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Making open access work: The 'state-of-the-art' in providing open access to scholarly literature

Abstract

Purpose: This paper is designed to provide an overview of one of the most important and controversial areas of scholarly communication: open-access publishing and dissemination of research outputs. It identifies and discusses recent trends and future challenges for various stakeholders in delivering open access (OA) to the scholarly literature.

Design/methodology/approach: The study is based on a number of inter-related strands of evidence which make up the current discourse on open access, comprising the peer-reviewed literature, grey literature and other forms of communication (including blogs and email discussion lists). It uses a large-scale textual analysis of the peer-reviewed literature since 2010 (carried out using the VOSviewer tool) as a basis for discussion of issues raised in the OA discourse.

Findings: A number of key themes are identified, including the relationship between 'Green' OA (deposit in repositories) and 'Gold' OA (OA journal publication), the developing evidence base associated with OA, researcher attitudes and behaviours, policy directions, management of repositories, development of journals, institutional responses, and issues around impact and scholarly communication futures. It suggests that current challenges now focus on *how* OA can be made to work in practice, having moved on from the discussion of *whether* it should happen at all.

Originality/value: The paper provides a structured evidence-based review of major issues in the OA field, and suggests key areas for future research and policy development.

Introduction

Providing open access to the research literature has become one of the major challenges in the field the scholarly communication. Whilst the challenge of developing a literature which is "digital, online, free of charge, and free of most copyright and licensing restrictions" (Suber, 2012, p. 4) has been discussed for over 20 years, it is now more widely accepted as a credible prospect, and this is being reflected in changes in researcher behaviours, publisher approaches and funder policies. This paper aims to assess the current 'state-of-the-art' of open access in order to identify recent trends and future challenges. It highlights a number of key issues which are discussed in more detail elsewhere in this special issue.

Approach

The analysis in this study has involved examination of five inter-related strands of evidence which form parts of the current discourse on open access:

1. Peer-reviewed journal literature
2. Professional and Higher Education press
3. Grey literature
4. Informal communications
5. Open-access data sources

The peer-reviewed and professional journal literature not only consists of peer-reviewed journal articles but also review articles, correspondence, opinion pieces and editorials, all of which have also been included in order to take in the widest possible views presented within this formally-published setting. The professional and Higher Education press include publications such as the *Times Higher Education Supplement* and *Chronicle of Higher Education* as well as more specialised publications such as *Research Fortnight* and *Bookseller*. Grey literature includes reports mostly commissioned by government agencies and funding bodies, but also includes work made available by publishers and market analysts. In addition, this category encompasses policy documents from various organisations including institutions, funders, governments and NGOs. Informal communications include email discussion lists (such as the Global Open Access List) and social media communications, particularly blogs (with particular emphasis being given to non-personal blogs, such as the *Scholarly Kitchen* blog and *LSE Impact* blog). Much of the evidence in this section can be identified using the Open Access Tracking Project (OATP) online tagging system which provides regular updates of relevant online sources identified by volunteer 'taggers'. Finally, open-access data sources include well-known community-generated sources such as BASE (Bielefeld Academic Search Engine), DOAJ (Directory of Open Access Journals), ROAR (Registry of Open Access Repositories), and SHERPA services, including RoMEO (publisher policy registry), Juliet (OA funder policy registry), and OpenDOAR (Directory of Open Access Repositories).

These strands of evidence are, of course, interrelated. It is, for example, common for important contributions to the grey literature, such as reports generated by government agencies, to be discussed in the HE press, email discussion lists and blogs. Very often such reports also lead to publications in the professional and research literature. The UK Finch Report (Finch et al., 2012), one of the most influential reports covering the open-access question in recent years, is an example of this. It was widely discussed in the HE press (Howard, 2012; Jump, 2012a, 2012b), email discussion

lists (GOAL, 2012), blogs (Anderson, 2012; Harnad, 2012a; Poynder, 2012), but also in the journal literature, including articles by Dame Janet Finch herself and other members of the review committee (Finch, 2013; Hall, 2012a, 2012b; Jubb, 2014). This study has aimed to cover all of these different sources. It is not, therefore, simply a review of the peer-reviewed literature but rather an attempt to assess key recent developments and current trends in the area of open access using these various sources as an evidence base.

The journal literature was, however, used as a starting point. The study began with a set of searches on the Scopus database for literature from 2010 onwards. Searches used various keywords, including specific terms such as "open access" and more general terms such as "scholarly communication", with results being manually sorted to exclude irrelevant material ("open access" is used in a variety of contexts apart from scholarly communication). Items identified included peer-reviewed research papers and review articles, as well as other contributions (such as editorials and correspondence). A total of 680 relevant articles were identified on Scopus, 589 of which were accessible from the University of Sheffield network.

The full text of the available articles (including references but excluding wherever possible copyright notices and other supporting text) was downloaded and compiled into a single textual corpus comprising a total of 2,506,880 words. This corpus was then analysed using the VOSviewer software (version 1.6.0), a tool for visualising and analysing bibliometric and textual data (van Eck and Waltman, 2010, 2011, 2014). As part of the preparation of the text for analysis, a thesaurus was created based on the corpus. This enhanced the processing of the text by VOSviewer in various ways by, for example, merging synonyms (e.g. "article processing charge", "APC", "article processing fee", "article publication charge", "author fee"), normalising spelling (e.g. "centre" and "center", "behaviour" and "behavior") and eliminating irrelevant or common terms (e.g. "figure", "table"). Significant words with 250 or more occurrences in the corpus were selected for analysis, resulting in 305 terms being identified, of which, the 85% most relevant (according to the VOSviewer relevance ranking) were included in a resulting visualisation (Figures 1 and 2).

The VOSviewer visualisation is a "two-dimensional map in which terms are located in such a way that the distance between two terms can be interpreted as an indication of the relatedness of the terms…based on co-occurrences in documents" (van Eck and Waltman, 2011, p. 50). Terms are therefore clustered, with a cluster or major sub-cluster effectively representing a topic or theme. For this corpus, unsurprisingly, the "term map" created has "open access" at the centre. It consists of two main clusters of terms most clearly seen in the Network Visualisation in Figure 1, where the sizes of the node and the font used indicate the prominence of the term. The Density Visualisation shows the prominence of terms by colour (with red indicating the highest density) and is in Figure 2. On the left-hand side of the map is a large cluster (Cluster 1) with a number of points of intensity, including terms such as "research", "author", "policy", "institution", "library", and "repository". This cluster also includes another sub-cluster around "cost" and other prominent terms (best illustrated in the magnified view of the Cluster in Figure 3) including "researcher" and "institutional repository". On the right hand side, the other main cluster (albeit a smaller one) consists of terms including, "journal" and "OA journal", "article", "publishing", "study" (Cluster 2). There are also other sub-clusters around "APC" and "subscription". In addition, there are two much smaller clusters of scattered terms largely in between the two main clusters. One of these smaller clusters consists of a number of terms, including disciplinary-related terms ("Arts", "Humanities", "Medicine", "Science",

"Social Science"), countries ("China", "India", "USA"), and what might be called impact-related terms ("impact", "citation", "citation advantage", and "value"). There is another smaller cluster including "eprint".

