The ‘Total Cost of Publication’ in a Hybrid Open Access Environment

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Aims

1. Review major current open access developments
2. Report research on UK institutions experience of the APC market
3. Discuss possible futures for OA and scholarly communication

Key terms:
- ‘Green’ OA – deposit in OA repositories
- ‘Gold’ OA – OA publication in journals
- APC – Article-processing charge to pay for Gold OA for a particular paper
- ‘Hybrid’ journals – subscription journals offering OA options for individual articles based on APC payment
Open Access Key Developments

1. Rising adoption of OA in the mainstream of scholarly communication
2. Ongoing importance of disciplinary differences
3. Increasing influence of mandates
4. Growing market complexity
5. Developing institutional policies, systems and advocacy

Includes major stakeholders

Based on analysis of the OA discourse in peer-reviewed and professional journals, social media, etc (Pinfield, 2015) using the VOSviewer tool
Open Access Adoption

• OA is now entering the mainstream of research publishing and dissemination
• Higher levels of awareness and adoption by researchers
• More evidence emerging of size and shape of OA
• Various studies have estimated the proportion of the scholarly literature which is OA
  – Björk et al. (2010): 20% of papers published in 2008 were OA
  – Archambault et al. (2013): 48% of the literature published in 2008 was available in an OA form in 2012 – OA reaching a “tipping point”
  – Khabsa & Giles (2014): at least 27m (24%) of the 114m English-language scholarly documents on the web are freely available
  – Jubb et al (2015): 34% of research published 2012-14 available OA after 24 months
Journal publishing models employed by Global and UK authors

“…whereas UK take-up of OA publishing models was slightly below the world average in 2012 (13% as compared to 14% globally), it had moved ahead of the world average by 2014 (over 18% as compared to under 17%).”

(Jubb, M., et al., 2015)
Disciplinary Differences

- Studies of OA adoption show variations between disciplines remain significant
- Different disciplines have different established conventions around scholarly communication – these are reflected in OA adoption
- Studies generally show across Science, Technology and Medicine (STM) disciplines:
  - Gold OA predominantly adopted by Health and Life Sciences
  - Green OA favoured by Physics, Computer Sciences and Mathematics
  - Some disciplines e.g. Chemistry have lower levels of adoption
- Most Humanities and Social Sciences (HSS) disciplines have a problematical relationship with OA
- Where it has not become the norm there remains considerable suspicion and scepticism of OA
- Key practical issues remain: e.g.
  - Whether disciplines will converge on similar models (e.g. recent interest in pre-prints in Biosciences)
  - How monographs might be brought successfully into an OA environment
Importance of Mandates

- Policies encouraging/requiring OA being adopted by increasing number of funders, institutions etc. (2004 onwards)
- Rise in OA adoption partly attributable to mandates
- Trend towards ‘strengthening’ policies – “required” rather than “encouraged” (2011 onwards)
- Accompanied by compliance monitoring and introduction of sanctions for non-compliance
- Developments highlight the key issue of the synchronisation of policies (e.g. Green v Gold emphasis) across organisations, sectors, countries etc.
- Key practical issues remain: e.g.
  - The balance of Green and Gold OA
  - Basis for allocating funding
  - Conditions of access – e.g. licensing (CC BY etc)

Case Study – UK developments:
- Finch Report – 2012
- Research Councils UK policy (RCUK) – initial version, 2012
- Higher Education Funding Councils policy for the Research Excellence Framework (REF) – 2014
- Charity funders: Charity Open Access Fund (COAF), Wellcome Trust and other medical research charities – 2014
- Increasing numbers of institutional mandates
Market Complexity

Increasing complexity and variation in the market with experiments in business and delivery models

• Relatively low barriers to entry and market immaturity
• Established and new players
• Variations in OA journal publishing, including
  – New fully-OA journals
  – ‘Flipped’ titles (converted from subscription to fully OA)
  – Hybrid titles (subscription with APC-funded OA options)
  – Variable APCs and licences (sometimes for the same article)
  – Mega-journals e.g. PLOS ONE, Scientific Reports – fully OA APC-funded, large scale, wide scope, ‘objective peer review’
• ‘Predatory journals’ – downside of lower entry barriers, with ongoing concern about quality
• Early moves in the direction of ‘offsetting’ – where subscription prices are set against APC income to determine the overall price paid
• Large number of practical issues remain: e.g.
  – The extent to which HEIs/consortia can influence the shape of the market
  – Whether market/product complexities will be ironed out
Institutional Policies, Systems and Advocacy

