Author-Paid Publication Fees Corrupt Science and Should Be Abandoned

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"No good deed goes unpunished." - Anon

In 1973, following an OAPEC oil embargo, the US government sought to decrease their oil consumption, in part by raising the minimum standards for fuel efficiency of cars. Perversely, and despite its good intentions, this change would push both consumers and manufacturers towards larger, more dangerous, and *less* fuel-efficient cars (1). The critical factor was an exemption granted to "light trucks". This was intended to avoid adverse effects on industries that relied on large, heavy, and fuel-inefficient vehicles. However, it also meant that after the new standards were introduced, these vehicles became cheaper relative to smaller cars that were subject to

more stringent efficiency requirements. They were also more profitable for manufacturers who began to market them heavily as family vehicles. In addition, federal safety requirements only considered the safety of occupants, not other road users, further favoring large, fortress-like vehicles. Today, after 50 years of these policies, SUVs and trucks have grown to constitute more than 80% of new vehicles sold in the US.

A little over ten years ago, researchers in the social, behavioral and medical sciences faced a crisis of their own: the replication crisis, provoked by the discovery that many published results could not be replicated and were, in many cases, wrong. Just like the US government, the scientific community would respond to their crisis with policy reforms. Pre-registration aimed to increase replicability by reducing the scope for researchers to reimagine their work after data was collected. Some journals began emphasizing technical soundness over perceived importance, encouraging the publication of null results and offering a venue for work that previously disappeared into the file drawer. These publications, it was hoped, would offer a natural check to the flashy false-positives that thrived in impact-driven prestigious journals. Finally, Open Access (henceforth "OA") reforms aimed to benefit the public and underfunded researchers by making publications free to read. OA policies have been extremely popular, and more than 20,000 OA journals now exist whose content is freely available to all (see https://doaj.org/). Collectively, these reforms were intended to put an end to the era of impact-chasing, false-positives, and unpublished truths. In its place would arise a new culture centered on the routine publication and open dissemination of unembellished, robust results. Or so it was hoped. In practice, just as with fuel efficiency policy, things didn't work out as intended. Rather than solving existing problems, some of these scientific reforms have created new and perhaps

worse ones as researchers and publishers converged on unanticipated strategies inadvertently incentivized by these new policies. As we describe below, central to this corruption of science has been pay-as-you-publish "gold" OA publishing. The remedy is to abandon author-paid OA publishing and seek less harmful alternatives.

The economics of publishing

Although the internet has reduced the cost of publishing, it is nevertheless expensive to run a journal. Publishers need money to pay for typesetters, proof-readers, and editors. They pay to host digital publications online, and some print physical editions as well. How publishers secure funding creates an incentive structure that affects their publication strategies. Prior to OA, most journals were funded through reader subscriptions, often paid by institutions. University libraries, for example, would (and still do) negotiate with publishers for access to content. This incentivizes journals to publish content that readers will pay to read—which, in theory, should correspond to high quality work. However, no system is perfect, and the replication crisis highlighted that readers' interest in shocking or surprising results increases the false-positive rate because surprising results are disproportionately likely to be incorrect.

Open Access policies change these incentives, replacing them with new incentive structures, the specifics of which depend on the form of OA that is adopted. The most typical OA format is "gold" OA in which journals are funded through article processing costs (APCs) paid by researchers upon publication of their work. Other forms exist. For instance, "diamond" OA journals are free to both authors and readers; these are reliant on external donations and volunteers and are therefore typically limited in the scale of both their readership and output.

Hybrid journals still rely on subscription fees and so do not mandate APCs, however they allow authors to pay APCs in order to make their articles available to readers without a subscription. A final alternative is author self-archiving, so-called "green" OA. In this case, authors simply post a copy of their article (often without the journal's official formatting) on a personal website, online repository, or preprint server. Gold is the most common OA policy, and is the focus of our critique.

The hidden costs of gold Open Access

Gold OA links journal income to the numbers of papers published, not the number of readers. As such, it creates an incentive for journals to publish large volumes of papers, including low-interest papers that don't attract readers, because they generate income regardless. Examination of the 50 most productive journals (31 of which are gold OA, the other 19 hybrid OA) supports this (2): Gold OA journals produce more papers than hybrid journals (an average of 18,613 over 3 years, versus 11,707, $p=0.033$), but these papers receive fewer citations (average of 4.9 over two years, versus 8.6, $p<0.001$). Correspondingly, despite their greater productivity, gold OA journals have lower *h*-indices than hybrid journals (average of 207 versus 367, $p=0.007$).