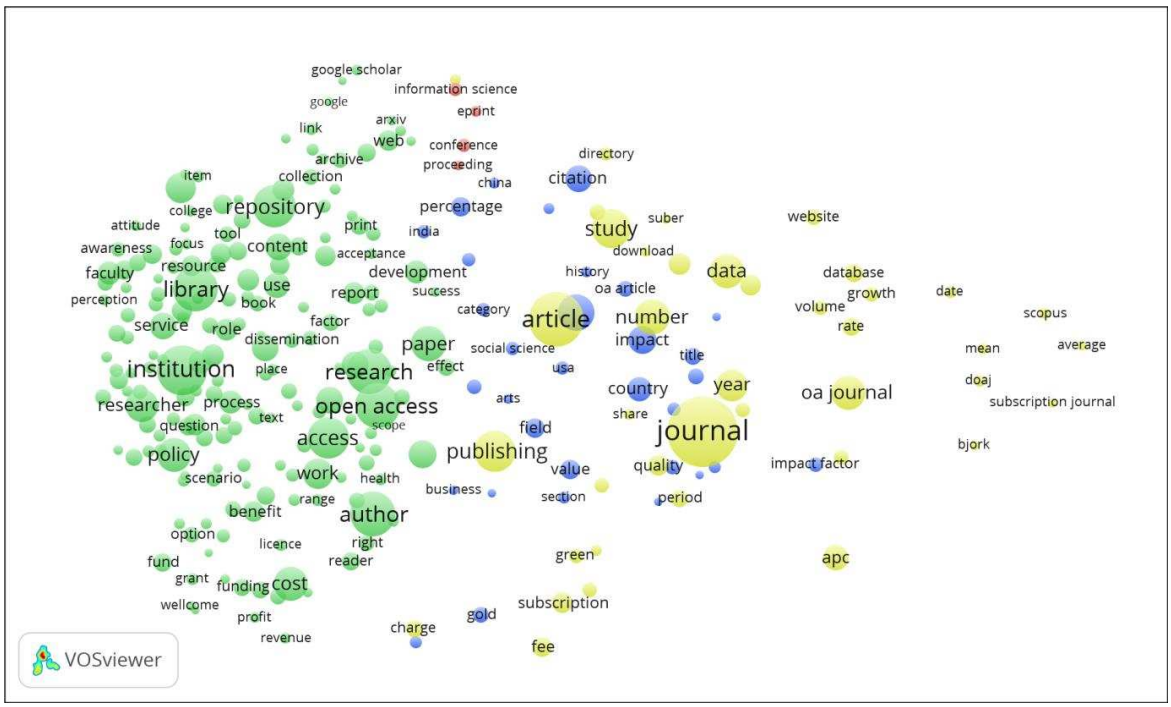

Figure 1: Network visualisation showing clustering for key terms from the open-access literature, 2010-2015

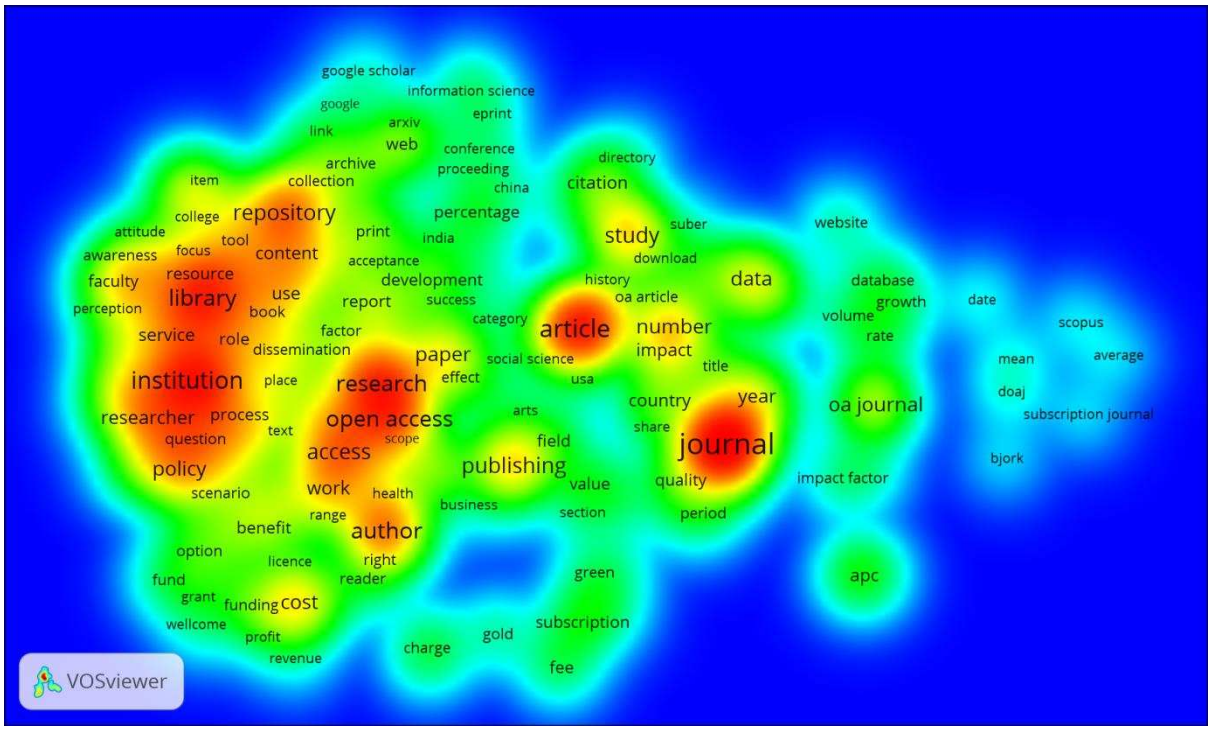

Figure 2: Density visualisation showing clustering for key terms from the open-access literature, 2010-2015