Challenges:

1. Costs and sustainability
2. Mandate compliance
3. Policies, processes and technologies
4. Communication and advocacy

Large numbers of issues remain in these areas
Repository Development

- Repository development globally 2005-12 initially focused on North America, Western Europe, Australasia and Japan, extended to South America and Asia
- Most repositories (80%) institutional
- Small number of large repositories and large number of small repositories (median size: 3093 items)
- Key practical issues:
  - Funding and sustainability
  - Embargoes introduced by publishers
  - Role of mandates in encouraging use (e.g. UK)


Deposits into the White Rose repository (the universities of Leeds, Sheffield, York, 2004-16)
Institutional Policies, Systems and Advocacy

Challenges:

1. Costs and sustainability
2. Mandate compliance
3. Policies, processes and technologies
4. Communication and advocacy

Large numbers of issues remain in these areas


The Growth of APC Expenditure

- Centrally-managed APC expenditure (from a sample of 23 HEIs) rose, particularly since 2012
- This represents a rise in actual expenditure but also a shift from distributed to centralised accounting (Jubb et al, 2015; Pinfield et al, 2017)

- The rise continued in 2015 (based on a sample of 13 institutions) (Shamash, 2016)
• There has been growth in APC expenditure growth across all HEIs since 2010
• One HEI accounts for nearly a third of expenditure in 2014
• 21 HEIs experienced growth of APC expenditure 2013-2014: 12 of more than 100% in a year

(Pinfield, Salter & Bath, 2017)
Average APC Level

<table>
<thead>
<tr>
<th>Mean</th>
<th>N</th>
<th>Sum</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>£1,586</td>
<td>4,853</td>
<td>£7,695,341</td>
<td>£0</td>
<td>£4,536</td>
<td>£1,502</td>
</tr>
</tbody>
</table>

- Summary of APC data for 2014 for 24 HEIs*
- APC mean lower than previous study: 2013 £1,676 cf 2014 £1,586; but NB Shamash (2016) shows an increase of £1,737.15 in 2015
- Minimum: some verified £0 payments

### APC Data 2007-2014 (Pinfield, et al, 2016)

<table>
<thead>
<tr>
<th>Year</th>
<th>APC numbers (number of institutions making payments)</th>
<th>Total cost</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>31 (1)</td>
<td>£40,595</td>
<td>£1,310</td>
</tr>
<tr>
<td>2008</td>
<td>67 (1)</td>
<td>£108,442</td>
<td>£1,619</td>
</tr>
<tr>
<td>2009</td>
<td>99 (3)</td>
<td>£177,200</td>
<td>£1,790</td>
</tr>
<tr>
<td>2010</td>
<td>380 (8)</td>
<td>£641,798</td>
<td>£1,689</td>
</tr>
<tr>
<td>2011</td>
<td>469 (9)</td>
<td>£818,150</td>
<td>£1,744</td>
</tr>
<tr>
<td>2012</td>
<td>570 (14)</td>
<td>£977,848</td>
<td>£1,716</td>
</tr>
<tr>
<td>2013</td>
<td>2445 (23)</td>
<td>£4,097,981</td>
<td>£1,676</td>
</tr>
</tbody>
</table>

### Mean APC from a sample of 14 HEIs (Shamash, 2016)

Open Access: Developments ➤ APCs ➤ Futures
APC Payments Ranges

- Box plot illustrates the range of payments by HEI for 2014
- Median APC represented by the line in each box, the box the interquartile range