The publication of low-interest work can be important to preserve important ideas whose time has not yet come—so-called "sleeping beauties" (3). But most low-interest papers are not sleeping beauties, and the publication of too many of these has the potential to harm the reputation of prominent journals. To avoid this, many publishers have launched lower-prestige gold OA journals that generate income from less newsworthy publications, while their more prestigious journals remain selective. Indeed, when prestigious journals reject papers, they often

offer “transfer” services whereby the submitted manuscript is automatically sent on to a lower prestige journal owned by the same publisher. The researchers benefit as the time cost of resubmitting the manuscript is reduced, the publisher benefits as they can reject a paper without losing out on the APC. An example is the gold OA journal *Scientific Reports*, published by Springer Nature, which receives transfers from other Nature journals and now publishes more articles per year than any other journal in the world (2).

As low-prestige gold OA journals have proliferated, they have begun to compete to attract authors. Strategies include increasingly quick and easy routes to publication, as well as invitations to guest edit special issues, in which the invited editors (but not the other contributors) are typically exempt from APCs. This bidding for authors has encouraged researchers to pursue a quantity-over-quality research strategy, further facilitated by the perception that OA publishing is itself a signal of quality and by institutional career incentives that reward the number of publications without assessing their value. As some researchers have decreased the quality of their work, new gold OA journals with lower standards have appeared to provide an outlet. Thus, gold OA combined with quality-agnostic career incentives engenders a coevolutionary process between researchers and publishers in which publishers sacrifice selectivity for volume and researchers sacrifice impact for quantity. This process has been sufficiently rapid that when journals are ranked by papers published per year, 18 of the top 30, and *all* of the top five are gold OA (2).

The negative effects this has on science (and science’s public perception) can already be seen in recent cases of mass retractions (4), predatory journals and paper mills (5), and the rise of AI-generated papers (6) and peer review (7). Less dramatically, the increasing volume of

publications also undermines human-written peer-review because there are now too many papers to review thoroughly. Even if you have the time, why carefully review a paper that few will read? As a result, low-impact journals are associated with shallower peer-reviews (8). The long-term consequence of this erosion of quality controls will be confused literatures and slowed scientific progress.

Can diamond, green, or hybrid Open Access help?

Given the various forms of OA available, the easiest solution may be to switch from Gold to a less corrupting alternative. However, identifying such an alternative is far from easy. Hybrid OA journals make use of APCs and so, to the extent that their funding comes from APCs, they are subject to the same incentives as gold OA journals. Moreover, within hybrid journals, publishing OA produces a citation boost and so reduces the relative prominence of work by underfunded researchers, with this penalty being exacerbated by the larger APCs at the most prestigious journals (9). This suggests that hybrid OA policies will do little to help.

A recent alternative is the replacement of gold OA APCs with institutional agreements to waive APCs for their employees (e.g. (10)). By replacing the *pay-as-you-publish* model with a *pay-in-order-to-publish* model, these agreements may be an improvement on gold OA. However, attention needs to be given to the new incentives they create. For instance, to incentivize quality research, institutions should avoid reaching such agreements with low quality journals. However, both publishers (seeking to maximize income) and researchers (seeking non-selective venues to maximize publication rates) may desire the opposite. In addition, such institutional policies do not typically benefit researchers from underfunded institutions, who must continue to pay APCs.

Diamond and green OA publishing do not involve APCs and so are not affected by the incentives that APCs create. This also means they guarantee access to both readers and authors regardless of their funding. As such they may be a viable solution to the problems discussed above. Nonetheless, these journals face logistical concerns. Diamond OA journals are financially insecure and can struggle to scale up to the size of widely read journals without switching to gold OA policies. Green OA policies are similarly reliant on outside funding for preprint servers, while individual hosting is unreliable and not standardized. A solution to these issues is for funding bodies to switch from supporting gold OA, by mandating OA publication and providing funds for APCs, to funding green and/or diamond initiatives directly. For instance, the not-for-profit Open Library of Humanities (openlibhums.org) receives funding from libraries and other institutions which it uses to support diamond OA journals (11). Meanwhile, the Japanese government is spending ¥10 billion to create and maintain green OA repositories (12). The potential long-term success of green OA can be seen in repositories such as the arXiv, which has been consistently maintained since 1991. Moreover, in the fields in which posting preprints has been normative for many years—including physics, computer science, and economics—journals still play an important role for vetting and curation while preprints guarantee access. With suitable institutional and governmental support green and diamond OA journals may realize the potential of the OA movement.

