



Open Access: Market Size, Share, Forecast, and Trends

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Table of Contents

| | |
|--|----|
| Why This Topic? | 3 |
| Methodology | 3 |
| Definition and Structure of the Open Access Market | 5 |
| Sources of Revenue | 6 |
| Market Size, Structure, and Performance | 8 |
| Market Composition – Gold, Green, and Hybrid OA | 9 |
| Market Forecast | 13 |
| Key Trends and Market Drivers | 17 |
| Potential Disruptive Forces | 19 |
| Competitive Landscape | 22 |
| Competitive Performance by Segment | 23 |
| 10 to Watch | 25 |
| Essential Actions | 31 |
| Related Research | 34 |
| Appendix | 35 |

Table & Figure Titles

| | |
|--|----|
| Figure 1. Open Access Preliminary Market Size and Growth Rates, 2012 | 8 |
| Figure 2. Open Access Market Composition Estimate, 2012 | 9 |
| Figure 3. Open Access Revenue Preliminary Size, Share, and Growth by Product Type, 2012 | 11 |
| Figure 4. Open Access Market Revenue Forecast and Growth, 2011-2015 | 14 |
| Table 1. Open Access Market Forecast by Type of Journal, Volume, and Revenue | 16 |
| Table 2. Open Access Journals Preliminary Leaderboard and Market Share Estimates, 2012 | 22 |
| Figure 5. Open Access Revenue Market Share by Type of Journal, 2012 | 24 |
| Table A1. Open Access Policies and Mandates of Key Funders | 35 |

Why This Topic?

No debate has shaken scientific publishing in the past 20 years quite like the open access movement. Awareness has risen in the popular press, in the UK's House of Commons, in funding bodies, and in places of research. Underlying the debate is the decades-long concern about the publishing model of peer-review processes, their fairness and their impact on the flow of research, knowledge, and discovery in society. The open access movement continues to morph as it challenges traditional modes of scholarly publishing and changes the way most major players in the space approach their futures.

In this report, which is an update to Outsell's *An Open Access Primer – Market Size and Trends* (published September 21, 2009), we analyze the market's size in terms of revenue, examine both gold and hybrid journals, consider the future of green OA, and present a revenue forecast for open access-sourced journal revenue for 2013 to 2015. To underpin our projections, we provide analysis of which competitors control significant shares of the market — and which new entrants are particularly on trend and worth watching.

Open access publishing is here to stay, but its evolution and ability to overtake existing subscription models remains an open question. Outsell's goal is to cut through the noise and provide insights that support healthy and forward-looking business strategies for all stakeholders in this space — including publishers, policymakers, funders, authors and researchers, technology providers, and investors.

Methodology

We built our market sizing estimates using a three-pronged approach:

- First, we used Outsell's Information Industry Database (our proprietary database of companies in the information industry) to identify active journal publishers. We calculated the number of open access articles published each year through targeted searches on each publisher's platform or website, filtering by year, journal, article type, and OA status to the extent possible.
- We multiplied these totals by publicized article processing charge amounts (APC), differentiating by product type and various levels of APC. We qualified this estimate by applying the guidance received through our research about revenues from additional income streams, such as institutional memberships (which cover or defray APC charges for a member institution's submissions), and applied knowledge gained through primary and secondary research of the frequency and level of discounted or waived APCs.

- We corroborated our estimates by reviewing publicly available information and annual or quarterly filings about the open access revenue streams as a proportion of total business for those publishers identified as open access publishers.

Outsell then conducted interviews with executives at traditional and open access publishers, with research funders, and with specialized science, technical, and medical information managers. These conversations occurred in addition to Outsell's daily dialogue with the industry, helping us build our comprehensive view of the open access market, both in terms of revenue and publishers' strategic actions.

Definition and Structure of the Open Access Market

In this report, we define open access as the publication of content (especially research articles) as digital, online, free of charge, and free of most copyright and licensing restrictions. The two main models are:

- **Green OA:** This is the self-archiving of articles on the web in institutional or subject-based open access repositories (OAR). This may be done in conjunction with final publication in a journal, in which case the content is usually but not necessarily the final refereed manuscript or the publisher's final version. For instance, the author may choose to archive a "preprint," the importance and usefulness of which varies by discipline. The sole costs inherent to this system involve maintenance of the platform, as the journal publisher handles most of the refereeing and editorial functions separately.
- **Gold OA:** This is the publication of an article in a free online journal. Rights remain with the author and articles may be freely, onwardly used. This model refigures the publisher as a service provider, one who earns no money after publication (in contrast to the now-prevailing subscription model). Publishers typically earn revenues by charging the author an article processing charge (APC) to cover the costs of peer review, editing, and publication.

A number of Hybrid OA models provide free access for research with varying levels of additional revenue streams, such as:

- A mix of business models within one journal, so that authors can choose to pay for open access to their research articles in certain journals, though all other articles in the same journal are available under paid use.
- Subscriptions, or "institutional memberships," which subsidize or defray APCs for members of that institution. For example, a university may elect to subsidize its academic staff's contributions to an open access journal by paying for a departmental membership. These memberships may bundle with other paid-for subscriptions. An example is the University of California's institutional membership in Public Library of Science (PLoS), dating back to 2004.
- Embargoed access, in which articles become freely available only after a specified time. The publisher is able to monetize the control of rights in the traditional manner during the embargo period. This model is used less than other hybrid models.

It's important to note that, for this particular analysis, we focused solely on the effect OA has on the journal ecosystem, as it is the market most clearly in the throes of change. Smaller but similarly driven movements are emerging in the markets for monographs, educational materials, and standards, but because OA is most advanced in the journal market (and the journal market has its own unique trends), we bracket these for the sake of this report.

Sources of Revenue

The growth of the open access publishing model is directly linked to funder mandates and requirements, which stipulate that research outputs paid for by the mandating institution or funding body should be made freely available at publication.

A selection of key funder mandates, such as at the Wellcome Trust, European Research Council, and Research Councils UK (RCUK), appears in an appendix to this report. A number of institutional mandates are also in place throughout the US (at, for instance, Massachusetts Institute of Technology and in Harvard's Business School, Law School, and Divinity School), in the UK (at the universities of Southampton and Nottingham), in China (at the National Science Libraries at the Chinese Academy of Sciences), and elsewhere. Future funder mandates will surely emerge as part of the European Commission's Horizon 2020 program for research and innovation, which is still in development.

In the United States, meanwhile, two bills with opposing viewpoints have appeared in different parts of Congress. The Federal Research Public Access Act (FRPAA) — which was introduced by Sens. John Cornyn and Joe Lieberman in 2006, 2010, and 2012 — supports OA policies for federally funded research and never made it out of committee. Its passage in the future is not altogether likely due to more pressing priorities and the work of managing the reauthorized America COMPETES Act. The Research Works Act (RWA), introduced by Rep. Darrell Issa and co-sponsored by Rep. Carolyn Maloney, opposed OA policies and was vehemently opposed by associations including the American Library Association, the Scholarly Publishing and Academic Resources coalition, and others in the research community, so much so that Reps. Issa and Maloney stated in 2012 that they would not push for further legislative action on the bill.

These top-down mandates do not translate automatically into open access adoption. Unlike the traditional subscription model, at the moment most OA sales channels are highly individualized, meaning the author or customer submits an article and that author pays the APC — think of it as the difference between a B2B and a B2C sales model. Beyond that, there is little clarity on where the money comes from — policies differ as to whether publication charges are paid through grants, through library budgets, through a dedicated institutional fund, through a dedicated government fund, or through some mix of each. Institutions can also pay for “memberships” to open access journals, which subsidize their authors’ APCs, but researchers pursue these to widely varying degrees.

Under the green model, research institutions, universities, or governments often host and fund repositories. The costs to maintain these platforms are substantial, though most repositories provide no additional function beyond archival services for preprints, presubmission manuscripts, or accepted manuscripts. In one example of repository funding, Cornell University, which hosts the popular arXiv repository, requested additional financial assistance from third-party funders to maintain the site in 2010. In August 2012, the Simons Foundation announced a grant to subsidize the site for up to \$350,000 a year for the next five years.

