Proposal for a new model of transformative agreements:
A smooth transition from subscriptions to APCs

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Why do we propose a new transformative model?

We see the need for a new transformative model because existing models as Publish & Read and Read & Publish do not best serve the needs of libraries and publishers in transforming their acquisition budgets and revenues, respectively, from subscriptions to APCs. Particularly the Publish & Read model has unfavorable features regarding coordination costs, disruptive workflow adjustments, and timing. This discussion paper assesses the P&R and the R&P transformative models and proposes an alternative model, which is responsive to the progress in open-access transition.\(^1\)

A simple model of the world

To support the arguments of this paper, we run a simulation on a global model.\(^2\) In this model, the world consists of 100 libraries that belong to higher-education and research organizations that are different in size and publication output.

```r
Library<-c(paste("Library",1:100))

When the organizations are ordered by their publication output of affiliated corresponding authors in descending order, the publication output follows approx. a geometric distribution (see Annex A for real-world examples)

```r
Y<-c(1:100)
plot(Y, dgeom(Y,0.1), type="h", ylim=c(0,0.2), main="Geometric distribution for p=0.1", ylab="P(Y=y)", xlab="y")
```

\(^1\)This work is licensed under a Creative Commons Attribution 4.0 International License. Additionally, a html or pdf file as well as an R Markdown Notebook is provided at DOI: 10.4119/unibi/2939995. In the R Markdown Notebook, you can execute the code and the results appear beneath the code.

\(^2\)Note, all numbers and parameters in this model are fictive but of reasonable size and distribution.
The total number of published articles per year at a particular publisher is

```r
print(publ_total)
```

```r
## [1] 5001
```

For libraries, subscription costs in \( t=0 \) are related to the number of the institutional publication output (because of the organizations’ size) but tend to be more flat (i.e. subscription costs for low-publishing organizations are higher as if they were charged by published article count; subscription costs for high-publishing organizations are lower as if they were charged by published article count).

```r
share_of_subscription<-dgeom(Y,0.03)
tr<-10823990
subscription<-share_of_subscription*tr
```

```r
plot(Y,publ, xaxs="i",yaxs="i",type="h" ,xlab="Libraries", ylab="")
lines(subscription/1000, type="p", pch= 18)
legend("topleft", legend = c("Subscription costs in thousand euros","Number of articles"),
  lty= c(NA,"solid"), pch=c(18,NA),cex=0.8)
```
The one hundred libraries can also be regarded as percentiles of libraries. For example, Library 1 can represent the 1% of libraries from the most-publishing organizations worldwide.

The global subscription costs per year for the publisher’s journals are

```
total_revenue <- sum(subscription); print(total_revenue, digits=8)
```

```
## [1] 10000004
```

which corresponds to the publisher’s total revenue. To derive an APC, the publisher divides the total revenue by the number of annually published articles:

```
APC <- round(total_revenue/publ_total); print(APC)
```

```
## [1] 2000
```

This corresponds to the average APC that a publisher would need to charge for receiving the same revenue under a pure open-access APC-model.

The following equations set initial variables:

```
OA <- logical(length = 100) # Libraries participating in transformative agreement; none in t=0
payment <- numeric(length = 100) # payment of library to publisher
OA_share <- sum(publ*OA/publ_total); print (OA_share) # global OA-share
```

```
## [1] 0
```

Here is the set of variables describing the global model:

```
# the global model
data.frame(Library, publ, subscription, OA)
```
<table>
<thead>
<tr>
<th>Library</th>
<th>publ</th>
<th>subscription</th>
<th>OA</th>
</tr>
</thead>
<tbody>
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</tr>
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<td>FALSE</td>
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<tr>
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<td>Library</td>
<td>0</td>
<td>15441.24</td>
</tr>
</tbody>
</table>

Publish & Read will not deliver open-access transition without massive coordination effort

In a Publish & Read agreement, libraries pay a P&R fee per article that is published by an affiliated corresponding author in a hybrid journal, and additionally get access right to the closed-access content of the
High-publishing organizations would suffer immediate and huge cost increases. If they did not get significant additional funds from government or funders, for example, they would refuse to participate in a P&R agreement. On the contrary, average or low publishing organizations would conclude the contracts because they would experience cost savings.