APC Payments by Subject

<table>
<thead>
<tr>
<th>Data for the 24 UK HEIs</th>
<th>Health and Life Sciences</th>
<th>Physical Sciences and Engineering</th>
<th>Social Sciences</th>
<th>Arts and Humanities</th>
<th>Total (deduplicated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total spend*</td>
<td>£5,526,217</td>
<td>£2,757,244</td>
<td>£620,368</td>
<td>£115,216</td>
<td>£7,596,649</td>
</tr>
<tr>
<td>No of articles*</td>
<td>3337</td>
<td>1,701</td>
<td>428</td>
<td>88</td>
<td>4,710</td>
</tr>
<tr>
<td>Mean</td>
<td>£1,656</td>
<td>£1,621</td>
<td>£1,449</td>
<td>£1,309</td>
<td>£1,611</td>
</tr>
<tr>
<td>Min</td>
<td>£0</td>
<td>£0</td>
<td>£71</td>
<td>£71</td>
<td>£0</td>
</tr>
<tr>
<td>% spend</td>
<td>61.3%</td>
<td>30.6%</td>
<td>6.9%</td>
<td>1.3%</td>
<td>100%</td>
</tr>
<tr>
<td>% articles</td>
<td>60.1%</td>
<td>30.6%</td>
<td>7.7%</td>
<td>1.6%</td>
<td>100%</td>
</tr>
</tbody>
</table>

- Journals to which APC payments made mapped against REF (Research Excellence Framework) panels based on Scopus subject classifications for journals (4,710 of the 4,853 papers could be matched)
- Shows a preponderance of payments in the Health and Life Sciences area

* sum of the panels add up to more than the total as some journals are classified into more than one REF panel

## Top Publishers by APC Payments

<table>
<thead>
<tr>
<th>Publisher</th>
<th>Articles in Fully-OA Journals</th>
<th>Articles in Hybrid Journals</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elsevier</td>
<td>20</td>
<td>906</td>
<td>926 (19.1)</td>
</tr>
<tr>
<td>Wiley</td>
<td>25</td>
<td>709</td>
<td>734 (15.1)</td>
</tr>
<tr>
<td>Springer</td>
<td>8</td>
<td>329</td>
<td>337 (6.9)</td>
</tr>
<tr>
<td>PLOS</td>
<td>322</td>
<td>-</td>
<td>322 (6.6)</td>
</tr>
<tr>
<td>BioMed Central</td>
<td>290</td>
<td>-</td>
<td>290 (6)</td>
</tr>
<tr>
<td>Oxford University Press</td>
<td>28</td>
<td>202</td>
<td>230 (4.7)</td>
</tr>
<tr>
<td>BMJ</td>
<td>80</td>
<td>138</td>
<td>218 (4.5)</td>
</tr>
<tr>
<td>Taylor &amp; Francis</td>
<td>1</td>
<td>167</td>
<td>168 (3.5)</td>
</tr>
<tr>
<td>Frontiers</td>
<td>140</td>
<td>-</td>
<td>140 (2.9)</td>
</tr>
<tr>
<td>Nature Publishing Group</td>
<td>34</td>
<td>106</td>
<td>140 (2.9)</td>
</tr>
<tr>
<td>Others</td>
<td>232</td>
<td>1116</td>
<td>1348 (27.8)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1180</td>
<td>3673</td>
<td>4853</td>
</tr>
</tbody>
</table>

- Top-10 publishers by numbers of APC payments, 2014 (Pinfield et al, 2017)
- 3 OA publishers in the top 10; the majority are commercial publishers who also dominate subscription publishing
- Shamash (2016) only 3 OA publishers in top-21 publishers for 2015
- Payments for hybrid journals predominate (2014 and 2015)
• APC ranges charged by the top-10 publishers based on value of APC payments

Journal Types and Price Differentials

- 3 journal types identified by Bjork & Solomon (2014)
- Marked differences between APCs paid by type, with hybrids substantially more expensive (the hybrid mean is 58% higher than the mean of fully-OA journals from OA publishers)
- Correlation between average APC and average *Field-Weighted Citation Impact (FWCI) score

<table>
<thead>
<tr>
<th>Publisher Type</th>
<th>Mean</th>
<th>Number of journals</th>
<th>Number of articles</th>
<th>Sum</th>
<th>Min</th>
<th>Max</th>
<th>Median</th>
<th>Average FWCI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid journals – published by ‘subscription publishers’</td>
<td>£1,725</td>
<td>1613</td>
<td>3673</td>
<td>£6,337,723</td>
<td>£0</td>
<td>£4,536</td>
<td>£1,680</td>
<td>1.78</td>
</tr>
<tr>
<td>Fully-OA journals – published by ‘subscription publishers’</td>
<td>£1,311</td>
<td>74</td>
<td>306</td>
<td>£401,149</td>
<td>£0</td>
<td>£3,810</td>
<td>£1,229</td>
<td>1.49</td>
</tr>
<tr>
<td>Fully-OA journals – published by ‘non-subscription publishers’</td>
<td>£1,094</td>
<td>181</td>
<td>874</td>
<td>£956,469</td>
<td>£0</td>
<td>£2,960</td>
<td>£1,071</td>
<td>1.29</td>
</tr>
</tbody>
</table>

