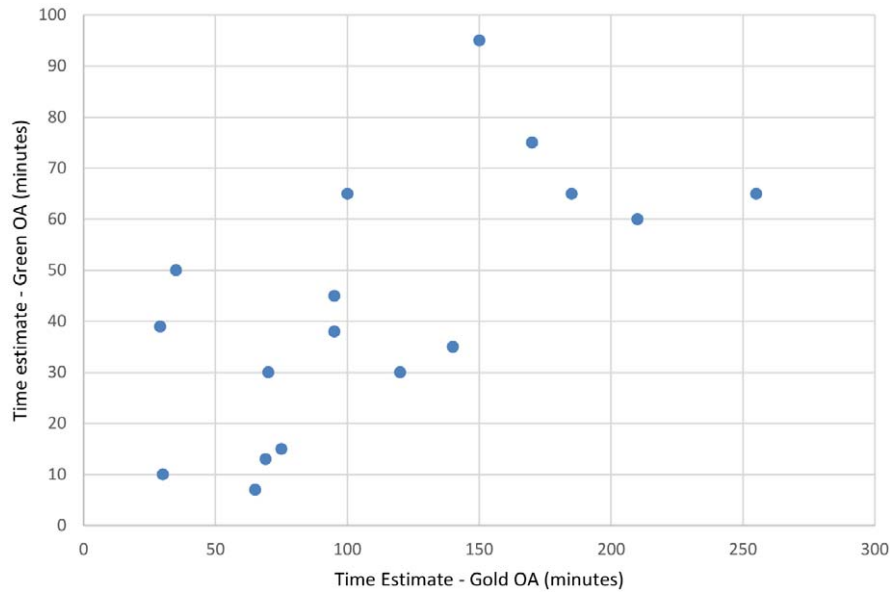


FIG. 3. Institutional time estimates—Gold and Green OA processes. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

TABLE 2. Gold OA costs scaled up.

Scenario	10,000 articles (2013/14 RCUK target)	25,000 articles (approximate REF-returnable outputs per annum)	70,000 articles (50% of UK article outputs)	140,000 articles (entire UK article output)
Cost to institutions (£88 per article)	£0.9m	£2.2m	£6.2m	£12.3m
Academic time in FTEs (31 minutes per article)	3	8	22	44
Administrative time in FTEs (103 minutes per article)	10	26	73	146

TABLE 3. Green OA costs scaled up.

Scenario	10,000 articles (2013/14 RCUK target)	25,000 articles (approximate REF-returnable outputs per annum)	70,000 articles (50% of UK article outputs per Scopus)	140,000 articles (entire UK article output per Scopus)
Cost to institutions (£33 per article)	£0.3m	£0.8m	£2.3m	£4.6m
Academic time in FTEs (16 minutes per article)	2	4	11	23
Administrative time in FTEs (32 minutes per article)	3	8	23	45

- 10,000 articles: 2013/14 RCUK target.
- 25,000 articles: approximate REF-returnable outputs per annum (each UK researcher returned as part of the REF process typically submits four outputs).
- 70,000 articles: 50% of UK article outputs.
- 140,000 articles: entire UK article output (Elsevier, 2013, p. 33).

The results are illustrated for Gold OA in Table 2 and Green OA in Table 3. Administrative costs modeled to cover the entire UK output of about 140,000 outputs per year

(Elsevier, 2013) are £12.3 million (\$18.6 million) for Gold OA and £4.6 million (\$6.9 million) for Green OA. FTE staff time for both academic and administrative time is calculated for the sector based on average time per article.

Scaling up activity in any given country may often relate to particular local policy requirements (of governments or funders, for example). In the UK, this means the Research Councils UK policy and Higher Education Funding Council for England REF policy. While the specifics of the issues associated with implementation of these policies will only

be of particular interest to those based in the UK, the general issues to which analysis of these policies gives rise are likely to be of interest in any countries developing OA policies with either a Gold or Green emphasis. They are presented here, therefore, as case studies.

Perhaps most important, costing work carried out as part of this research on the RCUK and REF policies highlights the key point that costs of ensuring compliance with policy directives of this sort are considerably higher than simply allowing voluntary adoption of either the Gold or Green route. This is the case since costs include, for example, time spent on activities such as policy communication and compliance reporting as well as processing APCs. Specifically, costs of implementing Gold OA reported by participants in relation to RCUK policy compliance included expenditure on systems and software, additional staff time on advocacy and support (apart from that directly associated with paying APCs), and overheads. Some of the staff time in addition to processing APCs was reported to be at senior levels, illustrating that achieving compliance with policy mandates often requires significant effort in planning and communicating best practice, at least during a transitional period until compliance becomes part of business as usual.