```r
for (i in 1:100) {
  if (PaR_fee[i] > subscription[i]) {OA[i] <- FALSE
    payment[i] <- subscription[i]}
  else {OA[i] <- TRUE
    payment[i] <- PaR_fee[i]}
}
```

```
## Mode FALSE TRUE
## logical 16 84
```

In total, the 16 most-publishing organizations would disapprove a P&R agreement, which would result in a low open-access share and huge revenue losses for the publisher:

```
OA_share <- sum(publ*OA/publ_total); print (OA_share)
```

```
## [1] 0.1845631
```

```
sum(payment)
```

```
## [1] 5896055
```

The publisher anticipates this and does not offer P&R agreement to individual libraries.

There are two options to design P&R agreements revenue-neutral for the publisher. The first is to conclude the P&R agreement with all libraries in a coordinated way. This is a very unrealistic option since up to date there is no chance that all libraries worldwide commit to pay for open-access publications and agree on such a transformative model at the same time. The second option is that the publisher concludes agreements with subsets of libraries (e.g. national agreements), where both high- and low-publishing organizations take part. The requirement is that the sum of historical subscription revenues from each subset of libraries is equal to or lower than the sum of future P&R fees and APC payments, receptively. (If the sum of historical subscription revenues does not exactly matches future APC payments, the P&R fees can be adjusted up or down during the transition phase.) The following example demonstrates the second option.

Let us say Library 10, 30, 60, 100 come from the same country and negotiate a national transformative agreement with the publisher.

```
OA <- logical(length = 100) # Libraries participating in transformative agreement; none in t=0
payment <- subscription # Payment of library to publisher; that is subscription in t=0
```

```
country <- c(10, 30, 60, 100)
Library_C <- Library[country]
publ_C <- publ[country]
subscription_C <- subscription[country]
PaR_fee_C <- PaR_fee[country]
data.frame(Library_C, publ_C, subscription_C)
```

```
## Library_C publ_C subscription_C
## 1 Library 10 194 239456.14
## 2 Library 30 24 130214.89
## 3 Library 60 1 52217.09
## 4 Library 100 0 15441.24
```
If the publisher and the national library consortium will manage to conclude the P&R agreement, the publisher’s total revenue does not change.

```
OA[country]<-TRUE
payment[country]<-PaR_fee[country]
OA_share<-sum(publ*OA/publ_total); print (OA_share)
```

If such kind of national or regional agreements are concluded, the open-access transformation can success via P&R agreements. However, there are difficulties to consider when pursuing national P&R agreements.

First, there might be countries or regions where high-publishing organizations dominate, or where there are just low-publishing organizations. P&R agreements with such countries or regions cannot be revenue neutral for the publisher.

Second, within a national library consortium, high-publishing organizations would be faced with huge cost increases if they were charged by article count. Therefore, either

- for the internal allocation of costs, the consortium applies the logic of R&P agreements (internal switch from P&R to R&P as has been done with the DEAL-Wiley Publish and Access Agreement in Germany), or
- the government manages to massively re-allocate funds from low-publishing to high-publishing organization, or
- the government / a research funder provides huge additional funds to high-publishing organization for a long time.

That requires a huge coordination effort within the country/region and adjustment procedures that maybe cannot be implemented instantaneously.

The final difficulty in concluding national P&R agreements is that the circle of participating libraries has to be known and certain before the negotiations start. An opt-out or opt-in of libraries would influence the agreement conditions, and therefore, should not happen after the negotiations. Moreover, a dropout or inclusion particularly of high-publishing organization should be avoided in all rounds of P&R agreements until the global open-access transformation reaches a high level, and there would be no way back to subscriptions.

To conclude, for P&R agreements to transform the scholarly journals successfully to open access, huge coordination efforts, a massive and instantaneous re-allocation of funds, or permanently large additional funds are necessary. Publishers will not offer P&R agreements to individual libraries or loose consortia with liberal opt-in or opt-out regulations.

---

3 Every one-sided change in the set of participating libraries will affect the publisher’s revenues as well as the consortial costs. Particularly, high-publishing institutions will have a massive impact. A dropout of high-publishing institutions (back to subscriptions) will seriously impair the publisher’s revenues; an inclusion of high-publishing institutions will boost publisher’s revenues. In both cases the open-access transition cannot be cost- and revenue-neutral any more.
Read & Publish will not deliver huge progress in the open-access transition

In a Read & Publish agreement, libraries continue to pay the same amount as for subscriptions, but additionally affiliated corresponding authors can publish open access without additional costs in the hybrid journals. Hence, the R&P fee equals the historical subscription costs.

\[ \text{RaP\_fee} = \text{subscription} \]

Let us assume the libraries independently and simultaneously decide whether to conclude an R&P agreement in \( t=0 \). They will do so if they are not much worse off signing such an agreement.