### APC Price and Quality

Based on all journals | Based on journals in which 24 UK universities published APC articles in 2014
---|---
**Distribution of all journals** | **Quality Tier (by FWCI)** | **No of journals with APC articles (from 24 UK HEIs)** | **No of articles with APCs (from 24 UK HEIs)** | **Proportion of journals** | **Proportion of articles** | **Weighted Mean Ave FWCI** | **Mean Ave FWCI** | **Mean Ave APC paid (£) including VAT if charged**
---|---|---|---|---|---|---|---|---
5% | 1.0 | 266 | 954 | 15% | 20% | 2.92 | 3.11 | £1,936
5% | 1.5 | 288 | 864 | 16% | 18% | 1.88 | 1.90 | £1,713
10% | 2.0 | 475 | 1603 | 27% | 34% | 1.36 | 1.37 | £1,503
10% | 3.0 | 321 | 663 | 18% | 14% | 0.99 | 0.99 | £1,449
10% | 4.0 | 182 | 322 | 10% | 7% | 0.76 | 0.76 | £1,472
10% | 5.0 | 125 | 169 | 7% | 4% | 0.55 | 0.56 | £1,371
10% | 6.0 | 47 | 68 | 3% | 1% | 0.41 | 0.40 | £1,459
10% | 7.0 | 24 | 34 | 1% | 1% | 0.26 | 0.25 | £1,325
10% | 8.0 | 14 | 17 | 1% | 0% | 0.16 | 0.15 | £1,352
10% | 9.0 | 12 | 13 | 1% | 0% | 0.03 | 0.04 | £1,102
10% | 10.0 | 3 | 3 | 0% | 0% | 0.00 | 0.00 | £1,237

- APC data matched to Field Weighted Citation Impact (FWCI) scores in Scopus to test if there was a correlation between APC price and citation impact (as a proxy of quality)
- Journals were grouped in 10 different FWCI categories for analysis (each of 10% of the journals with the top two tiers 5%)
• APC price against FWCI for the sample of 2014 APCs
• Shows a strong correlation between price and quality (as measured by citation)
• Different possible explanations, including: higher costs of producing higher-quality more selective titles; and/or willingness of authors to pay higher prices for higher-impact titles

Subscriptions

Aggregated subscription expenditure for the 24 HEIs for 7 publishers*, 2011-2014 (including annual % changes)


- Subscription costs rose overall 2011-2014
- Subscriptions costs rose n particular 2013-2014
### ‘Total Cost of Publication’ by Institution

- TCP for the sample of 7 publishers* using 2014 APC and subscription data and administration costs of £88 per article
- Includes hybrid titles only in order to address issue of additionality of payments