The various costs for implementing the RCUK policy for 2013/14 across the UK totaled £9.3 million (excluding the cost of APCs), or \$14 million, and are listed in Table 4. Costs labeled the “Green route” and “Gold route” relate specifically to the costs of academic and administrative time spent making articles OA. Other costs involved in implementing RCUK policy are also presented. These include staff time costs for both academic managers and administrators, technical infrastructure costs (“Systems and software”), and overheads. “Other costs” comprise a wide range of additional costs, many of them one-off in nature, including marketing collateral, events management, temporary staff time, and consultancy.

The majority of these costs are borne by research organizations, and are not recoverable from RCUK funding. In addition, universities have spent an estimated £11 million (\$17 million) on article processing charges from RCUK block grants, with an unknown level of APCs funded from individual research projects. The total cost of implementing the policy for the UK in 2013/14 was therefore at least £20

million (\$30 million). The total administrative staff time dedicated to implementing the policy equated to at least 95 full-time equivalent staff members (FTEs), with the time of academic staff representing a further 16 FTEs. In total this means over 110 FTEs have been devoted to implementation of the RCUK OA policy in the 2013/14 academic year, broken down as illustrated in Table 5.

These figures are illustrative of costs associated with compliance with a policy with an emphasis on Gold OA. Similar costs are likely to be incurred in other countries with similar policies to the RCUK one in operation.

Costing the REF policy implementation, with its emphasis on Green OA, provides an interesting contrast to the Gold-oriented RCUK policy. At this stage, however, any attempts to estimate the cost to institutions of compliance with the REF policy remain somewhat speculative since, unlike the RCUK policy, which is already fully in operation, the REF policy does not go “live” until 2016 (although many institutions are already beginning to implement its requirements on an incremental basis). Nevertheless, institutions in their responses did comment on areas where the REF policy was expected to result in additional costs, as follows:

- Staff involvement in monitoring and validation of metadata for repository deposits (mentioned by 12 respondents).
- Academic support and training (mentioned by 10 respondents).
- Advocacy and communication (mentioned by nine respondents).
- Development of repository software (mentioned by six respondents, with cost estimates ranging from £10,000 to £30,000 (\$15,000 to \$45,000) per institution).

Although the extra work may be partly absorbed by existing staff, the level of input needed from senior academic management is expected to be significant, and several institutions noted an intention to recruit additional administrative support to handle the expected increase in repository deposits. Table 3 illustrates the potential cost to institutions of depositing articles in the institutional repository in accordance with the REF policy. This is based on the data derived from this study on average time and cost per deposit, excluding the costs of advocacy, policy, and infrastructure development.

On balance, it seems likely that the total cost of deposit under the REF policy will be at the upper end of the range

TABLE 4. Costs of complying with the RCUK open access policy, 2013/14.

General area	Activity	Cost (million £)
Making articles OA	Green route	0.1
	Gold route	0.9
Policy implementation	Academic managers	1.2
	Administrators	3.2
	Other costs	0.4
	Systems and software	1.3
	Overheads	2.2
Total		9.3

TABLE 5. Staff time spent complying with the RCUK open access policy for the UK, 2013/14.

General area	Activity	Administrative Staff time (FTEs)	Academic Staff Time (FTEs)
Making articles OA	Green route	1	0.5
	Gold route	10.6	3.1
Policy implementation	Academic managers	83.8	12.4
Total		95.4	16

TABLE 6. Potential efficiencies for Gold open access.

Scenario	10,000 articles (2013/14 RCUK target)	25,000 articles (approximate REF-returnable outputs per annum)	70,000 articles (50% of UK article outputs)	140,000 articles (entire UK article output)
Cost at 2013/14 average of £88 per article	£0.9m	£2.2m	£6.2m	£12.3m
Cost at best case scenario of £36 per article	£0.4m	£0.9m	£2.5m	£5.0m
Potential savings per annum	£0.5m	£1.3m	£3.6m	£7.3m

given in different scenarios in Table 3 (i.e., circa £4–5 million), as most institutions are likely to require deposit of all peer-reviewed journal articles and conference proceedings in anticipation that some of them will ultimately be selected to be submitted to the REF (to be REF-submittable they will have to have been deposited on acceptance by the journal). There are, however, several caveats to this figure, including the following:

- Not all of the 140,000 articles attributable to UK authors are produced by HEIs.
- It is unlikely 100% of articles will be deposited in an institutional repository, as there will be legitimate exceptions and deposit in subject repositories is also acceptable.
- Not all of these costs will be incremental, as a minority of articles are already being deposited.
- Further economies of scale can be expected at higher processing volumes, which would likely push down average deposit time and costs and therefore limit the incremental cost indicated above.