```r
for (i in 1:100) {
  if (RaP\_fee[i] > subscription[i]) {OA[i] <- FALSE
    payment[i] <- subscription[i]}
  else {OA[i] <- TRUE
    payment[i] <- RaP\_fee[i]}
}

summary(OA)
```

## Mode  TRUE
## logical 100

This independently and simultaneously decision of libraries would result in an immediate 100% OA-share. However, in that case libraries from low-publishing organizations would cancel the agreements in the next period, as there would be no need for an access component and they could save costs by paying solely APCs on behalf of their authors. (In this model, the 16 most-publishing organizations would stick to the R&P agreement and the other libraries would cancel.)

\[ \text{APCs} = \text{publ\*APC} \]

### In a pure OA world

```r
for (i in 1:100) {
  if (RaP\_fee[i] > APCs[i]) {
    payment[i] <- APCs[i]
  }
}

head(data.frame(Library, publ, subscription, RaP\_fee, APCs, payment), 40) # truncated table
```

## Library publ subscription RaP\_fee APCs payment
## 1 Library 1 501 314978.11 314978.11 1002000 314978.1
## 2 Library 2 451 305528.77 305528.77 902000 305528.8
## 3 Library 3 405 296362.90 296362.90 810000 296362.9
## 4 Library 4 365 287472.02 287472.02 730000 287472.0
## 5 Library 5 328 278847.86 278847.86 656000 278847.9
## 6 Library 6 296 270482.42 270482.42 592000 270482.4
## 7 Library 7 266 262367.95 262367.95 532000 262367.9
## 8 Library 8 239 254496.91 254496.91 478000 254496.9
## 9 Library 9 215 246862.00 246862.00 430000 246862.0
## 10 Library 10 194 239456.14 239456.14 388000 239456.1
## 11 Library 11 175 232272.46 232272.46 350000 232272.5
## 12 Library 12 157 225304.28 225304.28 314000 225304.3
## 13 Library 13 141 218545.15 218545.15 282000 218545.2
## 14 Library 14 127 211988.80 211988.80 254000 211988.8
## 15 Library 15 115 205629.14 205629.14 230000 205629.1
## 16 Library 16 103 199460.26 199460.26 206000 199460.3
## 17 Library 17 93 193476.45 193476.45 186000 193476.4
## 18 Library 18 83 187672.16 187672.16 166000 187672.1
## 19 Library 19 75 182042.00 182042.00 150000 182042.0
## 20 Library 20 68 176580.74 176580.74 136000 176580.7
## 21 Library 21 61 171283.31 171283.31 122000 171283.3
## 22 Library 22 55 166144.81 166144.81 110000 166144.8
|---------|------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
|         |      | 23         | 49         | 161160.47  | 161160.47  | 98000      | 98000.0
|         |      | 24         | 44         | 156325.66  | 156325.66  | 88000      | 88000.0
|         |      | 25         | 40         | 151635.89  | 151635.89  | 80000      | 80000.0
|         |      | 26         | 36         | 147086.81  | 147086.81  | 72000      | 72000.0
|         |      | 27         | 32         | 142674.21  | 142674.21  | 64000      | 64000.0
|         |      | 28         | 29         | 138393.98  | 138393.98  | 58000      | 58000.0
|         |      | 29         | 26         | 134242.16  | 134242.16  | 52000      | 52000.0
|         |      | 30         | 24         | 130214.89  | 130214.89  | 48000      | 48000.0
|         |      | 31         | 21         | 126308.45  | 126308.45  | 42000      | 42000.0
|         |      | 32         | 19         | 122519.19  | 122519.19  | 38000      | 38000.0
|         |      | 33         | 17         | 118843.62  | 118843.62  | 34000      | 34000.0
|         |      | 34         | 15         | 115278.31  | 115278.31  | 30000      | 30000.0
|         |      | 35         | 14         | 111819.96  | 111819.96  | 28000      | 28000.0
|         |      | 36         | 13         | 108465.36  | 108465.36  | 26000      | 26000.0
|         |      | 37         | 11         | 105211.40  | 105211.40  | 22000      | 22000.0
|         |      | 38         | 10         | 102055.06  | 102055.06  | 20000      | 20000.0
|         |      | 39         | 9          | 98993.41   | 98993.41   | 18000      | 18000.0
|         |      | 40         | 8          | 96023.61   | 96023.61   | 16000      | 16000.0