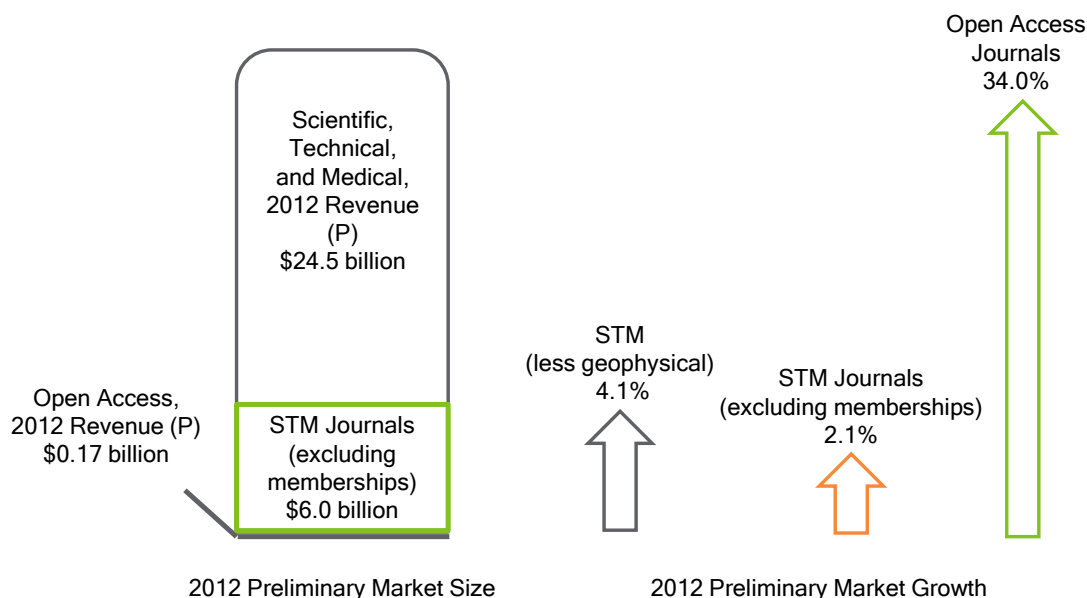
Market Size, Structure, and Performance

Outsell estimates that total revenues collected from open access journal publication equaled \$172 million in 2012, a 34.0% increase over the \$128 million collected in 2011. While this is impressive growth, it represents less than 1 percent (0.6%) of the total Scientific, Technical, and Medical Information segment (excluding geophysical data, which operates on different market dynamics so it is excluded from this analysis).

Drilling down to the journal market specifically, Outsell estimated that journal subscription revenue (which excludes society membership revenues) amounted to \$6.0 billion in 2011, which makes open access 2.2% of this market for the most recent year in which we have built such an estimate.

In 2012, the open access segment is sure to outgrow the rest of the market, and our preliminary estimates suggest that the OA share of subscription and rights sales will encompass 2.8% of that total — a roughly 60 basis-point increase in share in what is itself an expanding market. Figure 1 illustrates this 2012 preliminary estimate.

Figure 1. Open Access Preliminary Market Size and Growth Rates, 2012



Source: Outsell's Information Industry Database

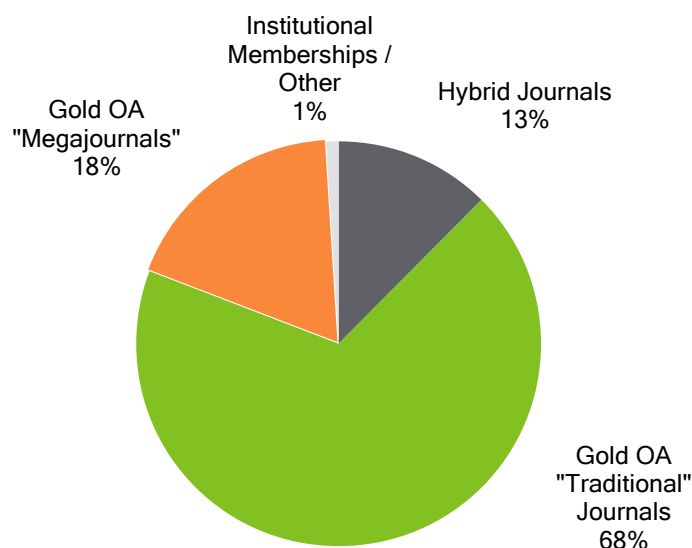
A 2012 *paper* published in *BMC Medicine*, the latest in an ongoing study by academics Mikael Laakso and Bo-Christer Björk, calculated that in 2011 the number of articles available in full, immediate open access journals encompassed 9% and 11% of all articles indexed in Scopus and Web of Knowledge, respectively. Hybrid articles added just under 1% of all articles to that total in both cases, meaning that the combination of gold and hybrid open access accounted for 10% or 12% of indexed articles, depending on the database.

The contrast is notable between Laakso and Björk's estimate of the proportionate volume of articles and Outsell's estimated proportion of revenue. Funder mandates and researcher awareness have had a positive effect on OA take-up, but the relationship between volume and revenue growth rates is not 1:1 — in fact, it is almost 2.2:1.

Market Composition — Gold, Green, and Hybrid OA

We estimate that the vast majority of OA revenues stemmed from two gold open access options (87% in total, or about \$150 million), as opposed to hybrid journals (13%, or \$22 million) or institutional memberships (1%; just below \$1 million). Figure 2 represents the market composition.

Figure 2. Open Access Market Composition Estimate, 2012



Source: Outsell's Information Industry Database

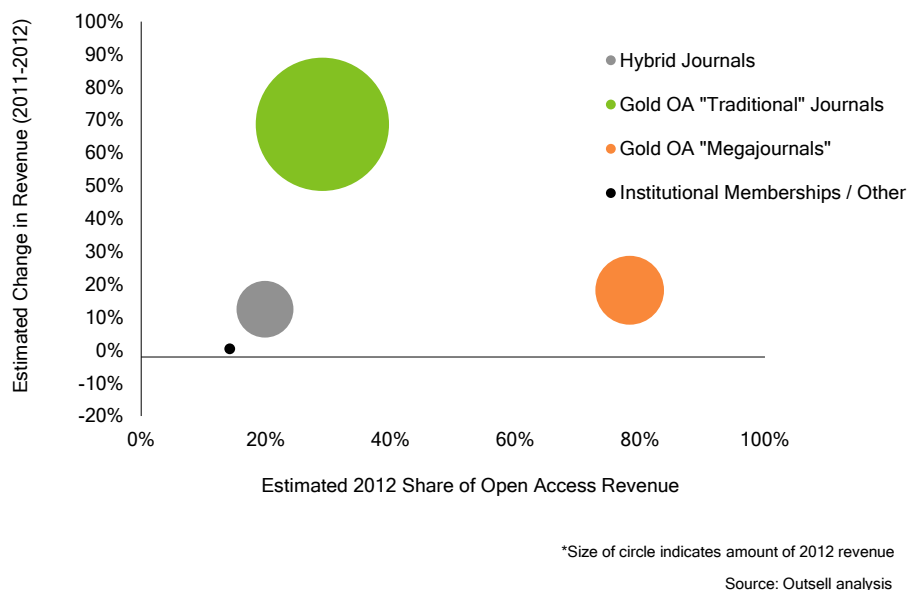
Among gold open access options, we estimate that 21% of these — \$32 million, or 18% of total open access revenues — stemmed from “megajournals,” a journal format pioneered by *PLoS ONE* that uses a “technical correctness” peer-review acceptance criteria. In part, megajournal publishing volumes are naturally higher as a byproduct of the peer-review processes they use, allowing more research to be published. Traditional gold OA makes up the remaining 68% of OA revenues, or \$118 million.