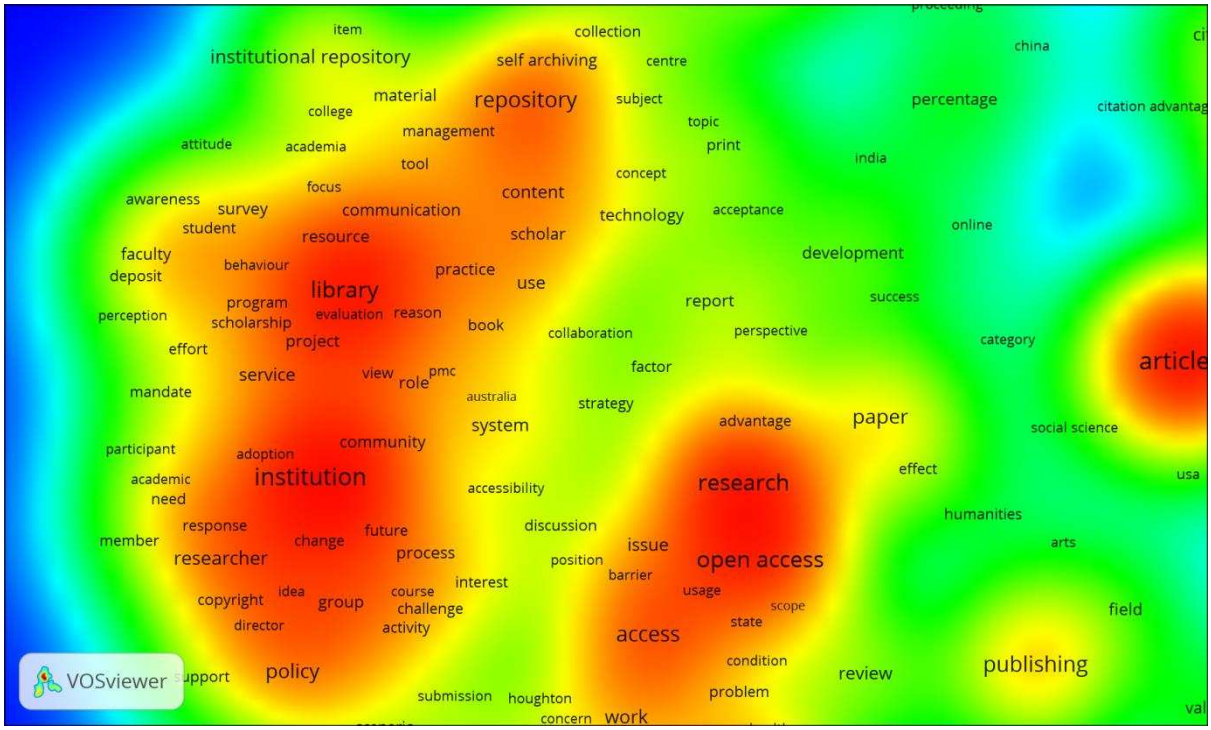

Figure 3: 'Magnified' view of the density visualisation for key terms in Cluster 1

In many respects, the two main clusters might be seen as corresponding to the two main 'routes' to open access: deposit in OA repositories ('Green' OA) and OA publication in journals ('Gold' OA). It is interesting, although not surprising, that there appears to be a pattern in the literature associated with this major duality. It is also notable that throughout the map there are a number of terms relating to tools, including "DOAJ", and "OpenDOAR". Throughout, there are also terms relating to empirical research ("percentage", "participant", etc.) indicative of efforts to construct an evidence base around OA in the literature. The larger cluster on the left-hand side (Cluster 1) is the most complex, containing a set of closely interconnected themes which are difficult to delineate. However, one attempt to do so might summarise the themes as, firstly, *research and researchers*; secondly, *policies*; thirdly, *repositories*; and fourthly, *institutions* (with *libraries* relating in particular to the last two). These themes can be added to those prominent in the other clusters: *journals* in Cluster 2 and *impact* in the remaining small clusters.

The visualisation, therefore, provides a useful overview of key themes, themes which were used in this study as a basis for further analysis of the sources identified above, and used to organise the analysis and discussion below. The themes are summarised as:

- Green-Gold relationship
- Evidence base
- Research and researchers
- Policy
- Repositories

- Journals
- Institutions
- Impact

These themes are examined in turn below in order to provide an overview of the current OA 'state-of-the-art', accompanied by discussion a number of wider issues to which these themes give rise. The key points are then summarised as a set of propositions designed to capture the current situation.

Findings and Discussion

1. The Green-Gold relationship

The Green-Gold duality is a well-established feature of the OA discourse. It underlies much of the OA literature and policy debate (and is apparently reflected in the overall shape of the VOSviewer map). However, one key feature of the current OA landscape is ongoing uncertainty and disagreement about the relationship between the Green and Gold routes. Suber (2012), in his seminal monograph on OA, argued that the two are "complementary and synergistic" (Suber, 2012, p. 58) both in the short and long term. Guédon has argued a similar case (Guédon, 2008). Pinfield (2009) presented several models of a synergistic relationship between repositories and journals based on an analysis of developing OA services. In practice, many institutions have worked to support both Green *and* Gold simultaneously – creating and managing repositories whilst at the same time designing processes for enabling the payment of article-processing charges (APCs).

However, implicit in much of the ongoing debate amongst OA advocates and others appears to be the assumption that Green and Gold OA are rivals. Debate following the publication of the Finch Review in the UK in 2012 made this clear (Mabe and Price, 2012). Stevan Harnad, the vociferous advocate of Green OA, has criticised any moves towards Gold OA (Harnad, 2012b, 2013a). Whilst many Gold advocates have been a little more circumspect in voicing their views, they have continued to express scepticism about the value of repositories. For example, on discussion lists (where Green advocates tend to be more regular contributors) Jan Velterop, one of the founders of BioMed Central, has often put the case for Gold (Velterop, 2012). The debate, therefore, continues, and, whilst the terms of the debate seem to be agreed (there is an implicit understanding that Green and Gold are the two main possible routes to OA), there is little agreement about how OA will and should develop. This tension underlies much of the ongoing discourse and the account which follows.

2. The evidence base

One of the challenges associated with OA is in developing an evidence base which can inform ongoing discussions about how scholarly communication might be shaped in future. Whilst the evidence base needs to be strengthened in many ways, work carried out to date already shows the rising importance of OA in the scholarly communication environment. Studies carried out of the growth of repositories (numbers and content), making use of a variety of sources including for

example OpenDOAR and BASE are indicative of this (Björk et al., 2014; Pinfield et al., 2014). Similar studies of the growth of OA journals, often based on DOAJ data, show a similar growth trajectory. Summaries of key data based on publicly-available sources often appear in blogs and other informal communications. For example, Heather Morrison's blog series (Morrison, n.d.), has reported the growth of OA of different sorts since 2005.

More formal studies have been published in the last five years which attempt to estimate the proportion of published literature which is OA: Björk et al. (2010) estimated 20% of articles published in 2008 was OA; Gargouri et al. (2012), 22%. A study produced by Elsevier (2013) identified levels of global uptake in various models of OA: Fully-Gold OA, 5.5%; hybrid 0.5%; Green OA of final accepted manuscript, 5% etc (Elsevier, 2013, p. 55) but significantly stated that "these uptake rates cannot be meaningfully summed across these models because of different measurement methods and periods" and also because of possible duplication across different models. The same year another study sponsored by the European Commission by Archambault et al. (2013) suggested that OA was reaching a "tipping point" based on its estimates that 48% of the literature published in 2008 was available in an OA form in 2012. The study covered 22 disciplinary fields and did show considerable variation by discipline, but in certain disciplines it concluded the majority of articles were now OA, including "general science and technology" (64%), "biomedical research" (61%), "biology" (57%), and "mathematics and statistics" (56%). However, the methodology used by Archambault et al. (2013) has certain limitations, particularly in relation to the gap between publication and measuring of OA availability, and the small sample size used. Nevertheless, Chen (2014) has more recently produced a study with results indicating a similar level of OA in the literature. Whilst there are caveats to all of the studies, they do seem to indicate ongoing growth in OA from a variety of perspectives to a point that it can be said that OA is now entering the mainstream of scholarly communication.

Evidence has also been developed of the effects of OA (or its potential effects). One prominent example of this (highlighted in the VOSviewer visualisation) is the area of citation advantage ("citation", "citation advantage"). A wide variety of different studies (the majority of those undertaken on the topic), across different disciplines and using somewhat different methodologies, have now found an citation advantage for OA outputs, although the scale of the advantage varies between studies (Archambault et al., 2013; Atchison and Bull, 2014; Donovan and Watson, 2011; Hitchcock, 2013; Kousha and Abdoli, 2010; McCabe and Snyder, 2014; Wagner, 2010). This line of evidence has had a particular impact on discussions about the efficacy of OA mostly within the academic community.