```
sum(payment)

## [1] 5896055
```

This would result in a huge revenue loss for the publisher—a fact that would force the publisher to abandon the R&P model in favour of an APC or P&R model. That, in turn, would imply huge cost increases for high-publishing organizations, which they anticipate.

Even if the publisher offers R&P agreements successively to libraries (not to all at the same time), libraries from high-publishing organizations anticipate the inevitable turn to a P&R or APC model as the OA share significantly rises (e.g., above 50%). Therefore, the 16 most-publishing organizations will not sign R&P agreements and stick to subscriptions if governments or research funders do not provide them additional funds. In consequence, the OA share remains low.

```
for (i in 1:100) {
    if (APCs[i]>subscription[i]) {OA[i]<-FALSE
    payment[i]<-subscription[i] } else  {OA[i]<-TRUE
    payment[i]<-RaP_fee[i]}
}

summary(OA)

## Mode FALSE TRUE
## logical 16 84

OA_share<-sum(publ*OA/publ_total); print (OA_share)

## [1] 0.1845631
```

```
sum(payment, digits=8)

## [1] 10000012
```

With the R&P agreements, we arrive at a stable equilibrium with relatively low OA shares at the global level as long as high-publishing organization do not see routes to manage the transition of their acquisition budgets with foreseeable cost increases from the R&P to the P&R model.
The need for a new transformative model

The simulations of the Publish & Read as well as the Read & Publish model show that they both are not best suited for the transformation of subscription journals to open access and the underlying revenue and cost streams.

For P&R agreements to transform the scholarly journals successfully to open access, huge coordination efforts, a massive and instantaneous re-allocation of funds, or permanently large additional funds are necessary. Moreover, publishers will not offer P&R agreements to individual libraries or loose consortia with liberal opt-in or opt-out regulations.

With R&P agreements, the open-access transformation will stuck at low OA shares. To progress further, a switch to the P&R model would be necessary with its own obstacles as discussed above.

Therefore, we see the need for a new transformative model that facilitates the switch from a pure R&P to a pure P&R model by lowering coordination costs, avoiding disruptive workflow and cost adjustments, and putting less pressure on timing.

A smooth transition model

Requirements on the model

We want the new model to fulfill the following requirements:

- No permanent or serious changes in global library spending
- No permanent or serious changes in publishers’ revenues
- No disruptive changes in libraries’ individual expenditures
- Smooth transition from subscription to APC revenues for publisher
- Smooth transition from content access to OA funding for libraries

The smooth transformative agreement equations

Libraries pay one fee for unlimited open-access publishing in hybrid journals and reading the complete closed-access content for the publisher’s complete journal portfolio. Alternatively, the model can also be set up for a single journal, or a subset of the journal portfolio.

At the starting point, the fee corresponds to the historical subscription fee for each individual library. The agreement can also include APCs for publishing in pure OA journals on top, or an additional one-time fee for perpetual access rights for archival content, but neither of these components are at the core of the contract or affect the model.

To derive a revenue-neutral APC, the publisher divides the initial subscription revenue by the number of annually published articles:

\[
\text{total_revenue} <- \text{sum(subscription)}; \quad \text{print(total_revenue, digits=8)}
\]

## [1] 10000004

\[
\text{APC} <- \text{round(total_revenue/publ_total)}; \quad \text{print(APC)}
\]

## [1] 2000

The APC is fixed (in real terms) over the transition phase and published. Since subscription revenues are hard to verify by a third-party, libraries have to assess themselves whether the so-calculated APC is of reasonable size. The share of the open-access content of the journal portfolio is calculated as follows and is published each year and verifiable via DOIs and Unpaywall.
Within the open-access transition