Green open access does not appear in this estimate because such services do not generate any revenues, though industry estimates indicate that green OA repositories could hold up to an additional 10% to 12% of the total volume of articles published each year.

The emphasis on traditional gold OA models is unsurprising considering the historically low uptake of hybrid open access options, the successful launch of an increasing number of traditional-model gold OA journals by large publishers, and the recent rise of the alternate-criteria “megajournal” model. The incidence of a few popular megajournals such as *PLoS ONE*, *BMJ Open*, and *Scientific Reports* has led to high growth off a smaller base when compared against the larger market for traditional gold OA journals. That traditional market includes journals from a larger array of commercial publishers (Elsevier, Springer, and John Wiley & Sons, for example), societies (the Institute of Physics, IEEE), and not-for-profits (Oxford University Press, Cambridge University Press, and PLoS).

Hybrid journals, though offered by many traditionally subscription-led publishers, encompass a smaller share and carry less momentum judging from this option's low levels of uptake, as reported by the publishers Outsell spoke with. Our estimate for the size, share, and growth rate of revenue stream by product type appears in Figure 3.

Figure 3. Open Access Revenue Preliminary Size, Share, and Growth by Product Type, 2012



The growth of open access before 2012 was led primarily by funding-rich disciplines such as the biomedical sciences, and through mandates at the Wellcome Trust and the National Institutes of Health, two of the largest funders of scientific research worldwide. But variances exist even within each broad discipline. Take physics as an example, where certain areas see extraordinarily high support for open access. The most notable outlier, high-energy physics, is soon to become entirely OA (see our analysis of the SCOAP³ initiative in this report's 10 to Watch section). Meanwhile, the more experimental areas of physics research that lie outside the Big Science area of high-energy physics see less interest and incidence of OA publication, and they are underrepresented in the physics subject-based repository arXiv. Previous and continuing growth is rooted most fundamentally in the funding mechanisms and mandates in place in specific disciplines and subdisciplines, as opposed to an industry-wide phenomenon equally affecting all areas of study.

In Outsell's view, the rise in gold and hybrid open access before 2012 reflects publishers and societies in certain fields recognizing the viability of a gold OA business model and offering new products and options to support authors dealing with a growing number of (increasingly multidisciplinary) institutional and funder mandates.

As mandates become broader in their application, hybrid options support limited uptake markets, such as the social sciences and humanities, perhaps just until the market for a subject-specific "traditional" gold OA journal coalesces. The megajournal model, on the other hand, by its very definition makes few or no distinctions between disciplines. In fact, megajournals are a venue that opens up OA publication to a broad set of authors undifferentiated by discipline, novelty of research, or interest to a specific community — no subject-specific journal or "originality" criteria is required. We note, however, that megajournals and hybrid models are growing more quickly but off of respectively smaller bases, and that ongoing growth is driven ultimately less by product specifications and more by deeper incentives such as quality, reputation, and, of course, mandates.

Market Forecast

Uncertainty obscures the future of the OA market at the time of this writing, although Outsell believes its viability and presence in the industry is assured. Some of the unknowns are, for example, immediate: Though an increasing proportion of RCUK-funded research will be compelled to publish in gold OA journals after April 2013, and £10 million will be allocated in block grants to higher education institutions in the UK to fund this, much work remains to clarify how institutions will carry out this work in practice, and what the mechanisms and consequences will be. The experiences of RCUK and its researchers will surely contribute to the decision-making of other worldwide funding bodies, but the speed with which theoretical support becomes action is a murkier picture.

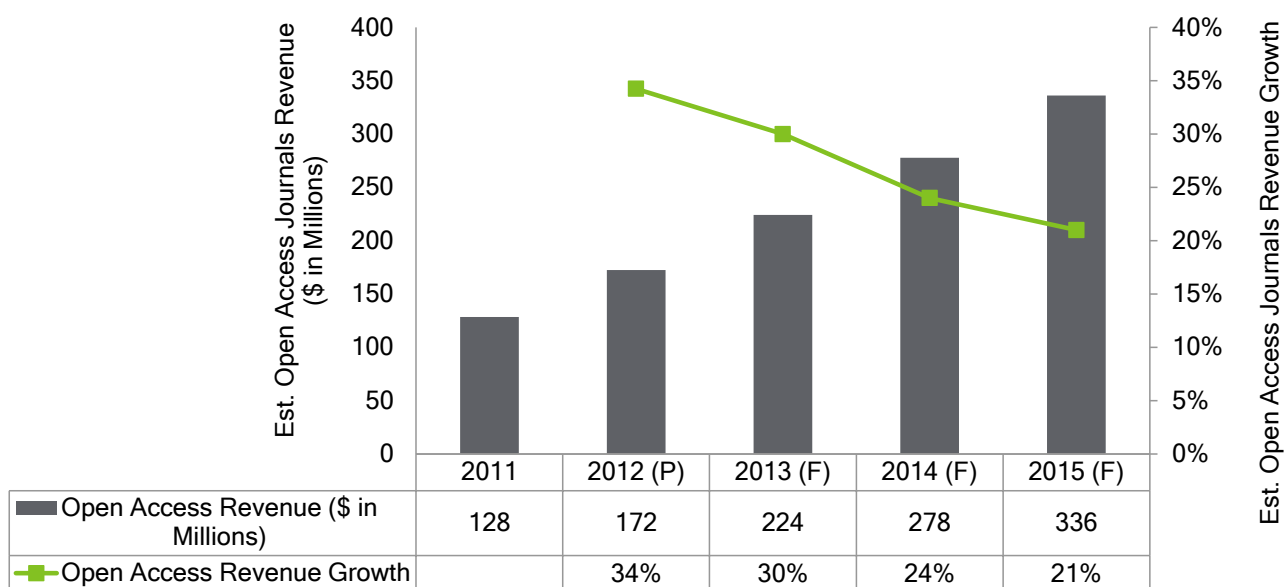
Outsell sees three scenarios that could drive OA revenue as a higher proportion of total STM market revenue, stemming first and foremost from the ultimate behavior of funding bodies.

- **Scenario 1 — New European Mandates Encourage Gold OA:** Outsell anticipates the most likely scenario is that European funders and RCUK-funded institutions will support gold OA and its cost structures, though investments in local and federated funding mechanisms will have to precede any great transition in author behavior. These bodies have demonstrated their willingness to engage with the OA movement by supporting sustainable gold OA, and while our analysis is that the infrastructure to manage this transition will happen very gradually over our three-year forecast, this gold OA growth is reflected in our picture of the market through 2015.
- **Scenario 2 — New Mandates Stimulate Green OA:** It's possible given the current economic environment in Europe that RCUK and Horizon 2020 directives will not make adequate funds available for most researchers, and compliance will hinge on deposits to green OA repositories. Should these European mandates oblige greater green OA usage from authors, revenue erosion will increase during the forecast period as access to scholarly literature is increasingly done through broad, multidisciplinary repositories. Within a decade, the continued incidence of green OA would decrease the size of the whole journal ecosystem through shifted usage traffic, subsequent advertising revenue declines, and eventually fewer or cancelled subscription sales. The scenario is particularly grim for journals without a strong enough brand to maintain a presence independent of such great, open platforms. Outsell does not anticipate that funders will want to invite such negative consequences, so we deem this scenario possible but unlikely.

- **Scenario 3 — Mandates Accelerate in Non-European Research Centers:** The most unlikely, but still possible, scenario is that non-European governments such as the US or China will introduce additional mandates. Sentiment among Chinese librarians and researchers is positive toward OA publishing, and any mandate will likely be greeted with high compliance across a larger body of scientific output (as we noted in our Market Report, *STM in China: 2012 Market Size, Share, and Forecast*, published April 16, 2012). In the United States, top-down mandates have not progressed in Congress, and the 2010 reauthorization of the America COMPETES Act — which offers no mandate but recommends inclusivity and consultation from federal research-funding agencies developing OA policies — may in the short term check the pursuit of top-down OA legislation. In Outsell’s opinion, the cost and implementation of such broad mandates will prevent further immediate and decisive action from either China or the US, but a successful introduction of gold OA mandates in the UK and EU could theoretically shift the winds and accelerate the proportion of OA revenues and article publication as much as 20% to 30% above our forecast for 2015.