In contrast, another interesting line of evidence which has received attention beyond the academy, has been work undertaken to analyse the economic impact of OA, particularly the work of John Houghton and collaborators. This work is also highlighted in the VOSviewer map, where Houghton is one of the few names of individuals to occur, showing that his work has in many respects changed the terms of the debate. Houghton's work on OA initially focused on applying economic modelling techniques on return on R&D investment to the Australian economy (Houghton and Sheehan, 2006, 2009; Houghton et al., 2006). It came to particular prominence, however, in 2009 with the publication that year of a report commissioned by Jisc on the costs and benefits of OA on the UK economy (Houghton et al., 2009; Houghton and Oppenheim, 2010; Houghton, 2010). The report (written jointly by a team led by Houghton at Victoria University in Australia and one led by Charles

Oppenheim at Loughborough University, UK) consisted of a detailed modelling of costs and benefits of OA. It presented findings of major expected benefits from both Green and Gold OA, even during a period of transition, resulting in greater efficiency (lower costs) whilst at the same time substantially increasing returns on R&D expenditure (increased benefits). Houghton's subsequent studies of other countries showed similar findings (Houghton, 2009a, 2009b). The Houghton report (as the 2009 study has become known), prompted a great deal of debate and discussion, immediately on discussion lists, and then reflected in the peer-reviewed literature (Harnad, 2010; Houghton, 2011). Subsequent work undertaken with Alma Swan modelled costs and benefits during any transition process to OA arguing that whilst both Green and Gold OA resulted in economic benefits, the greater benefits, at least during the transition process, would be realised by an emphasis on Green (Houghton and Swan, 2013; Swan and Houghton, 2012).

Both of these areas of study (citation impact and economic benefits) are examples of the growing evidence base around open access. The VOSviewer visualisation of literature provides an indication of different approaches to evidence gathering, with the occurrence of vocabulary associated with empirical studies ("study", "average" etc). The map also indicates a number of sources of data used for such studies, including DOAJ, OpenDOAR and Scopus. These sources, and those like them, are consistently used in studies of and advocacy for OA. However, it is clear that whilst the evidence base enabling a greater understanding of OA is growing, it still needs to be further developed.

A report produced by the Research Information Network (RIN, 2014) has usefully identified the main strands of evidence that need to continue to be developed to monitor the uptake and impact of OA in future. Whilst their report is aimed specifically at the UK, the four measures it identifies have wider significance:

- Accessibility: "the numbers – and the proportions of the overall totals – of all articles…that are accessible free of charge" (RIN, 2014, p. 3) from different types of OA (fully-OA journals, hybrid journals, repositories etc).
- Availability of OA options: from publishers, particularly in terms of compliance with funder requirements
- Usage: levels of use of OA materials from different sources
- Financial sustainability: expenditure on APCs and subscriptions by institutions, and impact of different business models on key stakeholders

Of these, usage is perhaps the most problematical since OA resources can be widely scattered (the same resource, or different versions of it, available in a number of different places). Certain areas of financial sustainability are also problematical, particularly costs of publishing (where data is often considered to be commercially confidential). Despite these issues, it is likely that initial attempts to provide data based on these proposed measures by a research team led by the RIN, will help to establish a baseline of the size and shape of OA particularly in the UK, but also help to refine the proposed measures (RIN report, due for publication, Summer 2015).

3. Research and researchers

Despite the evident growth of open access, one of the most noticeable current themes in the OA field is that there continue to be significant levels of disinterest, suspicion and scepticism about OA

amongst researchers. Most OA advocates and librarians will certainly recognise this and it is borne out by the need for ongoing communication and advocacy campaigns in institutions and perhaps most evident during Open Access Week (October) each year (widely discussed in OATP resources). Nicholas et al. (2014) have provided evidence of cautious researcher attitudes, particularly amongst US and UK faculty. Much of the suspicion and scepticism they identified was related to strong support for the existing 'tried and tested' scholarly communication systems associated with well understood quality assurance processes (particularly peer review) and trusted quality flags (especially journal titles as 'brands'). This and other studies have illustrated that in their capacities as both authors and readers, researchers are also conscious of the importance of traditional proxy measures of quality (particularly journal impact factors) and quality measurement processes (such as the Research Excellence Framework in the UK), and feel obliged to shape their behaviours to maximise their performance against these measures – even if they do not like them. However, interestingly, Nicholas et al. (2014) also found that "some of the distrust, or dislike, of OA from an author and reader perspective that was very evident can be put down to misunderstandings and unfamiliarity" (Nicholas et al., 2014, p. 129). In particular, there was a perception of a necessary connection between OA and lower quality, and a dislike of the idea of paying to publish which was perceived as vanity publishing. Another related concern, discussed elsewhere, particularly in the medical literature, is that of conflict of interest, where the pay to publish model is perceived to create incentives to accept publications in conflict with quality control. Such concerns remain throughout the research community, with quality perhaps the most prominent. One scientist, Anurag Agrawal, in a letter to *Trends in Plant Science*, included issues of quality amongst several problems with OA which he summarised as: "little quality control, conflicts of interest, and no stamp of rigor or potential impact" (Agrawal, 2014, p. 133).

The debate in the *Trends in Plant Science* journal sparked by Agrawal's letter in many respects typifies much of the academic debate about OA. His "four… reasons to be sceptical of open access publishing" (summarised above) are typical of many of the concerns voiced in the academic community. However, they were rebuffed in a set of letters to the journal from other researchers (Carter et al., 2014; Curry, 2014; Lanfear and Pennell, 2014). Lanfear and Pennell (2014) argued that many OA journals in the field were highly selective and, even judged by traditional measures, such as impact factor, high quality. However, along with the other correspondents, they agreed that authors needed to exercise caution because of the variability in quality amongst OA journals. Nevertheless, Curry (2014) and Carter et al (2014) emphasised that many of the criticisms regarding quality and potential conflicts of interest in journal publication also apply to subscription journals, not just OA. They also suggested that many of the established norms for judging quality (and academic performance), such as impact factor, should be challenged, particularly with the emergence of new (arguably, less crude) measures of quality mostly focused at the article level.

This debate has been echoed in a wide range of discipline-specific journals over recent years, with editorials and letters as well as articles focused on OA in that discipline. Many of the arguments deployed are, of course, similar across disciplines; however, one noticeable trend with regard to OA is that disciplinary differences remain an important factor in influencing the overall shape of OA adoption. Whilst analyses carried out in recent years differ at a detailed level, the general trends of disciplinary adoption of OA are clear: Gold OA has been adopted predominately in the Health and Life Sciences, and Green OA in Computer Sciences, Mathematics and Physics (Archambault et al., 2013; Björk et al., 2014; Gargouri et al., 2012; Laakso and Björk, 2012). A large number of discipline-

specific studies have contributed to a greater understanding of the landscape and generally reinforce this overall picture, including Biomedicine (Kurata et al., 2013), Business and management (Lyons and Booth, 2011), Conservation Science (Fuller et al., 2014), Construction Management (Björk, 2012), Engineering (Mischo and Schlembach, 2011), Library and Information Science (Way, 2010), and Veterinary science (Nault, 2011). These mostly empirical studies of levels of usage and awareness show rising levels of uptake of OA but at the same time high levels of ignorance and uncertainty about OA.