- the proportion of the fee that attributes to access closed content shrinks and
- the proportion of the fee that attributes to OA publishing rises according to the closed-access/open-access ratio of the whole journal portfolio content.

The OA-publishing part of the fee for a particular library is calculated as

\[
publish\_fee = publ \times OA\_share \times APC
\]

where \( publ \) represent the number of eligible articles of corresponding authors from the respective organization to be published in hybrid journals of the publisher. The number of eligible articles can be estimated first, and then tracked. Alternatively, the publisher offers a lump sum charge based on the past-year number of eligible and published articles.

The reading part of the fee for a particular library relates to the share of the closed-access content and its individual, initial subscription costs:

\[
read\_fee = subscription \times (1 - OA\_share)
\]

If necessary, the read fee can be adjusted for growth in closed-access content and inflation.

To sum up, libraries pay one fee for unlimited open-access publishing in hybrid journals and reading the complete closed-access content so that the total fee amounts to:

\[
smooth\_transition\_fee = publish\_fee + read\_fee
\]

A note beforehand: Even with the smooth transition model, an open-access transformation will not succeed if high-publishing organizations do not commit to the open-access principle and do not receive additional funds in the long term.

**Examples for fees and revenues in Smooth Transition Agreements**

In the following, we present several examples that show how fees of the libraries and revenues of the publisher are affected during the transition phase.

Let us look at the expenditures of a high-publishing (Library 5), an average-publishing (Library 25) and a low-publishing organization (Library 90). We assume the open-access share to be zero at the beginning \((t=0)\). The publisher offers Smooth Transition Agreements successively to libraries without a specific order concerning the publishing output.

\[
APCs = publ \times APC
\]

\[
Lib5 = vector(mode = "numeric", length = 5)
Lib25 = vector(mode = "numeric", length = 5)
Lib90 = vector(mode = "numeric", length = 5)
Lib90[1] = smooth\_transition\_fee[90]
\]

# The global model in t=0

# a shortened table

data.frame(Library, publ, subscription, APCs, smooth\_transition\_fee)[c(1:25,91:95),]

The table shows that at the beginning (with OA shares approx. zero) the Smooth Transition Fee would equal
the subscription fee for all libraries so that a particular library is not worse off to conclude the agreement and
be the first mover even if it is from a high-publishing organization. Let us say the three libraries (Library
5, Library 25, and Library 90) and seventeen other libraries (from high- to low-publishing) are the first to
conclude such an agreement. That would raise the open-access share in the next period to:

\[
OA_{t=1} = \text{logical(length = 100)} \quad \# \text{set initial value; none in } t=0
\]

\[
OA[\text{seq.int(from=5, to=100, by=5)] <- \text{TRUE} \quad \# \text{20 libraries from high- to low-publishing conclude}
\]

\[
\text{the agreement}
\]

\[
\text{summary(OA)} \quad \# \text{Number of libraries participating in the agreement}
\]

\[
\# \text{pay-offs}
\]

\[
OA_{\text{share}} <- \text{sum}(\text{publ} \times OA/\text{publ_total}); \quad OA_{\text{share}}
\]

\[
\# [1] \quad 0.1605679
\]

\[
publish\_fee <- \text{publ} \times OA_{\text{share}} \times \text{APC}
\]

\[
\text{read_fee} <- \text{subscription} \times (1 - OA_{\text{share}})
\]

\[
\text{smooth\_transition\_fee} <- \text{publish\_fee} + \text{read\_fee}
\]
The Smooth Transition Fee increases according to the open-access share of the journal portfolio content for high-publishing organizations and decreases according to the open-access share for low-publishing organizations. In contrast to the Publish & Read model, the expenditure changes for libraries are not disruptive during the transition from subscriptions to APCs. Similarly, the publisher’s revenue is not significantly effected as long as there is no systematic bias against the participation of high-publishing organizations (see the following code for the transition phase t=0 to t=5).