In the most likely scenario, Scenario 1, Outsell anticipates that OA revenues will grow at a CAGR of 27% from 2012 to 2015, to reach a total market size of \$336 million in 2015, as Figure 4 shows. Growth, while increasing in real terms, is likely to decrease as an annual percentage as the market base expands. In this three-year timeframe, we forecast OA will still represent only 1.3% of our total Scientific, Technical, and Medical (less Geophysical) Information segment, and only roughly 5% of the total journal market by revenue.

Figure 4. Open Access Market Revenue Forecast and Growth, 2011-2015



Source: Outsell’s Information Industry Database

Assuming that the two key mandates (RCUK and Horizon 2020) would increase the number of authors required to publish open access, we believe the growth of OA articles by volume will continue but that megajournal-style peer-review publishing options will see the biggest acceleration and increase in share. We also anticipate that the average charge per article will slide upward with the launch of new, higher-value journals from strongly branded commercial and society publishers such as Elsevier, Wiley, and Nature, though this will affect mostly gold and hybrid article revenues. Hybrid models will lose overall share in volume, though these new mandates may drive some small pockets of increases in particular disciplines.

Using these assumptions, we corroborated our top-line growth estimates with our projections for expected growth by journal type, by both volume and revenue. The results show the quickest growth will be in gold “megajournals” in both volume and value, followed by gold OA — increasing more in revenue than volume because of the launch of more higher-quality titles versus a lesser increase in article numbers. We expect a similar, though shallower, path for hybrid journals.

Outsell estimates that the average APC (distorted somewhat by discounts and waivers, but excluding membership revenues) was about \$660 in 2011; in 2015, this will increase to roughly \$950 due in part to the increased number of well-branded journal publishers offering OA options at higher price points, and in part to the decline of low-value, extremely low-cost pure-OA publishers. Assuming that the total articles indexed in Scopus increases by a CAGR of 4.5% each year, the proportion of all gold or hybrid OA articles would increase by 6 basis points, to encompass about 17% of all journal articles in 2015.

If we set the baseline at Outsell's top-line and segment-level forecasts, corroborated by Laasko and Björk's figure of just under 194,000 gold or hybrid articles in 2011 identified in the Scopus database, we can expect roughly 352,000 open access articles to be published each year by 2015. We further estimate that 95% of those (336,000) will be gold open access. Table 1 summarizes these findings.

Table 1. Open Access Market Forecast by Type of Journal, Volume, and Revenue

| | Number of articles (in 000s) | | | Revenue by type of journal (\$ in Millions) | | |
|------------------------------|---------------------------------|----------|-------------------|--|----------|-------------------|
| | 2011 | 2015 (F) | 2011-2015 CAGR | 2011 | 2015 (F) | 2011-2015 CAGR |
| Hybrid | 12 | 16 | 7% | 18 | 26 | 9% |
| Gold "Traditional" | 167 | 248 | 10% | 92 | 198 | 21% |
| Gold "Mega" | 14 | 88 | 57% | 18 | 110 | 58% |
| Institutional Memberships | | | | 1 | 2 | 27% |
| TOTAL | 194 | 352 | 16% | 128 | 336 | 27% |

Source: Mikael Laakso and Bo-Christer Björk; Outsell analysis

Green OA, of course, requires a different kind of forecasting to illustrate its effects. Though lost potential revenues from green OA are difficult to quantify, Outsell also estimates that, based on Scenario 1, the revenue per subscription article will decrease by about \$100, from \$4,000 today to \$3,900. (This is assuming, as shown earlier, that the total number of articles increases by 4.5% and journal subscriptions increase to roughly \$6.7 billion in 2015.) This decrease is consistent with patterns of tightening subscription budgets, the diversion of funds to OA options, and the potential cancellation of some subscriptions in favor of access through green OA platforms. It also suggests that revenue erosion caused by an increasingly OA market, as compared to a scenario in which green and gold OA remain at 2012 levels, would be \$104 million, or about 1.6% of the journals market in 2015.

As with any experimentation, the market could be driven forward just as easily as it could be disrupted, and publishers with a legacy subscription base may begin to see the overall turnover and profit margin of their portfolios decline in sectors with greatest OA adoption. Most of the journal industry's revenue and profit base in Scenario 1 will nevertheless remain overwhelmingly subscription-led.

Key Trends and Market Drivers

Outsell has identified trends and counter-trends that affect the open access decisions of all significant stakeholders. Our forecast for the next three years assumes the following market drivers will push growth.

Funder Mandates

The increase in OA uptake can be directly tied to the mandates of those who hold the purse strings. The decision by Research Councils UK to mandate gold OA publication for all research it funds will have a straightforward, positive effect on OA revenue. Though a significant step forward for OA proponents, the UK represents only 6 percent of the world's research output and closer to 10 percent of library budgets. That leaves a lot of subscription-based territory still in play.

Outsell's stance, however, is that the broadness of new mandates from RCUK and Horizon 2020 will create greater diversity in author groups with the need for an OA option. These early few years will also require education and support for newly mandated authors, who themselves will likely need guidance as they navigate the maze of funding sources, Creative Commons licensing requirements, and choices in the appropriate OA publication. Discipline-neutral investments, such as the creation of dedicated-OA advocacy roles within publishing houses and societies, interdisciplinary OA branding (such as Wiley Open Access, Oxford Open, and SpringerOpen), or the implementation (through acquisition or otherwise) of simple and reliable OA-based payment systems are today's response to a market in which particular disciplines are displaying increased acceptance of OA. Publishers are defensively making more investment in OA, and Outsell agrees it is a necessary investment, given our forecast. Building infrastructure now in these heavy OA disciplines signals willingness to react to authors' needs. Flexibility will encourage further attempts to support disciplines with smaller pockets of demand in the future.

Reorientation from Content to Service Provider

For OA, the publisher delivers value through services provided to the author, not in the ability to gain access. Common frustrations, such as the time lag of peer review, can hinder communication in fast-moving disciplines, and providers may start to compete more aggressively against these author-driven pain points to differentiate themselves. Outsell notes that many providers in 2011 and 2012 made it a point to survey authors to ensure alignment with key needs, a skill that will become even more important as author priorities shift in response to new mandates and changes to evaluation criteria. Though no one journal is likely to address every author's need, the current enterprise-focused landscape leaves many gaps to close — low-cost, quick, high-quality, open, interdisciplinary, or a combination of these — to maintain share among authors suddenly empowered with payment decisions.

Investing in Infrastructure

The next three to five years will likely be a period of transition for providers managing competing OA and subscription income streams, with investments in better payment collection systems and institutional agreements paradoxically rewarded with lower profit margins and decreasing subscription revenues. While a piecemeal approach might get by at low levels of take-up, the market growth Outsell anticipates requires organizational focus across disciplines to simplify this process for all parties. Opportunity exists for third-party services to ease these dilemmas with the right software and technology to reduce friction and squeeze more efficiency and value out of OA-dedicated systems.

Changing Models of Scientific Discourse

A traditional journal sets a specific bar on the number of articles per issue, and its quality is often expressed in how many articles get turned away. The philosophy behind the original light-touch peer-review model does not instate any sort of cap, opening the flow of research output. The model is highly scalable, though scaling internally with the appropriate staff and systems poses its own challenge. From a scientific viewpoint, more information of lesser significance, ambiguous or negative results, and repeat studies are floating downstream. For the useful information to remain useful, providers who lower barriers to publication will have to build or partner to support ancillary tools such as bibliometrics and text mining, which can sift through and surface findings of relevance to specific disciplines or problems. For more aggressive OA proponents, the tech-based and startup world could be an intriguing field for partnerships — if not a rich pool of acquisition targets — for post-peer-review discussion platforms (think Faculty of 1000, also known as F1000, and Hypothes.is), article-level metrics (think Altmetric, ImpactStory, or Microsoft Academic Search), discovery platforms (Mendeley, Zotero) and other as yet unarticulated ways to navigate the sea of information.