Future directions

Science is a complex process. Its success requires policies that incentivize researchers and journals to behave in ways that maximize its societal benefit. Such policies must strike a balance

between the quality and quantity of work produced while avoiding unanticipated negative consequences. Too much emphasis on quality delays discoveries by trapping researchers in endless planning, proposals, and revisions. Moreover, where quality is hard to identify, it can inadvertently catapult misleading results to prominence while the truth languishes in obscurity. Nonetheless, too little emphasis on quantity buries genuine discoveries under masses of uninteresting and contradictory publications. From this viewpoint, gold OA policies have harmed science by overly favoring quantity at the expense of quality. In hindsight, reliance on reader subscriptions is a powerful incentive for journals to robustly check the quality of the work they publish, and, in turn, for scientists to conduct high-quality work in the first place (provided that community norms also ensure high-quality peer review). This reveals reader subscription fees to be valuable safeguards to the scientific process, replaceable only by comparable indicators of reader interest or publication quality. Nonetheless, we should not look back with rose-tinted glasses. Prior to OA reforms, the acquisition of a vast number of journals by a handful of commercial publishers created monopolies that enabled publishers to charge exorbitant reader fees, driving up private profit margins with public money (13). Our criticisms of gold OA are thus not a suggestion to uncritically revert to prior practices. But neither do the problems with subscription fees excuse the harm done by well-meant gold OA reforms. Instead, we should learn from the past as well as the present, and design incentive systems that meet our goals whether or not the mechanisms themselves carry the label of progress.

More broadly, rather than simply adopting new policies (which inherently favors policies congruent with existing power structures), we strongly encourage further formal modelling of the scientific process to identify beneficial changes (14). Game theory and evolutionary modelling

are particularly suitable, and past work anticipated some of the problems discussed above. For instance, it was predicted that expediting the review process and encouraging the publication of novel null results, both of which gold OA supports, would decrease reliability, increase retractions and increase the peer review burden (15–17). Other work anticipated coevolutionary dynamics between authors and publishers (18). Critically, these methods can be used to assess policies *before* their implementation, thereby reducing the chances of unforeseen consequences. Recent modeling work on modified lotteries for grant funding illustrates how this can be done (19–21).

Beyond alternative forms of OA, a proposal we suggest for further evaluation is a re-emphasis on society journals. The proliferation of society-less OA journals means that too often researchers publish in, review for, and serve as editors for journals they are not invested in. A renewed emphasis on society journals may remedy this. With fewer alternative journals bidding for work, editors and reviewers may be more able to demand major improvements or extensions to submitted work, though this would have to be balanced by the need for diverse outlets. Journals could even require a history of thorough reviews as a prerequisite for submitting one's own work, thereby incentivizing high-quality reviews and fairly distributing the peer-review burden. Societies may also be well positioned to develop holistic assessments of research productivity that go beyond mere enumeration of journal articles and account for the diverse ways in which individuals contribute to research and scholarship, easing the pressure to maximize publication rates which has overburdened quality assurance mechanisms. The existing set of society journals is likely to be insufficient to cover the wide range of research, which is increasingly at the interstices of traditional disciplinary boundaries. However, emphasizing the connections researchers have to their communities is likely to improve the monitoring of

standards (22), provided that those communities avoid becoming overly disconnected from others who can provide critical input (23).

Bearing in mind the unintended consequences of well-intentioned policy changes, from fuel efficiency to gold OA, we encourage readers to be cautious in their evaluation of our suggestions. Green and Diamond OA may not be sustainable in the long term; seemingly useful quality metrics may simply distort publishing in other ways; society journals may be vulnerable to corruption and abuse. Rather than adopting new policies that feel good and hoping for the best, policies should be examined through careful consideration, including formal modelling of the scientific process, to make sure they advance our goals. This sort of vetting is critical to avoid policy blunders; there is too much at stake to proceed blindly.

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