```r
for (i in 1:100) {
  if (OA[i]==FALSE) {payment[i]<-subscription[i]} else {payment[i]<-smooth_transititon_fee[i]}
}
# a shortened table
data.frame(Library, publ, subscription, OA, APCs,smooth_transititon_fee)[c(1:25,91:95),]
```

<table>
<thead>
<tr>
<th>Library</th>
<th>publ</th>
<th>subscription</th>
<th>OA</th>
<th>APCs</th>
<th>smooth_transititon_fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>501</td>
<td>314978.11</td>
<td>FALSE</td>
<td>1002000</td>
<td>425291.76</td>
</tr>
<tr>
<td>2</td>
<td>451</td>
<td>305528.77</td>
<td>FALSE</td>
<td>902000</td>
<td>401302.89</td>
</tr>
<tr>
<td>3</td>
<td>405</td>
<td>296362.90</td>
<td>FALSE</td>
<td>810000</td>
<td>378836.53</td>
</tr>
<tr>
<td>4</td>
<td>365</td>
<td>287472.02</td>
<td>FALSE</td>
<td>730000</td>
<td>358527.80</td>
</tr>
<tr>
<td>5</td>
<td>328</td>
<td>278847.86</td>
<td>TRUE</td>
<td>656000</td>
<td>339406.38</td>
</tr>
<tr>
<td>6</td>
<td>296</td>
<td>270482.42</td>
<td>FALSE</td>
<td>592000</td>
<td>322107.82</td>
</tr>
<tr>
<td>7</td>
<td>266</td>
<td>262367.95</td>
<td>FALSE</td>
<td>532000</td>
<td>305662.20</td>
</tr>
<tr>
<td>8</td>
<td>239</td>
<td>254496.91</td>
<td>FALSE</td>
<td>478000</td>
<td>290384.33</td>
</tr>
<tr>
<td>9</td>
<td>215</td>
<td>246862.00</td>
<td>FALSE</td>
<td>430000</td>
<td>276268.08</td>
</tr>
<tr>
<td>10</td>
<td>194</td>
<td>239456.14</td>
<td>TRUE</td>
<td>388000</td>
<td>263307.51</td>
</tr>
<tr>
<td>11</td>
<td>175</td>
<td>232272.46</td>
<td>TRUE</td>
<td>350000</td>
<td>251175.72</td>
</tr>
<tr>
<td>12</td>
<td>157</td>
<td>225304.28</td>
<td>FALSE</td>
<td>314000</td>
<td>239545.97</td>
</tr>
<tr>
<td>13</td>
<td>141</td>
<td>218545.15</td>
<td>FALSE</td>
<td>282000</td>
<td>228733.97</td>
</tr>
<tr>
<td>14</td>
<td>127</td>
<td>211988.80</td>
<td>FALSE</td>
<td>254000</td>
<td>218734.45</td>
</tr>
<tr>
<td>15</td>
<td>115</td>
<td>205629.14</td>
<td>TRUE</td>
<td>230000</td>
<td>209542.31</td>
</tr>
<tr>
<td>16</td>
<td>103</td>
<td>199460.26</td>
<td>FALSE</td>
<td>206000</td>
<td>200510.33</td>
</tr>
<tr>
<td>17</td>
<td>93</td>
<td>193476.45</td>
<td>FALSE</td>
<td>186000</td>
<td>192275.98</td>
</tr>
<tr>
<td>18</td>
<td>83</td>
<td>187672.16</td>
<td>FALSE</td>
<td>166000</td>
<td>184192.31</td>
</tr>
<tr>
<td>19</td>
<td>75</td>
<td>182042.00</td>
<td>FALSE</td>
<td>150000</td>
<td>176897.08</td>
</tr>
<tr>
<td>20</td>
<td>68</td>
<td>176580.74</td>
<td>TRUE</td>
<td>136000</td>
<td>170064.77</td>
</tr>
<tr>
<td>21</td>
<td>61</td>
<td>171283.31</td>
<td>FALSE</td>
<td>122000</td>
<td>163370.00</td>
</tr>
<tr>
<td>22</td>
<td>55</td>
<td>166144.81</td>
<td>FALSE</td>
<td>110000</td>
<td>157129.76</td>
</tr>
<tr>
<td>23</td>
<td>49</td>
<td>161160.47</td>
<td>FALSE</td>
<td>98000</td>
<td>151018.93</td>
</tr>
<tr>
<td>24</td>
<td>44</td>
<td>156325.66</td>
<td>FALSE</td>
<td>88000</td>
<td>145354.75</td>
</tr>
<tr>
<td>25</td>
<td>40</td>
<td>151635.89</td>
<td>TRUE</td>
<td>80000</td>
<td>140133.46</td>
</tr>
<tr>
<td>91</td>
<td>0</td>
<td>20311.24</td>
<td>FALSE</td>
<td>0</td>
<td>17049.91</td>
</tr>
<tr>
<td>92</td>
<td>0</td>
<td>19701.90</td>
<td>FALSE</td>
<td>0</td>
<td>16538.41</td>
</tr>
<tr>
<td>93</td>
<td>0</td>
<td>19110.85</td>
<td>FALSE</td>
<td>0</td>
<td>16042.26</td>
</tr>
<tr>
<td>94</td>
<td>0</td>
<td>18537.52</td>
<td>FALSE</td>
<td>0</td>
<td>15560.99</td>
</tr>
<tr>
<td>95</td>
<td>0</td>
<td>17981.40</td>
<td>TRUE</td>
<td>0</td>
<td>15094.16</td>
</tr>
</tbody>
</table>

sum(payment) # publisher revenues in t=1