Whilst adoption patterns may be reasonably clear, explanations of such patterns are less so. Explanatory approaches for the Health and Life Sciences preference for Gold have focused on their strong emphasis on pre-publication peer review (because of the close link with clinical practice) and the relative 'wealth' of the disciplines (characterised by large research grants) able to fund APCs (Björk et al., 2010). Explanations of the greater adoption of Green OA by disciplines such as Computer Science, Mathematics and Physics have focused on a greater acceptance of pre-print circulation (Björk et al., 2010; Spezi et al., 2013) plus (in the case, for example, of High-Energy Physics) research clustered around large facilities where sharing is part of widespread practice. Such factors have resulted in the development of large OA publishing ventures in the Health and Life Sciences (such as BioMed Central) and well-known subject repositories in Computer Science, Mathematics and Physics (particularly arXiv). However, many of the explanations to date have tended to be very broad brush, at the level of meta-disciplines (such as 'Health and Life Sciences') in which the nuances of particular disciplinary practices (Becher and Trowler, 2001; Fry and Talja, 2007; Whitley, 2000) often get glossed over.

Perhaps one of the most interesting aspects of the discussion on disciplinary differences has focused on the differences between the Arts and Humanities, and also the Social Sciences, compared with Science, Technology and Medicine disciplines. Interestingly, all of these meta-disciplinary terms occur in the VOSviewer map and reflect a distinction that in many respects has traditionally been made in the publishing industry: HSS and STM. Eve's (2014) seminal monograph on OA and the Humanities provides an overview of the key issues in this area, prominent among which is the importance of the monograph. One aspect of work on OA over recent years has been analysis of OA publishing models for monographs. Exploratory work has been carried out in this area (Collins and Milloy, 2012; Ferwerda, 2010a, 2010b; Milloy et al., 2011) from which Ferwerda (2014) has distilled a number of possible business models including 'freemium' models (combining sale of print copies with open access to online), sponsorship of publication, author-side article processing charges, library-side licensing or subsidy, and crowdsourcing. However, business models for OA books remain uncertain and controversial (Bate, 2014; Davies et al., 2014).

It is likely that uncertainty around OA publication of monographs as well as lack of funding to support pre-publication APCs, have been key factors in creating some hostility to OA from within HSS. OA has been attacked as unworkable for HSS (Babones, 2012; Meadows, 2013). Even more fundamentally, labelling the APC-funded OA business model as "pay to say", Sabaratnam and Kirby (2012) have characterised OA as a threat to academic freedom; a claim supported by others (Baruch et al., 2013). Clearly, OA remains controversial across the disciplines but particularly in HSS.

4. Policy

Much of the controversy around open access has developed not merely as a response to the growth of OA itself but particularly to the introduction of policies encouraging or requiring researchers to make their outputs open access. Over the last five years, an increasing number of these so-called 'mandates' have been introduced and it is clear that they are making a significant contribution to uptake of OA (Archambault et al., 2014; Kennan, 2011; Lariviere et al., 2012; Pinfield et al., 2015; Xia et al., 2012). This is reflected in the VOSviewer map, with terms such as "policy" and "mandate" prominent in Cluster 1. As of the beginning of May 2015, SHERPA Juliet listed 148 mandates internationally from research funders (SHERPA, n.d.). In addition, ROARMap identified 479 research organisation mandates (mostly from universities). Vaughn (2013) has provided an interesting account of the process in the USA of developing agreed approaches to mandates illustrating the complexity and controversy associated with the process. This is likely to continue to be the case particularly as federal US funding agencies are required in 2015 to develop new approaches to OA in response to the Federal Office of Science and Technology Policy (OSTP). Such developments are likely to be highly significant not least because of the large proportion of global research outputs these agencies fund. The US National Institutes of Health (NIH) were pioneers in the development of OA policy along with agencies such as Max Planck in Germany and the Wellcome Trust in the UK. In recent years, many funders in different countries (government-sponsored and charity-funded), including those that have had OA policies for some time, have introduced new mandates or have moved to "strengthen" existing mandates in order to ensure compliance (Wellcome Trust, 2012). In the UK, since 2012 the major research funders have put in place new robust policies, including Research Councils UK (RCUK, 2013), the Higher Education Funding Councils (HEFCE, 2014), and major medical charities (through the Charities Open Access Fund, COAF) (Wellcome Trust, 2014). There has been debate about the efficacy of mandates in driving OA uptakes but the weight of evidence suggests robust policies from funders accompanied by compliance on monitoring and sanctions on non-compliance do result in higher levels of uptake (Burgess, 2015; Gargouri et al., 2010; Pinfield et al., 2014). Although more controversial, there is also some evidence of efficacy of institutional mandates which have also steadily grown in number over the last five years (Gargouri et al., 2010; Harnad, 2009, 2011; Swan et al., 2015).

The debate around OA in recent years has commonly focused on these various policy initiatives and on related reports often written to inform policy development. Perhaps most influential of these was the Finch Report (Finch et al., 2012) which itself is featured in the VOSviewer map in Cluster 1, situated between the "policy" and "cost" sub-clusters. Finch was important not just because of its specific recommendations but also because of the international debate it (and subsequent reviews of its recommendations) generated (Andersson and Svensson, 2013; Baruch et al., 2013; Finch, 2013; Hall, 2012a, 2012b; Harnad, 2013b). Its first recommendation was that, "a clear policy direction should be set towards support for publication in open access or hybrid journals, funded by APCs, as the main vehicle for the publication of research, especially when it is publicly funded" (Finch et al., 2012, p. 7), and it was this emphasis on Gold OA that gave rise to much of the debate. That was particularly the case since the recommendation was immediately accepted by the UK government and RCUK, with the latter introducing a policy reflecting this Gold-centric approach supported by allocations of block grants to UK-wide institutions to pay for APCs and related expenditure. The policy adopted for COAF is similarly Gold-centric. In contrast, HEFCE has more recently adopted a Green-centric approach to support its future research evaluation exercise (the REF), requiring

outputs to be placed in repositories if they are to be eligible for consideration in the REF. This has created a tension in mandates in the UK, and such 'mandate messiness' is likely to be a cause of concern in the medium-term in the UK. It is not just a UK problem, however. Wherever there are multiple agencies in different countries or international organisations funding research, it is likely that mandate messiness will be a concern from a significant number of researchers and their institutions for the foreseeable future.

One particular aspect of the policy debate which has come under increasing scrutiny is around licences and permissions (both of which terms occur in the VOSviewer map in Cluster 1). In particular, the debate has focused on issues of the 'degree of openness'. Suber's (2008, 2012) distinction between "Gratis" and "Libre" open access is often used to frame this discussion: "Gratis OA is free of charge but not more free than that…Libre OA is free of charge and also free of some copyright and licensing restrictions" (Suber, 2012, p. 66). In effect, this means that Gratis OA is free to read but Libre OA is free to read *and* reuse. Reuse was built into the Budapest Open Access Initiative definition of OA which included a long list of reuse possibilities ("permitting any users to read, download, copy, distribute, print, search…" etc) (BOAI, 2001). It is important to recognise, however, as Suber does, that Gratis and Libre OA are not two distinct categories but rather a spectrum of choices – hence *degrees* of openness. The SPARC *How open is it?* guide (SPARC, n.d.) includes four different levels of openness, each of which corresponds to different Creative Commons licences. Much of the debate around the degrees-of-openness issue has in fact focused on the CC licences (Carroll, 2013; Gulley, 2013; Hrynaszkiewicz and Cockerill, 2012), with many research funders requiring licences (such as CC-BY) which allow reuse, including commercial exploitation (Hrynaszkiewicz and Cockerill, 2012; Hrynaszkiewicz et al., 2013). Some researchers have expressed reservations about their work being used in such a way, although funders in contrast typically wish to reduce the friction to knowledge transfer between academic outputs and commercial use. Interestingly, Harnad (2012c) has argued that a focus on reuse (Libre OA), along with funder emphases on Gold OA, have in fact delayed OA becoming mainstream. He argues that Green Gratis OA should be the current priority since it can be widely achieved with least resistance.