Potential Disruptive Forces

In the short term, we believe Outsell's list of market trends will feed the growth of OA's share in the journal market through 2015. In the long term, however, a number of counter-trends and consequences may affect the market. Outsell anticipates that the following potential disruptive forces will be the crucial factors in whether the market indeed continues its growth trajectory.

Theory is Nice, But It's Not Behavior

Though funder mandates will increasingly make OA a required consideration for authors making publication decisions, these authors will simultaneously balance interests with greater historical inertia — namely, quality (mostly measured in impact factor) and appropriate fit of their target journal. In practice, the actual implementation of any mandate will require that these multiple incentives also align. If funding falls short of the required amount to pay an institution's every APC, there will be some rationing involved, and this raises a more serious access question. In less capital-rich research areas, the funding available for APCs could struggle to meet demands for publication, if not overshadow the cost of performing the research in the first place. In the end, it is the author's choice to publish OA that makes the business model work, and mandates and moral arguments alone are likely not the mechanisms to achieve this.

Disciplinary Disinterest

In capital-intensive research disciplines, the presence of deep-pocketed funders with the wherewithal to subsidize the cost of publication has galvanized OA uptake in fields such as biological and health sciences. On the other hand, consider that of RCUK's seven research councils — all of which will be obliged to require open access for researchers' outputs — only two support fields like social sciences and the humanities. Outsell's discussions with providers anecdotally raised numerous distinctions within even STM disciplines — not all of physics, for instance, is as enthusiastic as those in high-energy physics, and chemistry has proved in some cases to be a remarkably resistant field. For disciplines that have yet to reach enough critical mass in OA funding and interest to launch a dedicated-OA journal, a hybrid option appears the logical way to ease the transition. When authors are given the choice, however, several of the publishers Outsell spoke with reported low take-up of OA in their hybrid journals, with 1% to 2% being a common benchmark. While hybrid serves a certain proportion of the market, it does not seem to be a transition-inducing device, and it raises some questions about whether OA will advance beyond a few sporadic articles in unenthusiastic disciplines with few to no gold OA options.

Scaling Up

As a revenue stream, an OA journal has the potential to scale more easily than subscription products — income is tied to the supply of content, not to its demand, so an increase in research output spells more income. As an operational model, however, OA displays key differences: Rather than negotiating with a centralized institution, in most cases OA journals collect payments from numerous individual authors, with correspondingly diverse levels of creditworthiness and administrative efficiency. This does not even begin to touch on the difficulties of scaling up an editorial and peer-review system, a problem the most successful megajournal publishers feel. Maintaining flexibility in operation and editorial models has been a key skill to learn, but it remains to be seen whether services can stand up to exponentially increasing scale and still remain competitive on speed and rigor of peer review, ease of submission and publication, and the myriad other criteria by which authors will judge their service providers. Authors are sure to notice any deterioration in quality or services, and any decline will empower them to submit elsewhere to the detriment of any under-delivering product line.

Payment Systems in Flux

Anticipating an increase in OA payments has led to some movement toward clarifying payment systems, with all stakeholders acknowledging the need to centralize more of the APC collection processes. Logically, however, a common fund implies centralized decision-making, so whoever controls the purse strings could potentially become an arbiter for article publication decisions — by imposing price caps, for instance, budgeting for a *PLoS ONE* submission instead of *PLoS Medicine*. It remains to be seen whether this centralization will in turn create a bottleneck or have a rationing effect on the supply-side in the short term, either of which could prove dangerous to the flow of scientific communication.

Unintended Consequences

Widening the platform and lowering the barriers (and the cost) for publication could theoretically prevent some of this rationing. A typical megajournal, despite its low price point and low peer-review barrier, could emerge as a foil to the layer of midlevel journals that offer adequate impact factors but little competitive differentiation. A megajournal with a strong brand could easily be seen to swallow enough submissions to endanger this portion of the ecosystem. Green OA platforms, similarly, are broad and open repositories that, at their most successful, could lead to the cancellation of subscriptions at libraries that find they can give patrons the same information for free from collections of preprints. Though neither scenario is yet a reality, the society publishers and small commercial operations in the long tail of the STM journals market are most endangered by this vision of the future.

Openness is Just One Part of the Economy

New forms of scholarly communication, such as social networks, informal collections of prepublished material, data archives, and post-publication critique, mean there is increasing amounts of information traded outside the canon, and we look with interest at how players like Mendeley, Hypothes.is, figshare, Rubriq, and F1000 will broaden and disrupt this space. This is not to say the journal is not important; the quality stamp of a rigorously curated publication is likely to remain necessary for the recognition of truly monumental work. Such articles are the peak of the triangle, however, and new access models are concerned with broadening the base. Each of these pieces can itself act as a data point in a new economy of tertiary information — information about how research adds value, addresses new questions, and changes lives. Open access is certainly one mechanism to allow for information to flow into these analytics tools, but we don't believe OA is a necessary or even a sufficient condition. In a way, focusing too hard on making articles freely available misses the deeper and, in Outsell's opinion, more revolutionary trends occurring in scientific information.

Competitive Landscape

Another important consideration in the trajectory of this market lies in which key players drive this growth, and in the relationship of these players to the market as a whole.

Outsell's analysis shows a consolidated market at the top for OA publication, with three providers anticipated to collect 58% of the revenues in 2012. We illustrate these findings in Table 2.

Table 2. Open Access Journals Preliminary Leaderboard and Market Share Estimates, 2012

| Company Name | Total 2012 Open Access Journal Revenues (\$ in Millions) | Estimated % Change from 2011 | 2012 Open Access Journal Market Share | Estimated Point Change from 2011 |
|-----------------------------------|--|------------------------------|---------------------------------------|----------------------------------|
| Springer Science + Business Media | 52 | 10% | 30% | (6.6) |
| Public Library of Science (PLOS) | 37 | 61% | 21% | 3.6 |
| Hindawi Publishing Corporation | 12 | 90% | 7% | 2.0 |
| Elsevier | 6 | 60% | 4% | 0.6 |
| John Wiley & Sons, Inc. | 6 | 46% | 3% | 0.3 |
| Oxford University Press | 5 | 11% | 3% | (0.6) |
| Nature Publishing Group | 4 | 74% | 2% | 0.6 |
| Bentham Science Publishers Ltd. | 4 | 12% | 2% | (0.4) |
| Wolters Kluwer Health | 3 | 16% | 1% | (0.2) |
| BMJ Publishing Group Ltd. | 2 | 86% | 1% | 0.3 |
| Total Leaderboard | 129 | 33% | 75% | (0.5) |
| Total Market (estimate) | 172 | 34% | - | - |

Note: Numbers have been rounded
Source: Outsell's Information Industry Database

Springer, which owes much of its leadership position to the acquisition of BioMed Central in 2008 but which has invested in Springer-branded OA options ever since, shows signs of relative maturity, as its growth rates have leveled off to a greater degree than its nearest competitors, Public Library of Science (PLOS) and Hindawi. For its part, PLOS has benefited greatly from the success of the first-in-its-class megajournal *PLOS ONE*, which has seen strong increases in submissions each year. Indeed, the increasing incidence of megajournals from competitors such as Nature (with *Scientific Reports*), Sage Publications (with *Sage Open*), and the not-for-profit BMJ Group (with *BMJ Open* and the six newly launched *BMJ Open Editions*) suggests it will begin to operate in a more competitive market in the future, though 2012 growth rates do not yet reflect this.

Hindawi's growth in 2012 reflects the growth of OA as a respectable publication channel across its diverse list. As a less expensive OA publisher, aided by a lower cost base than traditional publishers and fewer legacy systems to hurdle, Hindawi succeeded in harnessing the growing interest across the board for OA publication while addressing price sensitivities from a funding landscape in transition. Hindawi has worked hard to differentiate itself from neighboring early OA entrants, such as Bentham Science Publishers, which has struggled against allegations of poor editorial and marketing practices for some of its 219 OA journals.