```

## [1] 99659999
```

# t=2
OA[seq.int(from=4, to=100, by=5)]<-TRUE # the next 20 libraries conclude the agreement
summary(OA) # Number of libraries participating in the agreement
## Mode FALSE TRUE
## logical 60 40

# pay-offs
 OA_share=\sum (publ \times OA/publ_total); OA_share

## [1] 0.3381324
 publish_fee=publ \times OA_share \times APC
 read_fee=subscription \times (1-OA_share)
 smooth_transititon_fee=publish_fee + read_fee
 Lib90[3]=smooth_transititon_fee[90]

for (i in 1:100) {
  if (OA[i]==FALSE) {payment[i]=subscription[i]} else {payment[i]=smooth_transititon_fee[i]}
}
 sum(payment) # publisher revenues in t=2

## [1] 9852491
 # t=3
 OA[seq.int(from=3, to=100, by=5)]=TRUE # the next 20 libraries conclude the agreement
 summary(OA) # Number of libraries participating in the agreement

## Mode FALSE TRUE
## logical 40 60

# pay-offs
 OA_share=\sum (publ \times OA/publ_total); OA_share

## [1] 0.5354929
 publish_fee=publ \times OA_share \times APC
 read_fee=subscription \times (1-OA_share)
 smooth_transititon_fee=publish_fee + read_fee
 Lib90[4]=smooth_transititon_fee[90]

for (i in 1:100) {
  if (OA[i]==FALSE) {payment[i]=subscription[i]} else {payment[i]=smooth_transititon_fee[i]}
}
 sum(payment) # publisher revenues in t=3

## [1] 9753460
 # t=4
 OA[seq.int(from=2, to=100, by=5)]=TRUE # the next 20 libraries conclude the agreement
 summary(OA) # Number of libraries participating in the agreement

## Mode FALSE TRUE
## logical 20 80

# pay-offs
 OA_share=\sum (publ \times OA/publ_total); OA_share
The following figure illustrates the expenditure development for two of the libraries (Library 5 and 25) that concluded the Smooth Transformative Agreement from the beginning.

The following code calculates the revenue for the libraries:

```r
# publisher revenues in t=4
for (i in 1:100) {
   if (OA[i] == FALSE) {payment[i] <- subscription[i]} else {payment[i] <- smooth_transititon_fee[i]}
}
sum(payment) # publisher revenues in t=4
```

```r
# t=5
OA[seq.int(from=1, to=100, by=5)] <- TRUE # the next 20 libraries conclude the agreement
summary(OA) # Number of libraries participating in the agreement
```

The following code calculates the OA share and publishes the fee:

```r
OA_share <- sum(publ * OA / publ_total); OA_share
```

```r
# publisher revenues in t=5
for (i in 1:100) {
   if (OA[i] == FALSE) {payment[i] <- subscription[i]} else {payment[i] <- smooth_transititon_fee[i]}
}
sum(payment) # publisher revenues in t=5
```

The following code sets the parameters for the plot and creates the plot for the libraries:

```r
plot(Lib5/1000, ylim=c(0, 700), xaxs="i", yaxs="i", type="n", xlab="Period", ylab="Thousand euro")
abline(a=subscription[5]/1000, b=0, lty="dashed", lwd=2, col="red")
abline(a=APCs[5]/1000, b=0, lwd=2, col="red")
lines(Lib5/1000, type="b", pch=19, lwd=2, col="red")
abline(a=subscription[25]/1000, b=0, lty="dashed", lwd=2, col="blue")
abline(a=APCs[25]/1000, b=0, lwd=2, col="blue")
lines(Lib25/1000, type="b", pch=19, lwd=2, col="blue")
```
The expenditures of Library 90 fall from EUR 20,939 to EUR 0 because there are effectively no publications from this organization at the particular publisher.

The twenty libraries that conclude Smooth Transformative Agreements in each period could be (but not need to be) a national or regional library consortium. Moreover, this new model offers the possibility for a two-speed open-access transition considering regional preferences for open access (e.g., the USA prefer the green route and the European countries the gold one) without burdening the budgets of progressing high-publishing organizations or high-publishing countries too much.

**Conclusion**

The real advantage of the smooth transition model above R&P or P&R is that library acquisition budgets have the chance to evolve gradually from subscription expenditures to APCs. Neither instantaneous policy changes for library funding are required, nor massive coordination effort. However, even with the smooth transition model, an open-access transformation will not succeed if high-publishing organizations do not commit to the open-access principle and do not receive adequate additional funds in the long term. The attraction of the smooth transition model is that libraries, governments and funders gain time to develop, adopt, evaluate and revise funding reallocation and workflows as the open-access transition progresses. Temporary
mistakes in policy changes do not cause severe damage as library expenditures rely in large parts on historical subscriptions in the first half of the global open-access transition even at high-publishing organizations. This also reduces the uncertainty at the libraries’ and publishers’ side surrounding the switch from subscriptions to APCs and from the R&P to P&R model, respectively.

Annex A: Real-world examples of publication output distributions

The following figures show the number of articles published at PLoS journals in 2018 as indexed in the Web of Science Core Collection. The query was done on-line via the website of Web of Science and the data was analyzed by the inbuilt “Analyse Results” tool and sorted by organizations (organization-enhanced). The first two plots show organizations all over the world, the third one counts articles from authors affiliated with German organizations. The figures provide evidence that global publications as well as publications from one country follow a geometrical distribution.
Articles at PLoS journals in 2018 as indexed in the Web of Science Core Collection

Organization
All records

Articles

0 5000 10000 15000
0 200 400 600 800
Articles at PLoS journal in 2018 as indexed in the Web of Science Core Collection

German organization
Truncated at min. 5 articles per organization