Harnad's case makes the point that there can be significant differences in the ways OA can be implemented. Differences between different countries, partly influenced by differing emphases in policy, have indeed been highlighted in various parts of the OA discourse, especially in relation to Green-Gold balance. Countries occurring in the VOSviewer analysis include Australia, China, Germany and India as well as the USA and it apparent that approaches to OA policy and take-up have varied across these and other countries. The OA literature includes a large number of country-specific studies, including those from China (Cheng et al., 2012; Hu et al., 2013; Shao et al., 2013; Zhao and Wu, 2014) and India (Balaji Babu et al., 2012; Gutam et al., 2010; Mukherjee, 2014; Sahu and Arya, 2013; Sawant, 2011, 2012, 2013) providing studies of research attitudes and overviews of services implementations. It is interesting that these BRIC countries are particularly covered in the literature on OA since they are making an increasingly important contribution to academic research and communication in general (Elsevier, 2013). Overviews of global adoption of OA also indicate a now growing adoption outside of Western countries (Pinfield et al., 2014; Xia, 2012).

5. Repositories

Open-access repositories have formed an important part of OA implementation since the beginning of the OA movement (Björk et al., 2014). Pinfield et al's (2014) analysis of the global growth of OA repositories from 2005 to 2012 using OpenDOAR data reports a 1660% rise of repository numbers from 128 in December 2005 to 2,253 in December 2012. The majority of repositories were institutional (83%) with a much smaller proportion of other sorts of repositories, particularly subject repositories (11%). However, subject repositories were responsible for the vast majority of the content contained in repositories, with most institutional repositories (IRs) being very small (the median figure for all repositories being no more than 3,093 items). Some of the large subject repositories, including arXiv and PubMed Central (PMC), both mentioned in the VOSviewer map, are now mature services, or as Nicholas et al (2012) put it, have "come of age". However, many IRs are still little more than pilot implementations.

Ironically, there is a voluminous literature on IRs, no doubt at least partly because of the distributed nature of the repositories inevitably involves a wide range of people who can usefully share their experiences (as reflected in the prominence of "institutional repository" in the VOSviewer map). Such outputs first appeared in the early 2000's (Ashworth et al., 2004; Crow, 2002; Pinfield et al., 2002) and have continued in the five years up to 2015. These include overviews (Bluh and Hepfer, 2013; Buehler, 2013), as well as case studies of individual institutions' experience, such as Imperial College London (Afshari and Jones, 2013), Ljubljana (Koler-Povh et al., 2014), Ohio SU (Connell, 2011), Rochester (Bell and Sarr, 2010). There are also numerous country-specific studies, including Bangladesh (Hossam Haider Chowdhury et al., 2011; Islam and Akter, 2013; Mukhlesur Rahman and Mezbah-ul-Islam, 2014), India (Balaji Babu et al., 2012; Sawant, 2011, 2012), Indonesia (Farida et al., 2015), Korea (Shin, 2010), Nigeria (Igwe, 2014), Spain (Rodríguez-Armentia and Amat, 2010), Thailand (Wipawin and Wanna, 2014), Sweden (Andersson and Svensson, 2013), USA (Nykanen, 2011 – covering small institutions), Zimbabwe (Nyambi and Maynard, 2012). In addition, there are a number of regional studies, including the Arabian Gulf (Sajjad Ahmed and Al-Baridi, 2012), Europe (Peters and Lossau, 2011), Asia (Abrizah et al., 2010; Nazim and Mukherjee, 2011), and Developing Countries (Jain, 2011). Finally, there are format studies including theses (Hawkins et al., 2013; Stanton and Liew, 2012), and more recently, data (Antell et al., 2014). Such studies focus on issues associated with building the repository infrastructure, concentrating particularly on the challenge of populating repositories. Solutions of advocacy and connecting repositories more closely to the workflows of researchers (Afshari and Jones, 2013; Bell and Sarr, 2010; Russell and Day, 2010) or institutional management (Bonilla-Calero, 2014), as well enhancing functionality (Shafi, 2013) have all featured.

A particular problem with content building in repositories which is become more apparent in recent years is that of deposit embargoes (Laakso, 2014; Sutton, 2013). Sutton (2013) reported a "shift towards embargoes that are longer and more constraining" than previously, with complex rules about *where* items may be deposited (for example, on personal webpages but not repositories) and *why* (for example, voluntarily but not in response to a mandate), as well as *when* (for example, after 12 months or more). In the light of such developments, it remains to be seen the extent to which embargoes significantly impede Green OA in future, especially as it seems that at least some of the embargoes have been introduced by publishers specifically to limit the effectiveness of Green-oriented mandates.

Another particular challenge for repositories (of all types) is achieving their sustainability. Sustainability issues experienced by arXiv, perhaps the longest established and one of the best-known subject repositories, illustrate the problems. Unlike PMC, arXiv is not funded on an ongoing basis by large research funders, and has therefore had to seek a new host (Cornell University) and new funding streams (a new membership program) (Cornell University Library, n.d.). Such problems typify wider problems associated with repositories where funding models are still unclear and therefore sustainability remains a challenge.

Whilst populating and sustaining the global network of OA repositories may remain a challenge, technical discussions have moved on from the foundational issues of setting up repositories connected through interoperability protocols (Lagoze and Sompel, 2003; Smith et al., 2003; Sompel and Lagoze, 2000), to integrating repositories in a wider scholarly infrastructure that can enhance both research and research management. The implementation of standards such as the ORCID author identifiers are an example of this. There is also a focus on usability that is designed to help enable to repositories work at scale (Johnson, 2015).

6. Journals

The Gold OA landscape has in recent years been characterised by increasing complexity and variation as new and existing players in the publishing market experiment with new business and delivery models. Interestingly, established publishers have chosen both to launch new fully-OA journals as well as introduce OA options on their existing subscription journal titles (so-called 'hybrid' subscription/OA journals). In addition, new players have entered the market introducing a variety of fully-OA journals, joining longer-established journals provided by PLOS and BMC. Most of these journals are either funded through sponsorship or by APCs. The APC market has now become highly complex. Kingsley (2014) has provided a useful overview of the complexities which include variable APCs for different customer groups (such as learned society and non-members, or existing subscribers and non-subscribers) and for different OA options (such as different licence conditions or immediate and delayed OA to publications). Morrison et al's (2015) analysis of fully-OA titles from DOAJ suggests 90% of a 1,373 APC-funded journal sample charged variable APCs.

Radical new models of journal publication have been introduced (Binfield, 2014), most notably the OA mega-journal (Wellen, 2013), exemplified by *PLOS ONE* (MacCallum, 2011). *PLOS ONE* is now the largest journal in the world, having published 31,500 articles in 2013, although its monthly output declined somewhat in 2014 (Davis, 2014). It accepts papers on a wide range of subjects across STM which are peer reviewed to assess their 'soundness' rather than on any assessment of 'importance' or 'novelty' (criteria deemed to be more subjective but important in selection for most traditional journals). This new phenomenon reverses journal publishing trends of the last 50 years characterised by ever greater specialisation and is therefore a potentially disruptive force in the publishing market (Wellen, 2013), particularly since the approach has been imitated (albeit with some variation) by other journals, such as *Nature Scientific Reports* and *PeerJ*. Most of these journals carry out pre-publication blind peer review but a number of OA journals have also introduced new approaches to peer review, particularly open peer review of which there are a large number of variations (Ford, 2013).