However, there are compensating factors. These include the likelihood that many articles will be deposited in more than one institutional repository, which in the case of multi-authored works is highly likely. It is also likely that a number of works fall outside the coverage of the Scopus database. Furthermore, institutions in their responses stated that they anticipated that the REF requirement for deposit on acceptance is likely to introduce additional time and cost into the Green OA process.

It is important to stress that the estimates given represent only the cost and time of processing and validating article deposits in accordance with REF OA policy. Advocacy, communication, and training costs are not reflected in the figures, but in light of the evidence of this study will undoubtedly be substantial. Equally, these estimates do not include other cost items identified by survey respondents, such as the further development of institutional repositories. Overall, institutions' expectation is that the effort required to achieve compliance for REF will, if anything, be greater than of the RCUK OA policy. However, further work would be needed to determine the total cost of REF compliance with any degree of certainty.

Future Efficiencies

The opportunities to reduce the administrative cost of Gold OA per article are notable, although the level of

savings will only become significant at a sector level if APC volumes continue to rise. If all transactions were processed in line with the current "best-case" estimates made by institutions, the cost per article would fall by £52 (\$79), or over 60%, from £88 (\$133) to £36 (\$54) (only slightly above the current £33 or \$50 cost of Green OA), and the time spent could be reduced from over 2 hours to less than 1. The potential savings this would represent for the UK sector in a range of possible scenarios are set out in Table 6.

A significant contributing factor to the time involved in Gold OA is the requirement to liaise with publishers (in contrast to Green OA, which is largely an internal process for institutions). Many of the survey respondents noted a wide range of experiences in dealing with publishers to make articles OA. "Born OA" publishers were generally identified as being quick and easy to deal with, and prepayment schemes with these publishers could allow authors to arrange Gold OA in a matter of a few minutes, with a CC-BY license as standard. By contrast, institutions cited numerous cases where they had difficulties in managing and monitoring payments to hybrid publishers or where incorrect licenses were applied, although experiences varied widely between the different subscription publishers. These "difficult" cases significantly increase the average time for Gold OA ("worst-case" figures suggest at times it can take more than a day to successfully process a single APC), and limit institutions' attempts to develop a streamlined process for the management of APCs.

To date, most efforts to streamline Gold OA have been focused on the payment stage, whether through the use of intermediaries or publisher prepayment accounts. Yet this step only accounts for 25% of the time and 20% of the cost in the APC management process for institutions. There is an equally pressing need to address the following areas:

- Reducing the small number of "difficult" cases, which account for the majority of the time spent. This will require working closely with certain publishers to identify and address causes of delay in the process.
- Improving automation and data-sharing in the process, which could reduce time spent by authors at the outset and by administrators at the triage and closure stages in particular.

The potential savings from streamlining the Green OA process are relatively small on a per-article basis—moving from the current average to the "best-case" position would reduce costs per article by £17 (\$26), or 50%, from £33

TABLE 7. Potential efficiencies for Green open access.

Scenario	10,000 articles (2013/14 RCUK target)	25,000 articles (approximate REF-returnable outputs per annum)	70,000 articles (50% of UK article outputs)	140,000 articles (entire UK article output)
Cost at 2013/14 average of £33 per article	£0.3m	£0.8m	£2.3m	£4.6m
Cost at best case scenario of £16 per article	£0.2m	£0.4m	£1.1m	£2.2m
Potential savings per annum	£0.1m	£0.4m	£1.2m	£2.4m

(\$50) to £16 (\$24). Time per deposit would be reduced from 48 to 22 minutes. In light of the rapid increase in rates of deposit expected under the REF policy, the potential savings do become significant as article numbers rise (Table 7).

A lack of author familiarity with the Green OA process was the most commonly cited cause of delays at present, although other concerns reported by respondents included:

- Obtaining the correct version of the article for deposit, particularly for coauthored papers.
- Checking compliance with publisher policies, which can often be difficult to interpret.
- Communication with publishers where policies are unclear or do not allow compliance with funder mandates.

The evidence suggests that efforts to cut the costs of Green OA may perhaps be best focused on two areas:

- Making the deposit process as quick and easy for authors as possible.
- Working to achieve greater clarity in publisher policies.