#### Table: Total Cost of Publication by Institution

<table>
<thead>
<tr>
<th>Institution</th>
<th>Subscriptions (%)</th>
<th>APC (%)</th>
<th>Admin cost (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangor</td>
<td>£765,872</td>
<td>93.2%</td>
<td>£2,200</td>
<td>£821,679</td>
</tr>
<tr>
<td>Bath</td>
<td>£1,186,086</td>
<td>93.4%</td>
<td>£4,488</td>
<td>£1,269,566</td>
</tr>
<tr>
<td>Birmingham</td>
<td>£2,004,295</td>
<td>89.5%</td>
<td>£14,168</td>
<td>£2,240,532</td>
</tr>
<tr>
<td>Bristol</td>
<td>£2,181,422</td>
<td>88.5%</td>
<td>£12,408</td>
<td>£2,465,056</td>
</tr>
<tr>
<td>Cranfield</td>
<td>£567,832</td>
<td>94.9%</td>
<td>£1,320</td>
<td>£598,620</td>
</tr>
<tr>
<td>Durham</td>
<td>£1,308,700</td>
<td>92.7%</td>
<td>£5,456</td>
<td>£1,411,424</td>
</tr>
<tr>
<td>Glasgow</td>
<td>£1,871,363</td>
<td>90.3%</td>
<td>£10,032</td>
<td>£2,073,474</td>
</tr>
<tr>
<td>Imperial</td>
<td>£2,262,852</td>
<td>83.0%</td>
<td>£18,744</td>
<td>£2,724,720</td>
</tr>
<tr>
<td>Lancaster</td>
<td>£919,913</td>
<td>95.6%</td>
<td>£2,200</td>
<td>£962,166</td>
</tr>
<tr>
<td>Leicester</td>
<td>£545,000</td>
<td>90.4%</td>
<td>£2,552</td>
<td>£560,610</td>
</tr>
<tr>
<td>Liverpool</td>
<td>£1,678,451</td>
<td>91.6%</td>
<td>£6,864</td>
<td>£1,831,950</td>
</tr>
<tr>
<td>Loughborough</td>
<td>£903,882</td>
<td>92.9%</td>
<td>£3,432</td>
<td>£973,317</td>
</tr>
<tr>
<td>LSHTM</td>
<td>£431,170</td>
<td>80.8%</td>
<td>£4,576</td>
<td>£533,798</td>
</tr>
<tr>
<td>Newcastle</td>
<td>£1,806,955</td>
<td>86.7%</td>
<td>£11,616</td>
<td>£2,083,456</td>
</tr>
<tr>
<td>Plymouth</td>
<td>£797,744</td>
<td>98.8%</td>
<td>£352</td>
<td>£807,172</td>
</tr>
<tr>
<td>Portsmouth</td>
<td>£547,687</td>
<td>98.4%</td>
<td>£352</td>
<td>£556,802</td>
</tr>
<tr>
<td>QMUL</td>
<td>£1,117,813</td>
<td>95.8%</td>
<td>£2,200</td>
<td>£1,167,068</td>
</tr>
<tr>
<td>RHUL</td>
<td>£683,004</td>
<td>99.0%</td>
<td>£352</td>
<td>£689,782</td>
</tr>
<tr>
<td>Salford</td>
<td>£798,763</td>
<td>96.5%</td>
<td>£1,144</td>
<td>£827,490</td>
</tr>
<tr>
<td>Sheffield</td>
<td>£1,498,839</td>
<td>87.1%</td>
<td>£10,208</td>
<td>£1,720,160</td>
</tr>
<tr>
<td>Sussex</td>
<td>£958,613</td>
<td>94.7%</td>
<td>£2,288</td>
<td>£1,012,745</td>
</tr>
<tr>
<td>Swansea</td>
<td>£879,687</td>
<td>95.3%</td>
<td>£2,200</td>
<td>£923,055</td>
</tr>
<tr>
<td>UCL</td>
<td>£2,940,492</td>
<td>64.0%</td>
<td>£91,080</td>
<td>£4,596,594</td>
</tr>
<tr>
<td>Warwick</td>
<td>£1,849,466</td>
<td>94.6%</td>
<td>£4,312</td>
<td>£1,954,540</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>£30,505,902</strong></td>
<td>87.5%</td>
<td><strong>£214,544</strong></td>
<td><strong>£34,847,775</strong></td>
</tr>
</tbody>
</table>

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* CUP, Elsevier, OUP, Sage, Springer, Taylor & Francis, and Wiley

Total Cost of Publication by HEI

- Total cost of publication (subscriptions + APCs + APC admin costs) for the sample of 7 publishers*, 2014
- APCs approx. 12% of the total cost of publication


‘Hidden’ Costs

• APCs paid outside the Centre of HEIs (“in the wild”; Andrew, 2016)
  – Estimates from various sources vary from between about 15% and 30% of APCs (Andrew, 2016; Pinfield & Middleton, 2016; Pinfield, et al, 2017)

• Colour and page charges – also not usually centrally coordinated
  – ‘Other costs’ as high as 7.5% of the total cost of publication (Gray, 2015)
Data Analysis: Summary (1)