Since it is often regarded as the cornerstone of scholarly communication, experimentation with different approaches to peer review has been viewed with suspicion by many. Perhaps more serious in terms of quality concerns is the wide variability of quality amongst OA journals. At the bottom end, it is clear that some OA journals have been set up as little more than scams. Jeffrey Beall's list of "predatory publishers" brought this problem to the fore (Beall, 2012, 2013a) and it has been one of the most widely discussed issues around OA by researchers outside of the core group of OA advocates (Bowman, 2014; Haug, 2013; Lăzăroiu, 2014; Pickler et al., 2014; Swartz, 2015) and is evident in the VOSviewer map in terms such as "quality". The so-called '*Science* Sting', in which a journalist, John Bohannon, sent a bogus article to OA journals some of which accepted it for publication apparently having peer-reviewed it (Bohannon, 2013), was also widely reported and seemed to illustrate problems raised by Beall. However, the significance of the problems for researchers has probably been exaggerated. Curry's (2014) advice to authors of only publishing in journals they also read seems a simple way for researchers to address the problem of avoiding submitting articles in bogus journals.

Nevertheless, Beall's list and the *Science* Sting prompted a great deal of publicity in 2013 and, between them, were a setback for OA, although both have been analysed (particularly via OA-related social media and discussion lists) and strong criticisms have been raised about their approaches and apparent motivations. The fact that Beall himself has apparently been motivated by an ideological objection to open access in principle not merely to some of the ways it is being implemented in practice, it was argued, contributed to an exaggeration of the problems (Beall, 2013b; Bivens-Tatum, 2014). His apparent use of the list as a vehicle for undermining OA rather than a mechanism for protecting its integrity was demonstrated by his opinion piece published in *TripleC* (Beall, 2013b), in which he labelled open access as "an anti-corporatist, oppressive and negative movement", and prompted a great deal of reaction from OA advocates, unsurprisingly most of it negative. However, Beall's list and the *Science* Sting have also prompted some reflection and action, including the DOAJ tightening up its inclusion criteria (Anderson, 2014; SPARC, 2015), which have undoubtedly been useful.

In many respects, the appearance of low-quality OA journals is a negative aspect of a positive feature of OA: that barriers to entry in the market have been lowered (Pinfield, 2013). This is likely to create greater competition in the market, something lacking in the traditional subscription system. Competition will also be promoted by greater transparency, again something lacking in the subscription market (where deals are traditionally often protected by confidentiality clauses in contracts). Recent attempts to analyse the APC market have shown it to be characterised by wide variations in prices charged (Morrison et al., 2015; Pinfield et al., 2015; Solomon and Björk, 2012). There is some evidence of there being a link between price and quality, with a correlation between the APC level and journal impact factor (Björk and Solomon, 2015). It might be suggested that this at least partly explains price variations – higher quality journals with higher rejection rates and more rigorous editorial standards are more expensive to produce. However, this is likely to be only a partial explanation. There is also probably a relationship between price and what the market will bear. Interestingly, the clear trend in the variation between different types of journals, particularly between hybrid journals and fully-OA ones, with hybrids being considerably higher in price (Björk and Solomon, 2014a, 2014b; Pinfield et al., 2015), might support this argument. Hybrids are generally well-established titles and therefore authors are more likely to be willing to pay high APCs for them. Evidence from the UK, with the implementation of the Gold-centric mandate and block

grants to institutions support payment of APCs, indicates that hybrids are now playing a major part in the market in APCs (Pinfield et al., 2015).

Hybrid journals are generally published by established subscription publishers (who may also publish some other fully-OA or subscription only titles), such publishers are capturing a significant proportion of the growing Gold OA market, particularly where there is a mandated Gold-oriented environment, such as the UK. The UK is therefore an interesting case study of the effects of a Gold-oriented policy environment. Pinfield et al's (2015) analysis shows that only two of the top 10 publishers in receipt of APC payments covering 2007 to 2013 from their sample of 23 UK institutions were fully-OA publishers (PLOS and BMC). The other eight, who between them were responsible for 60% of all centrally-paid APC income from the sample institutions, were all established commercial publishers. Whilst these publishers have introduced hybrid options, few shown signs of attempting to 'flip' their business models to fully-OA ones. Some 'flipping' initiatives have taken place internationally, notably SCOAP3 (which flipped key High Energy Physics titles from subscription to OA globally). However, this project, driven by research institutions rather than publishers, is an exception. The fact that it took several years to secure sufficient participation levels to implement SCOAP3, despite it serving a very specialised and relatively homogenous community, makes other similar initiatives look daunting. In the absence of radical change of this sort, the market for APCs, with a few notable differences, is beginning to resemble the subscription market – dominated by a small number of large commercial publishers. Whether this amounts to a process of "domestication" of open access, in a similar way to Bates (2013) argues the open data movement has been domesticated (beginning as a radical change movement but developing into one supporting conventional business interests), is an interesting and controversial question. However, developments such as the Springer takeover of BMC and subsequent gradual merger of the companies might be argued to be an example of domestication in OA.

7. Institutions

It is in this complex environment that higher education institutions are now at the centre of making open access work in practice. There are particular challenges in four main areas: firstly, costs and sustainability; secondly, mandate compliance; thirdly, communication and advocacy; fourthly, developing institutional policies, processes and technical infrastructures. All of these are a particular challenge because of the increasing need for OA to now be implemented at scale across the institution, rather than it being seen as a niche interest. Between them, they seem to indicate that institutions now face a potentially lengthy period of transition to large-scale OA.

Much of the recent debate about the first of these issues, costs and sustainability, has focused on the APC market, although issues of IR sustainability also remains important. Concerns about the APC market have often been discussed in relation to existing subscriptions, with institutions raising the issue of perceived 'double dipping' by publishers (Pinfield et al., 2015). Double dipping has proved to be a controversial idea (Anderson, 2013; Björk and Solomon, 2014b; Crotty, 2014; Prosser, 2015) but one that has resonated strongly with institutions conscious of the total costs of their relationships with publishers (subscriptions *and* APCs). Despite some claims that separate charges for subscriptions and APCs are legitimate and may even serve to limit overall price increases (Anderson, 2013; Smith, 2014), many institutions have expressed alarm that APC-funded Gold OA seems to

result in more money going to publishers for essentially the same services. Some publishers have responded by announcing 'no double-dipping' policies which often involve some sort of offsetting of APCs against subscriptions (Jisc Collections, n.d.; Royal Society Publishing, 2013). Such policies, however, are often difficult to test and benefits for particular institutions moving ahead with Gold OA are often lost in offsetting calculations based on global averages. This has led to discussion, much of it in the UK (because of its current emphasis on Gold OA), on how to design a market in which offsetting can occur in a way that benefits those with greatest APC expenditure (Björk and Solomon, 2014a, 2014b). One of the features of negotiations between institutions (or more normally consortia) and publishers over the medium-term future will be the extent to which these principles are built into pricing arrangements and perhaps form the basis of long-term flipping of business models. Either way, it is clear that the hybrid model as it is currently implemented by many publishers remains a challenge for institutions and policymakers, with some reacting by refusing to pay hybrid APCs at all (including the EU Gold OA pilot; OpenAIRE, 2015). Whilst such a stance is understandable, it is difficult to see how it will help to contribute to any long-term flipping.