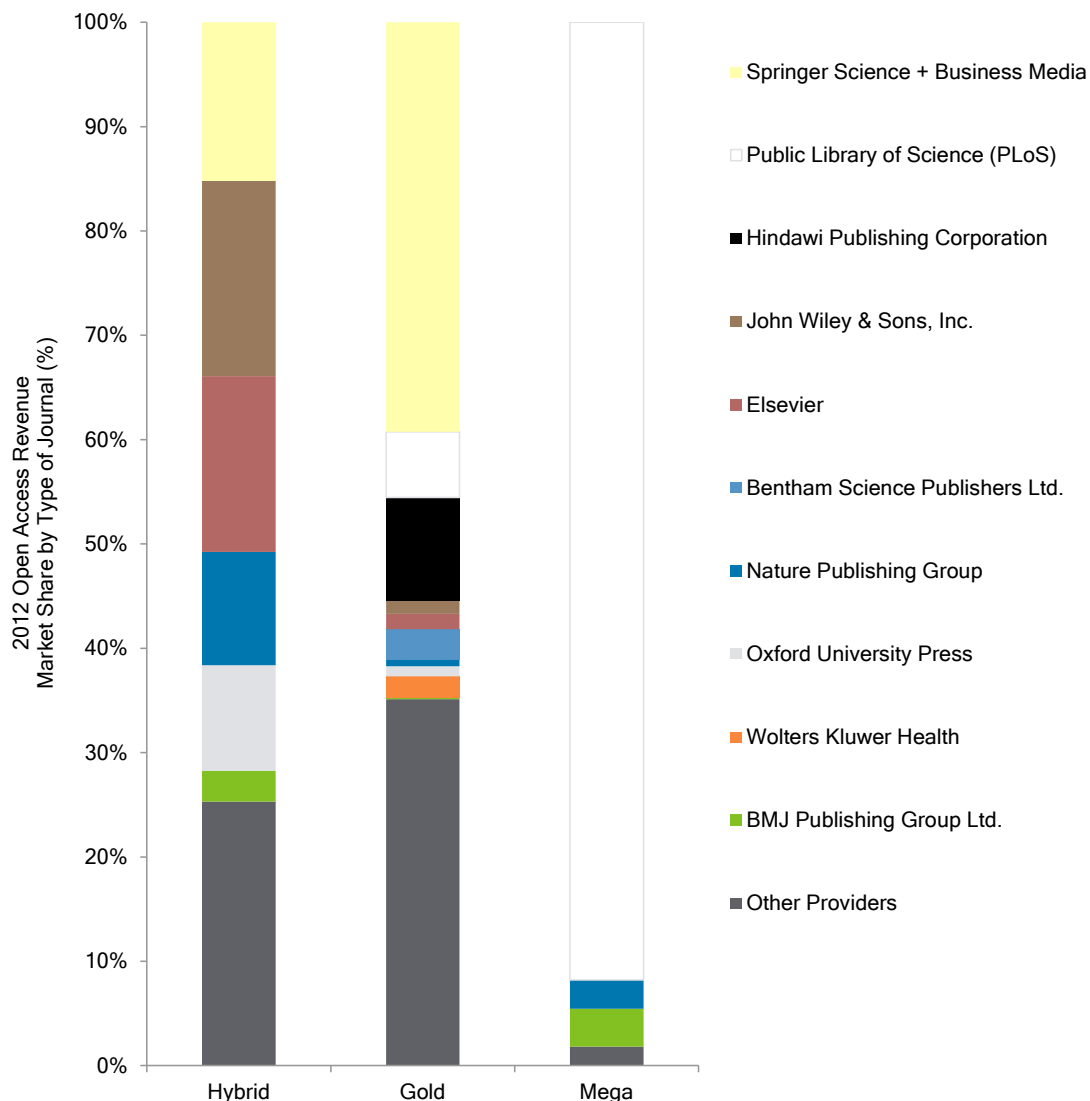
Among competitors with strong subscription foundations (except for Springer, of course), Wiley is the current leader in OA take-up, offering both hybrid and pure gold OA options. The industry behemoth, Elsevier, is by Outsell's estimate close behind, but this represents a smaller fraction of its total journal revenue.

Perhaps most notably, the "long tail" of journal publishers — those with less than \$2 million in OA revenues in 2012 — has gained in share over the rest of the leaderboard. This reflects our market forecast, which calls for increasing incidence of gold OA options (of both models) from providers who had previously steered away from OA publication, for whatever reason. We anticipate that the market will become commensurately less consolidated in the coming years, though the specific dynamics will be determined largely by strategic initiatives such as those outlined in our 10 to Watch section.

Competitive Performance by Segment

Outsell notes that there remains great diversity in the prevailing strategy of each of the largest OA providers. Figure 5 shows our estimates for the market share of each provider by model of journal: traditional gold, alternate-criteria "mega" gold, and hybrid. The graph does not, of course, reflect the size of each market; rather, it illustrates the diversity (or nondiversity) of the market for each product type.

Figure 5. Open Access Revenue Market Share by Type of Journal, 2012



Source: Outsell Information Industry Database

At a glance, one can see that the hybrid and gold open access markets are far less consolidated than that of the alternate-criteria megajournal market. PLoS is the clear leader in the megajournal market, holding more than 90% of market share with its pioneering *PLoS ONE* product. Nature's *Scientific Reports*, just finishing its first year, and BMJ's *BMJ Open* are other notable megajournals, but smaller by several orders of magnitude.

Among hybrid and gold journals, the market shows far greater diversity, with Springer the clear leader in gold open access. One key difference is the performance of traditional publishers, such as Elsevier and Wiley. Elsevier's broad portfolio of journals, more than 1,500 of which were available in a hybrid model in 2012, has allowed it to take a double-digit share of the hybrid OA journal market, but its late entrance into the gold OA journal market means it has a correspondingly lower share. Wiley, though smaller in absolute terms than Elsevier, has captured almost equal share of the open access market for hybrid and gold journals. Last, Nature Publishing Group's performance is notably high for a publisher its size, due in part to the success of *Nature Communications* in the hybrid category, with high take-up and high article processing costs producing healthy revenue for notable share.

In general, the hybrid market shows far greater diversity despite its smaller size in absolute terms. This speaks perhaps to the ease with which today's subscription-based incumbents may allow for integration of OA options into existing portfolios, as a first step of accommodating mandate-bound authors. The megajournal market, on the other hand, appears a difficult one to enter, with one clear leader and tough questions to answer first about discipline-specific desires for alternate-criteria publications.

10 to Watch

Outsell does not predict a dramatic swing toward OA in the next three to five years, and it will remain a small portion of the bottom line for the majority of publishers. Nevertheless, the actions of these 10 publishers, platforms, service providers, and repositories will be instructive to all players navigating the OA market.

Copyright Clearance Center

Copyright Clearance Center (CCC) is already entrenched in the STM ecosystem with RightsLink, a transaction engine for rights transactions. In October 2012, it announced a new suite of open access solutions built into RightsLink that would allow publishers to support more flexible rights and pricing variations – charging lower fees for researchers at member institutions, for instance, or varying the Creative Commons license as dictated by funder mandates and author choice. Post-publication, RightsLink can support the permissions documentation process, reducing friction for third parties who want to reuse content. Perhaps most important from a business standpoint, RightsLink and CCC can monitor use, reuse, and uptake data so that new powers to vary pricing can be matched by the ability to monitor the market's reaction.

eLife

As an open access journal subsidized by three research funders, eLife is a one-of-a-kind experiment, with the ambitious threefold goal of raising the profile of open access publication, improving the peer-review process, and using digital media to communicate new findings more effectively. Run as a separate 501c3 from its three funder benefactors (the Wellcome Trust, the Max Planck Society, and the Howard Hughes Medical Institute), the journal will not charge any fees for an initial three years, during which time it will work on a sustainability plan — and, presumably, publish high-quality research. Its parentage gives eLife the potential for prestige and the leeway for experimentation beyond traditional revenue streams, once it gains its footing, but its early success will depend on whether it can successfully address questions about the editorial independence of the journal. Its potential for disruption will only be realized if it can successfully demonstrate integrity and transparency in its processes.