- The APC market is currently complex (e.g. variable pricing, discounts, other additional charges etc.) and institutional data reflect this.
- UK centrally-managed APC expenditure has continued to rise steeply.
- APC payments varied considerably (in 2014 from £0 to £4,536 with the mean £1,586, from the sample of 24 HEIs).
- There was variation in the levels of payments across different institutions, reflecting research activity and policy differences.
- The largest number of institutional APC payments were made for articles in the Health and Life Sciences.
Data Analysis: Summary (2)

• Commercial subscription publishers are responsible for the largest proportion of the APC market
• Hybrid journal APCs are considerably more expensive than fully-open access titles
• There is a correlation between APC price and the citation rates of journals
• As well as APC costs increasing, subscription costs have continued to rise
• For the sample of seven publishers, APCs in 2014 constituted 12% of the ‘total cost of publication’ and 1% APC administration and 87% subscriptions;
Recommendations for Data Collection

• Data on expenditure in institutions of subscriptions, APCs and administration costs needs to continue to be collected and made public on an ongoing basis

• Reporting of APC expenditure data needs to be further standardised, including standardisation in the reporting of:
  – ‘Publication date’
  – APCs distinguished from many additional charges (e.g. colour & page charges)
  – Any splitting of single payments between different funders
  – Consistent inclusion of tax on payments (if charged)

• Subscription expenditure should also be reported and made publically-available for as wide a range of publishers as possible

• Further work should be done on clarifying administrative costs, particularly those associated with new activities such as APC payments

• Approaches need to be agreed for estimating and where possible recording payment of non-centrally-managed payment of APCs in institutions

• Where possible central databases of APC data should include analytical tools
Policy Implications

• What is the best balance/relationship between Gold and Green OA in policy terms?

• Can the payment of hybrid APCs be viewed as a viable ‘transition’ mechanism? Possible policy responses:
  – Exclusion of hybrid from APC payment schemes
  – Inclusion of hybrid
    • Without conditions?
    • Possible conditions: e.g.
      – Capping of APCs
      – Requirement of an ‘approved’ offsetting deal in place

• What should ‘offsetting’ arrangements with publishers look like (short-medium-long term) and how can they be set up?

• Can embargoes be reduced or eliminated and, if so, how?

• How can institutions be best supported in achieving their objectives?

• How can greater transparency of market information/data be facilitated?
Key possible features:

- It is likely **OA will become the default** mode of scholarly communication
- Scholarly communication will involve **greater interactivity** (‘social media-like’ technologies/services)
- Publication will become more of a **process** – a ‘flow’ – with different stages in the process associated with different ‘versions’ of outputs
- Publication will **not just about text-based fixed documents**, but incorporate data, rich media, software, live simulations etc
- The literature will become an integrated part of machine-readable/networked scholarly infrastructure
Key possible features:

- **Quality assurance will take place at various stages**, including pre- and post-publication, using human and automated approaches.
- **Metrics** will increase in importance but become more varied and wider in scope.
- Roles of key **stakeholders** will continue to change e.g. funders (more involved), publishers (continuing vertical and horizontal integrations) etc.
- Open access will become part of a wider move towards ‘**Open Science**’, including open data, open peer review etc (“Open content”, “open process”, “open infrastructure” – Corrall & Pinfield, 2014).
Summary of Themes and Issues

Current open-access themes:

1. Rising adoption of OA in the mainstream of scholarly communication
2. Ongoing importance of disciplinary differences
3. Increasing influence of mandates
4. Growing market complexity
5. Developing institutional policies, systems and advocacy

Key issues:

• How OA adoption can be best incentivised
• How disciplinary differences should be taken into account
• How Green and Gold can be ‘balanced’
• How ‘mandate messiness’ can be addressed
• How offsetting can be best achieved
• How institutions and subject communities can best develop repositories
• How embargoes can best be addressed
• How activities can be best distributed amongst institutions, central agencies and subject communities?
• ....
Questions and Comments

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References


References


Box Plot Definition for this Study

- The horizontal bold line in each box represents the median (second quartile) value.
- The bottom and top of each box represents the first and third quartiles respectively.
- The distance between these represents the inter-quartile range (IQR).
- Whiskers represent the lowest datum still within 1.5 IQR of the lower quartile, and the highest datum still within 1.5 IQR of the upper quartile (Tukey boxplot).
- Small circles (⊙) representing outliers and asterisks (*) extreme values.