With regard to the latter point, many institutions already use the SHERPA/RoMEO and SHERPA/FACT services to check publisher policies. However, in most cases, librarians stated that they do not feel confident relying on the accuracy of these services, or cannot obtain journal-specific data, so also refer directly to publisher policies. Several institutions participating in this project raised the question of whether libraries' current role in rigorously policing individual deposits to ensure compliance with publisher policies is sustainable as volumes increase. Three participant organizations noted that simply making the author responsible for the accuracy and legitimacy of deposits would be the easiest way to save time and cut costs in the process.

While there are clearly opportunities for achieving efficiencies in the business processes for Gold and Green OA, a key finding of this study is that only a minority of the costs associated with implementing a funder OA mandate, based on the example of the RCUK OA policy, arise from inefficiencies in the administrative processes themselves. By far the largest proportion of the costs relate to staff time, often at a senior level within the institution, spent on policy implementation, management, communication, advocacy, and infrastructure development. Participating institutions

anticipated a transition period lasting at least 3 to 5 years, during which more stringent compliance requirements and the interaction of multiple funder mandates will continue to demand significant management time and effort. The costs of engaging with researchers to promote and facilitate OA cannot easily be reduced if the goal of increased compliance is to be met.

Discussion

The data presented in this study provide evidence that business processes in HEIs for making articles Gold OA are considerably more expensive than those associated with Green OA. However, the position is not necessarily a static one. Gold OA publishing remains a relatively new and unfamiliar exercise for many institutions, and thus it is perhaps not surprising that more efficient processes have yet to be established. Green OA, on the other hand, has been around for a number of years and software and processes have evolved accordingly. Furthermore, Green OA is essentially an internal process for institutions, whereas Gold OA currently involves sometimes extensive liaison with publishers. As processes associated with Gold OA are streamlined and as interactions with publishers become less time-consuming, it is possible that the gap between Gold OA and Green OA administrative costs could be narrowed in the future. This would be the case particularly if additional responsibilities to report Green compliance were added to the existing process, increasing its costs.

It is also possible that different models for administering the Gold and Green processes may emerge and considerably impact the cost base. This study examined the costs of current institution-based models only (relevant for RCUK and REF policy compliance in particular). However, alternative models already exist. For example, the Wellcome Trust has made agreements with a number of publishers so that publishers themselves carry out the deposit of items (without any author intervention) in the PubMedCentral repository following payment of an APC for an article reporting Wellcome-funded research. This approach negates the need for institution-based deposit. Such alternatives will obviously affect cost levels and also where in the scholarly communication chain those costs are borne in the future. It remains to be seen if such models will become more widely adopted.

More immediately, and assuming institution-based management of the process, the data analyzed here can be used to augment the total cost of publication (TCP) calculations reported by Pinfield et al. (2015). These excluded costs for APC administration because of difficulties identifying such costs from their data, but the data presented here allow this component of the TCP to be added. The calculations presented by Pinfield et al. for 20 UK institutions in 2013 include subscription costs of £29,392,142 plus APC costs of £3,312,679. The APC costs are made up from 2,347 APC payments. Applying the weighted average administrative costs of £88 per APC from this study, the administration costs for 2,347 APCs comes to £206,536. This figure can then be added to the TCP calculation, making a total of £32,911,357 for the 20 institutions, of which subscriptions constitute 89%, APCs 10%, and APC administration costs less than 1%. This calculation does not, of course, include all administration costs borne by libraries in connection with publishing (existing costs for administering subscriptions are, for example, not included) since it was designed to identify *additional* costs associated with administering new OA-related activity only (i.e., payment of APCs only).

Significantly, the costs identified by this study and that of Pinfield et al. (2015) do not take into account color or page charges traditionally associated with some subscription journal publishing or the time taken to administer them. Interestingly, these charges are rarely considered in costing analyses and tend therefore to be hidden. This is particularly the case since payment of these charges is typically distributed across institutions and taken from a wide variety of different departmental budgets, rather than being centrally coordinated. It would be useful if future research was to encompass this additional cost of publishing.

In contrast, other costs currently associated with the publication process may be reduced over time, proving to be transitional. It is possible in particular that current subscription costs may be reduced as APCs become a more important way in which scholarly communication is funded. Since, at present, subscriptions represent by far the largest cost in this area (UK institutions are estimated to spend £175m, or \$264m, on journals and providing access to them; Finch, 2012), savings in subscriptions are likely to compensate for administrative costs elsewhere. Any timescales for such changes resulting in possible recovery of costs are, however, unclear.