Hindawi

Though Hindawi is one of the three biggest OA publishers, it was initially founded in 1999 as a traditional-model publisher and did not convert completely to OA until 2007. Headquartered in Egypt, its lower cost base has helped it to set competitive APCs, but its head start in focusing on the systems and competencies of a fully OA model also work to its benefit. Though operationally organized around in-house teams rather than the usual expert editor-in-chief model, Hindawi is very clear in its messaging on the services it provides to authors, its publishing statistics on acceptance rates and the speed of publication for each of its journals. The approach appears to be working, as its revenues doubled from 2011 to 2012. Though, because it relies on publication volume as a revenue stream, Hindawi must work hard to avoid appearing to dilute the quality of its journals to attain further growth. Its challenges will remain in successfully messaging the value of its services, and in staying competitive when balancing cost versus quality, both issues that matter to authors in an OA world.

Nature Publishing Group

Nature Publishing Group's portfolio includes multiple flavors of open access, posing an interesting case study as a publisher of high-quality journals engaging with new business and peer-review models. Though Nature publishes 15 pure gold OA journals (one more scheduled to launch in January 2013) and the rest of its non-Nature-branded journals largely offer a hybrid OA option, only one Nature-branded journal (*Nature Communications*) offers hybrid OA. Despite its higher-than-average APC of \$5,000, however, the hybrid take-up has hovered around 40% since the journal's launch in 2010. Nature's other high-visibility OA product is *Scientific Reports*, a "mega" gold OA journal launched in 2012 that will have published more than 1,000 papers in its first year across a variety of disciplines, from biosciences to physical sciences. While *Scientific Reports* and *Nature Communications* are so far aided by their association with the strong Nature brand, Nature will be intriguing to watch as it navigates the appropriate APC for its highest-quality journals, should it choose to go the hybrid route (or, even less likely, the gold route). In a market where costs are more transparent and price sensitivities are a logical next development, any decision (or nondecision) by Nature will be a leading indicator for authors, funders, and other publishers striving for high quality and openness at once.

Open Access Key

As a tool to facilitate the payment and collection of article processing fees, Open Access Key (OAK) represents a new breed of services provider addressing gaps in the current revenue flow from author to publisher. Founded in 2011 with its first payments processed in February 2012, OAK's value proposition is simple: It claims to reduce an institution or funding body's administrative costs when processing many individual payments to a variety of journals and publishers, and it offers a platform for automating processes such as the deposition of content into institutional and subject-specific repositories. Individual memberships are free, but institutional memberships allow a central administrator to monitor costs and usage data across groups of up to 500 researchers. It also provides an important service to publishers, particularly those struggling to establish or to scale their APC payment systems. Outsell views the early success of OAK among high-profile institutions such as the Wellcome Trust as the first wave in competition around services to reduce friction and create a more efficient marketplace. OAK is a startup built to address issues with the OA market, so Outsell believes its success will hinge on whether it can carve its niche before the arrival of larger entities and subscription agents — which will surely bring existing relationships with stakeholders to bear. If it is successful, expect more entrepreneurial interest in better services and efficiencies to follow.

PeerJ

PeerJ's pedigree is certainly impressive: It was co-founded in 2012 by Peter Binfield and Jason Hoyt, who came to the project from key positions at PLoS and Mendeley, respectively. Its admittedly experimental business model introduces a new revenue structure for open access, swapping the gold-model APC for a lifetime membership. Authors will be charged a one-off fee ranging from \$99 to \$298, depending on the level of service. Co-authors on each new publication must be paid members, which, given the number of authors typically included on research papers, gives the model a viral marketing aspect. To retain their memberships, researchers must participate at least once a year in reviewing for the journal. Outsell predicted at its launch that PeerJ's low prices would be sustainable (See our *Insight, New Open Access Publisher PeerJ Launches*, published June 18, 2012), though the business itself was open to more uncertainty. (We also noted that it is less likely that established players would be able to take up this model alongside other offerings.) More disruptively, the pairing of a subscription membership with a light-touch peer-review model and an OA preprint server is a re-imagining of the scholarly communication process entirely, changing the publisher's role from one of conferring a quality stamp to that of building a broad community.

Public Library of Science (PLoS)

PLoS' most famous contribution to the OA debate is certainly its pioneering of the megajournal model, though it was originally founded in 2001 as an advocacy group and has published high-quality research since 2003 with *PLoS Biology* and, starting in 2004, *PLoS Medicine*. Advocacy has remained central to its mission, as has experimentation that pulls down boundaries in scientific discourse. *PLoS ONE*, for instance, was the first journal to publish articles based solely on scientific validity and technical quality. The increasing volume of papers it publishes — almost 14,000 in 2011 and we estimate closer to 23,000 in 2012 — and the reduction of prepublication categorization (*PLoS ONE* is discipline neutral) lends itself to article-level metrics (ALM). ALMs are a first step toward repositioning research assessment to focus on the importance of the article, rather than its container, and to diversify the range of different types of research impact to be covered. Its success is its own challenge, however, as scaling up against the increasing volume of papers and the introduction of new layers to the scientific discourse requires additional staff and investment in technologies to address volume and to maintain a quality experience for authors and reviewers. PLoS' role as a publisher and advocacy group means its long-term goal will remain to transform research communication, though in the short term Outsell anticipates its greatest contribution will be in encouraging a shakeup in mentality about the possibilities of OA to push the boundaries of traditional models and metrics.

PubMed Central

PubMed Central (PMC), developed by the US National Library of Medicine, is an online repository of full-text biomedical journal articles, developed chiefly as an archive to enable public access to all research funded by the NIH or produced by publishers operating under an open access business model. As the open access approach has flourished, other countries such as the UK and Canada have developed their own PMC repositories, forming what is today an international network (See our *Insight, British Library Unveils New Tools for UK PubMed Central*, published February 2, 2012). The US PMC has archived more than 2.6 million articles as of January 2013, with full participation from more than 1,714 journals and selective deposits from an additional 1,952. Its robust collection of biomedical information makes it an important discovery platform in its own right — something that bears consideration for publishers investing in proprietary platforms. PMC further feeds the growth of tertiary publishing, as its connection to the PubMed database and PubMed's accompanying eUtils feeds data requests for use in other programs or interfaces. The number of PMC article views and citation data are already used in PLoS article-level metrics and in other altmetrics tools like ImpactStory, as is data from Web of Science, Scopus, and CrossRef. Where these other sources are commercial products, however, PMC is a government-subsidized entity. Its information is freely available and, in the spirit of "pure" OA, is designed to be freely, onwardly used. PubMed Central's success may raise questions about the role of green OA, particularly if its actions are seen to threaten the market share of services its publisher partners develop. But, as discoverability and data-sharing capabilities become more sophisticated, its role in encouraging more experimentation in analytics and bibliometrics analysis will make it a powerful resource on multiple levels.

SCOAP³

SCOAP³ (Sponsoring Consortium for Open Access Publishing in Particle Physics) is an experiment in OA publishing specific to high-energy physics (HEP). Most of the 7,000 papers published in HEP each year are freely available as preprints in arXiv, the green repository for physicists. However, the consortium operates under the recognition that journals and publishers continue to provide an important service. The goal of SCOAP³, therefore, is to realign money now directed toward subscriptions to pay for editorial services, not for access. By 2014, the consortium hopes to convert from paid to open a list of 12 HEP journals from seven publishers, with funding prices set through a bidding and negotiation process managed by the European Organization for Nuclear Research (CERN). The experiment stands out not just for its completeness (the HEP ecosystem will theoretically become 100% OA), but for its uniqueness — no other field is likely to have the same centralized body like CERN, the universal acceptance of OA, or such a small number of journals to convert. It has taken SCOAP³ seven years to get to the funding stage, and much depends on its ability to collect on pledges in actuality, not just in theory.