The second concern in institutions of policy compliance is complicated by mandate messiness. It also has financial implications quite apart from APC payments with evidence from RCUK compliance, for example, indicating costs of mandate compliance (including policy development, communication and reporting costs) adding significantly to the financial burden of institutions, at least in the short term (Johnson et al., n.d.). The need for effective ongoing communication and advocacy in institutions which address researchers' concerns is further illustrated. A great deal of guidance has been produced providing examples of good practice on how to implement such advocacy programmes (ARL, n.d.; Pathways Project, 2015; Swan, 2012). The final issue of designing institutional policies, processes and technical infrastructures has also received prominence in professional discussions (EUA, 2015; Shieber and Suber, 2015; Swan, 2012). One interesting aspect of this that has received recent discussion is the incorporation of IR systems into wider research management environments, particularly integrations with CRISs (Current Research Information Systems) (Björk, 2013; Jeffery and Asserson, 2009; Lyon, 2012).

In many institutions, libraries have played prominent roles in making OA work and the VOSviewer map indicates the importance of libraries in the literature. Libraries have often been responsible for managing repository services, negotiating with publishers (on subscriptions and APCs) administering central funds for payment of APCs, conducting ongoing communication and advocacy. They have also often led initiatives such as developing publishing services (Ayris et al., 2014; Lawrence, 2010; Lippincott, 2015; Mullins et al., 2012), an important recent development. Libraries have commonly provided a leadership role in their institutions and been responsible for the development of OA policies. This has created challenges for libraries as organisations and has often required the development or hiring of new skills and introduction of new teams (Cassella and Morando, 2012; Cox and Corrall, 2013) and structures (Thomas, 2013). There is also the challenge to encourage the development of an awareness and 'ownership' of OA approaches outside the library, something that is required if it is to become fully embedded in institutions.

Of course, open access to research outputs is not the only open agenda currently being pursued in HEIs. Other 'opens' such as open data and open educational resources have also become important (Corrall and Pinfield, 2014; e-InfraNet, 2013; Peters and Roberts, 2012; Peters, 2010). Although there is an ostensible set of linkages between these agendas, the extent to which they are currently

integrated in strategic planning in institutions seems to be extremely limited (Corrall and Pinfield, 2014). There is a case that a more integrated strategic approach to the different open agendas in HEIs may significantly contribute to their objective of making a beneficial impact on the research community and wider society (Corrall and Pinfield, 2014; e-InfraNet, 2013).

8. Impact (and beyond)

Impact is certainly an important topic within the OA discourse. It has traditionally been conceived in narrow ways: particularly in terms of journal citation rates. However, new ways of defining and measuring impact are now becoming important, particularly so-called 'altmetrics', which focus on a number of measures at the article level (Sud and Thelwall, 2014; Thelwall et al., 2013; Zahedi et al., 2014). Interestingly, mega-journals, such as *PLOS ONE* have made article-level metrics an integral part of their quality assessment approaches. One of the consequences of the fact that these journals typically assess articles before publication for technical 'soundness' only, not 'importance', is that "judgments about the importance of any particular paper are then made after publication by the readership (who are the most qualified to determine what is of interest to them)" (PLOS ONE, n.d.). Such judgements are necessarily reliant on article-level metrics and it will be interesting in future to see how such measures are more explicitly used to evidence academic 'importance'. Metrics such as usage may extend to impact outside the academic community, where practitioners may read and use an article but not cite it. The impact of OA beyond the academy, a primary stated driver underpinning many OA mandates (RCUK, 2013), however, still needs to be systematically investigated and documented, with only a few early attempts to do this in evidence in the formally published literature (Nunn and Pinfield, 2014; Zuccala, 2009, 2010), although more case study and anecdotal evidence is evident elsewhere (Research Exchange, 2012).

The use of metrics as an integral part of the scholarly communication infrastructure (in this case quality evaluation) is a prominent example of an increasingly important wider issue: the prospect of a "network-enabled" OA literature (Neylon, 2012). Whilst still in its infancy, this vision is now becoming a more realistic prospect. Features of such an infrastructure are likely to include interoperable text and data (Shotton, 2012), which can be searched, reused and recombined. A recent experiment in continuously-updated "living figures" in a journal article in the *F1000* OA journal (Colomb and Brembs, 2015) is an interesting example of what a more systemically open literature might look like. Priem's (2013) vision of a large-scale open interoperable scholarly communication infrastructure (which might be called an 'internet of scientific things') may not necessarily be achieved by 2020 as he forecasts, but is likely to become more of a reality in the long term as scalable systemically-open solutions begin to emerge. What is clear about such an infrastructure is that it comprises more than just papers – data, analytical tools and possibly venues for interaction are all important. One of the key questions that this raises is the future shape of the journal article itself, currently the core vehicle of current scholarly communication. The extent to which the article retains its central role and how it is likely to be reshaped are interesting questions, clearer answers to which are likely to emerge over the next decade.

Conclusions

The developments analysed in this paper all seem to tend towards the conclusion that the main challenge associated with scholarly communication is no longer *whether* open access should be at the centre of the system but *how*. This transition appears to have happened in the last five years. Most of the key issues associated with OA are now therefore primarily about making it work in practice not about whether it should happen at all. In particular, this overview has identified a number of issues which define the 'state of the art':

1. The Green-Gold OA debate continues to underlie much of the discussion on OA but there remains uncertainty and disagreement about the relationship between the two;
2. The evidence base enabling a greater understanding of OA is growing but still needs to be further developed; nevertheless, the evidence suggests that –
3. Open access is now entering the mainstream of scholarly communication; but despite this –
4. There continues to be significant levels of disinterest, suspicion and scepticism about open access amongst researchers; also –
5. Disciplinary differences remain an important factor in influencing the shape of OA take-up;
6. Mandates are proving to be essential for encouraging adoption of OA; but –
7. There remain important country-specific differences in policies and adoption patterns; also
8. There is an intensified focus on the 'degree of openness' for content;
9. Although there is a large-scale global network of OA repositories, populating and sustaining them remain challenging issues; also
10. Publishers' (increasingly restrictive) conditions on depositing outputs in repositories, including embargoes, have the potential to impede growth of Green OA; at the same time –
11. There are increasing amounts of experimentation, variation and complexity in the Gold OA market; but –
12. Subscription publishers are capturing a significant proportion of the growing Gold OA market, with little sign of moving to flip business models;
13. HE institutions are now facing a potentially lengthy 'transition' process in making OA work on the ground;
14. Libraries have often led policy, technical and administrative developments in institutions and carried out advocacy to other institutional stakeholders but the agenda needs now to be embedded more widely in institutions; particularly since –
15. The open agenda is manifesting itself in a variety of forms in institutions;
16. Impact is a central issue but new ways of defining and measuring impact are becoming more important;
17. The realisation of a "network-enabled" OA literature is still in its infancy but has transformative potential;
18. The potential for 'formal' scholarly communication becoming a more open interactive 'flow' is recognised but clear scalable solutions are yet to emerge.

All of these factors mean that open access is now at an interesting and challenging stage in its history, one that needs to be carefully analysed and discussed in order to ensure that future developments are shaped optimally.

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