A further area of uncertainty at present is the period over which institutions should expect to incur additional costs with respect to policy implementation and compliance. These are in large part transitional, but respondents to this study anticipated that this transitional period will last for several years. It is clear, however, that improvements in knowledge-sharing, joint development of systems (in collaboration with third-party vendors), and greater sharing of policies and procedures within the sector could result in substantial time savings. It is notable, for example, that many institutions have gone

through a lengthy internal consultation process to inform development of their institutional OA policy, resulting in documents that in substance look remarkably similar across the sector in the UK.

Further savings could be made in relation to compliance monitoring and reporting. As volumes rise, institutions may be forced to reconsider the level of checks it is reasonable to undertake in relation to repository deposits, for example. Most institutions also remain reliant on manual processes to identify their outputs relating to different funders at present. Automation, whether through improvements to institutional systems or consortial services, would reduce the administrative burden. Greater standardization in the data required by funders for compliance purposes, and the potential to collect and analyze this information electronically, would also be of value. Where possible, such standards should be agreed internationally to enable ongoing international comparisons to be made. With activity in this area in a number of countries, this is now becoming a viable goal.

Conclusion

The findings of this study shed fresh light on the costs of the business processes associated with making articles OA via either the Gold or Green routes. They indicate that the Gold OA process (taking on average 134 minutes at a cost of £88 or \$133 per article) remains inefficient, with little or no evidence of economies of scale at the present time. The Green OA process is more established, and does not require interaction between institutions and publishers, meaning it is correspondingly quicker and less costly (average 48 minutes at a cost of £33 or \$50 per article). It has also been shown how the costs of these two processes scale at a national level, with Gold OA potentially costing UK HEIs £12.3 million (\$18.6 million) per year for the entire UK article output of 140,000 articles, and Green OA £4.6 million (\$6.9 million).

It is possible that savings might be achieved through increasing efficiency in a number of areas. For Gold OA involving APC payments, reducing the small number of “difficult cases,” and improving automation and data-sharing in the processes involved, are likely to lead to considerable efficiency gains. For Green OA, further improving the deposit process for authors and working to achieve greater clarity in publisher policies are most likely to improve efficiency. The results provide a benchmark against which the impact of future changes and improvements in business processes can be assessed, and can be used to help quantify the potential institutional cost implications of OA policy initiatives.

Academic publishing is currently in a transitional period, during which the costs of cultural, process, and system changes for research organizations represent a significant overhead. At present, the overall costs of complying with funder mandates substantially exceed the business process costs of making publications OA using either the Gold or

Green routes. Institutions recognize the importance of increasing access to their research, but are concerned about the costs involved, which are expected to continue at a similar level for several years to come.

Finally, this study has demonstrated that the total cost of implementing the RCUK policy in 2013/14 was at least £20 million (\$30 million). It is likely that similar policies outside the UK will incur comparable costs, although contextualized analysis should be carried out to confirm this. From this baseline, further work will be needed to understand how the costs to research organizations of complying with OA mandates change over the coming years, and to monitor progress in achieving efficiencies in the business processes needed to support OA publication at scale. This work can help HEIs better prepare for the management of OA publishing and inform ongoing international debates on the future of scholarly communication and OA.

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Appendix: Participating Institutions

Institution name	Value of RCUK block grant 2013/14 (£)	Green OA time estimates	Gold OA time estimates
Bangor University	72,846		Y
Bath Spa University	—	Y	
Birkbeck College	50,998	Y	Y (admin only)
Bournemouth University	—	Y	Y
British Antarctic Survey	38,293		
Durham University	276,578	Y	Y
Goldsmiths, University of London	20,878	Y	Y
Imperial College London	1,150,458	Y	Y
King's College London	414,707	Y	Y
Lancaster University	139,788	Y	Y
Manchester Metropolitan University	11,442		
Nottingham Trent University	11,744	Y	Y
Open University	77,477	Y	Y
Royal Holloway, University of London	81,627	Y	Y
School of Advanced Study, University of London	—		Y
University of Northampton	—	Y	
University College London	1,149,066		Y
University of Bedfordshire	—	Y	
University of Bristol	581,597	Y	Y
University of Chester	—	Y	
University of East Anglia	161,538	Y	Y
University of Edinburgh	830,550	Y	
University of Exeter	215,932	Y	Y
University of Glasgow	407,728	Y	Y
University of Hull	19,614	Y	Y
University of Nottingham	536,256	Y	Y
University of Oxford	1,102,549	Y	Y (admin only)
University of St Andrews	203,593	Y	Y
University of Sussex	162,921	Y	Y
Total (29 Responses)	7,718,180	25	22