Springer

Springer's acquisition of BioMed Central in 2008 instantly made it the largest OA publisher in the world and increased the proportion of OA articles among its portfolio from 3% in 2007 to 10% in 2008. With the launch of *SpringerOpen* in 2010, this share grew to 16% in 2011. In 2012, it entered the megajournal market with *SpringerPlus*, and several months later began publishing OA ebooks. Springer's enthusiastic embrace of the OA market speaks to its confidence in the business model, and has helped it to carve out a place in a class of one at a crucial early juncture. At the same time, its subscription revenue is still a major part of its business. CEO Derk Haank has been on the record voicing his skepticism that OA will account for the majority of the journal publishing business. Springer's navigation of further expansion in the OA market will likely set the tone for continued evolution, with it having differentiated itself through its infrastructure and branding investments as a willing and high-quality provider of OA services.

Essential Actions

Clarity on the feasibility and desirability of open access would be far easier if the market immediately transitioned from one extreme to the other overnight, but in the murky real world it's the transition phase that will determine the OA movement's success or failure. Outsell does not foresee a clean switch soon, so we define success in our timeframe as the ability to accommodate author needs vis-a-vis mandate compliance and to ensure scientific rigor despite changing peer review, rights and reuse, and funding infrastructures. Outsell recommends the following essential actions for all stakeholders to balance disparate OA requirements against the broader need of furthering scientific discourse.

1. Monetize the Services that Matter
2. Co-Exist with the Research Community
3. Build Muscle around Scalability
4. Break Down Barriers
5. Experiment

✓ Monetize the Services that Matter

In an open access model, the editorial function of any journal is recast as a service to authors, empowering communication rather than allowing entrance. This requires a different mentality, and it's important to know what new metrics will pull authors in — and which will drive them away. A healthy dialogue with authors and societies to define new needs and the criteria for success will ensure the evolution occurs with everyone on board. In some cases, society publishers are already preparing for this change by adding a steady stream of new revenue models associated with their brands, such as continuing education and website advertising.

✓ Co-Exist with the Research Community

Communities of scientists are already taking advantage of new collaborative digital tools to freely share knowledge and data outside the confines of a journal, whether through preprint repositories or through engagement with and sharing of documents post-peer review. Rather than trying to bottle this conversation, it would be better to take advantage of it. As open access increases its share, success will be less about wresting control of the scientific conversation; rather, the value of any provider will lie more in its ability to disseminate knowledge in new forms and formats.

✓ Build Muscle Around Scalability

For those providers who began life in a subscription-based economy, growing an OA revenue stream will require a careful balance against existing revenue streams and back-end capabilities. OA and subscription customer service is sufficiently different in many cases where it is necessary to invest in new workflows and processes as systems balance from one to the other. Even within notably borderless models like the megajournal, a key competency is to quickly and efficiently scale up (or scale down) editorial and internal processes in response to fluctuating submissions, or perhaps identify what services (or providers) are worth acquiring to avoid building systems from scratch. Flexibility will be key, as OA's new brand of customer is more difficult to predict, and failure to prepare could result in a poorer experience for these authors — leading fewer authors to submit in the future.

✓ Break Down Barriers

Open access is going to be most challenging for the market's mid-tier of very specialist or narrow journals, particularly if the megajournal model begins to creep into more disciplines. This middle part of the ecosystem is where real thought should be put into the purpose of the peer-review process and into whether the system is best served by facilitating more interaction, providing a broad corpus of findings — negative, positive, conclusive, or not, as long as they are sound — or ensuring only top-quality output. All are now options to be considered.

✓ Experiment

Though revenue and growth are still volatile, the structure of the market is beginning to show the first signs of understanding how to harness and accommodate the needs of all stakeholders. The next three years is the time to begin testing what the market will and will not bear, while stakes are still small and infrastructure remains under construction. Outsell predicts we will see from all sides flexibility in pricing, better definition of needs and points of friction, and a fuller concept of the new benchmarks that inform uptake and growth.

For all but a few top-tier providers, the ultimate goal is not, after all, to have the greatest share of OA revenue. Rather, the overarching goal of the journal publishing industry is to enable scientists to discover, use, critique, and develop new problems or responses to research outputs, in whatever venue these scientists prefer. Achieving these objectives builds long-term brand and user loyalties. Testing the boundaries now will lay the groundwork for the winning business models of the future, more than any theoretical debate or mandate.

Related Research

More information on the companies analyzed in this report is available to Outsell subscribers at <https://clients.outsellinc.com/vendormarket/?report=1135>

See additional reports on this segment, available at http://www.outsellinc.com/scientific_technical_medical/

Reports

[Standards: 2012 Size, Share, Forecast, and Trends](#) (October 3, 2012)

[STM Information: 2012 Market Size, Share, Forecast, and Trends Report](#) (August 30, 2012)

[STM E-Books: 2012 Market Size, Share, Forecast, and Trends](#) (June 5, 2012)

[STM in China: 2012 Market Size, Share, and Forecast](#) (April 16, 2012)

[Open Educational Resources: Threat, Opportunity, or Both?](#) (May 23, 2011)

[Open Access Primer – Market Size and Trends](#) (September 21, 2009)

Insights

[Knowledge Unlatched to Offer New Open Access Model for Scholarly Monographs](#) (August 23, 2012)

[New Open Access Publisher PeerJ Launches](#) (June 18, 2012)

[British Library Unveils New Tools for UK PubMed Central](#) (February 2, 2012)

[A New Model Emerges for Open Access](#) (January 26, 2012)

Appendix

Table A1. Open Access Policies and Mandates of Key Funders

| Funder / Institution | Country | Date of Mandate | Mandate Requirements |
|------------------------------------|----------------|-----------------|---|
| Wellcome Trust | International | 2006 | Requires that electronic copies of any research papers accepted for publication in a peer-reviewed journal, and supported in whole or in part by Wellcome Trust funding, must be deposited into PubMed Central (or UK PubMed Central once established). |
| Australian Research Council | Australia | 2006 | Encourages, but does not require, archiving of research outputs in appropriate repositories within six months. Reasons for exempting research need to be provided in final report. |
| European Research Council | International | 2007 | Requires that all peer-reviewed publications from ERC-funded research projects be deposited upon publication into an appropriate research repository where available, such as PubMed Central, ArXiv, or an institutional repository, and must subsequently be made open access within six months of publication. |
| National Institutes of Health | US | 2007 | All investigators funded by the NIH must submit or have submitted for them to the National Library of Medicine's PubMed Central an electronic version of their final, peer-reviewed manuscripts upon acceptance for publication, to be made publicly available no later than 12 months after the official date of publication. |
| National Research Council (Canada) | Canada | 2008 | Requires deposit of NRC-funded research in NParC repository at the earliest possible opportunity, respectful of publisher embargos. |
| European Commission | International | 2008 | New grant agreements in the areas covered by the pilot (approximately 20% of the FP7 budget) will contain a clause requiring grant recipients to deposit peer-reviewed research articles or final manuscripts resulting from their FP7 projects into their institutional or, if unavailable, a subject-based repository. They will have to make their best efforts to ensure open access to these articles within six or 12 months after publication, depending on the research area. |
| Research Councils UK | United Kingdom | 2012 | Peer-reviewed research papers that result from research that is wholly or partially funded by the Research Councils must be published in journals that are compliant with Research Council policy on open access, which includes offering a "pay to publish" option or allowing deposit in a subject or institutional repository after a mandated maximum embargo period (usually six months). In addition, the policy mandates use of the Creative Commons "Attribution" license (CC-BY), when an article processing charge (APC) is levied. |

Source: ROARmap; Outsell Analysis



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