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Are we paying-to-play? A quantitative assessment of Canadian open access research in ecology and evolution

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Abstract

Open access (OA) allows for peer-reviewed research to be freely accessed and there has been a collective shift from both researchers and publishers towards more OA publishing. OA typically occurs either through article-processing charges (the gold road) or via self-archiving (the green road); the former can be expensive, while the latter has seen minimal uptake. The gold road of OA has led to predatory publishers and, to some, questionable publications. Here, I used publicly available grant information in Canada and combined this with individual publishing statistics to test a variety of factors and their influence on OA publishing. I showed that an individual's award amount, H-index, and gender did not influence the proportion of OA articles they published, but an individual's H-index scaled with the number of OA publications. Institute size influenced OA publishing patterns, with researchers at large universities (i.e., >20 000 full-time students) publishing proportionately more OA articles than medium and small institutes. I discuss the potential for this pattern to build on pre-existing systemic biases when it comes to funding and publishing.

Key words: publishing, article processing charges, journals, bibliometrics, H-index

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Introduction

Removing barriers to accessing research material is beneficial to society. In scientific publishing a common approach has been through an open access (OA) model, an idea that has its roots in computing and physics research (Suber 2006). There are two primary ways to making scholarly work OA (Eysenbach 2006), sometimes referred to the green and gold roads (Harnad et al. 2004). The first mode is to publish directly in journals that make the article freely available on their website and is primarily funded through charges to the authors, otherwise known as article-processing charges (APCs). The second mode, or green road, of OA is via self-archiving; here authors publish in traditional subscription-based journals, but make the article available on a public repository, often after some period of embargo. Established publishers are increasingly converting to the gold road (Björk 2016), but the majority of OA journals still do not charge APCs (Morrison 2018). The majority of journals permit the green road, but most researchers do not use it (Harnad et al. 2004; Eger et al. 2015). Sci-Hub—or so-called black OA (Björk 2017)—should be included in the discussion as such sites distribute scholarly work with complete ambivalence towards copyright (Himmelstein et al. 2018) and are growing in usage (Nicholas et al. 2019). The posting of preprints could arguably be another mode of OA, with a key difference being these are typically not peer reviewed.

States and funding agencies certainly recognize the importance of OA and various policies have emerged. In Europe for example, the controversial Plan S that will take effect in 2021 aims to remove paywalls by making all publicly funded publications available via OA immediately (Rabesandratana 2018), which would mean no embargo periods. China appears to support, but has yet to adopt, Plan S (Schiermeier 2018). In contrast, policies in North America have remained largely status quo (Rabesandratana 2019), though this might be changing (Brugger 2020). For now, the primary funding bodies in North America, and specifically Canada, require that grant-supported publications be made publicly accessible within 12 months of publication (Government of Canada 2016).

Prior to such policy initiatives, a collective shift in publishing towards OA was already transpiring (Severin et al. 2018), notably towards the gold road (Björk 2016). The majority of researchers appear to publish semi-regularly in OA journals with APCs (Solomon and Björk 2012). In addition to accessibility, possible advantages include increased visibility and citation metrics (Eysenbach 2006; Davis et al. 2008; Evans and Reimer 2009; Li et al. 2018). But with the increased demand for OA and potential publisher profits, some criticism has emerged (Suarez and McGlynn 2017). Contributing to the negative image of OA is the clear exploitation of some publishers (Beall 2012); the rigour of some OA journals has been openly questioned, resulting in curated lists of probable predatory OA journals (e.g., Beall's list). Phrases like pay-to-play now get tossed around, with a common perception being that a manuscript could not have been published in that journal, or at all, were it not for the gold road of OA.

The pay-to-play viewpoint, however, has an inherent negative connotation. Another way to frame it would be that if researchers had more money at their disposal, would they choose to make more of their articles OA? The answer to this question has important ramifications as, for example, in Canada small institutes receive disproportionately lower amounts of funding (Murray et al. 2016), female applicants have lower success rates and receive less funding than men (Urquhart-Cronish and Otto 2019), and early-career researchers (ECRs) receive approximately 25% less in funding on average (NSERC 2020); any bias in OA publishing due to funding has the potential to exacerbate these systemic problems. I was particularly interested in OA patterns in the fields of Ecology and Evolution given, not only my own research interests, but also what I have perceived to be a recent influx of gold road journals in the field. And more broadly, global and free access to reliable scientific models and information is more important than ever given the current pandemic, climate, and biodiversity crises.

Here, I took advantage of information from Canada's Natural Sciences and Engineering Research Council (NSERC) that has a public awards database, and combined this with Web of Science's author reports to address this question. I predicted that the number of OA publications would correlate to the grant dollar amount, but the proportion of total articles that were OA would not. In other words, my null hypothesis is that researchers would exhibit the same tendency to publish in OA regardless of the amount of money at their disposal. I further tested the influence of institute size, H-index, and gender in OA publishing rates.

Materials and methods

I collected information on individual Discovery Grant (DG) recipients from 2011 to 2014 Ecology & Evolution panel using NSERC's publicly available Awards Database. Specifically, I obtained the first and last name of the recipient, amount per year in Canadian dollars, and year of award. These data are publicly available and obtainable from NSERC in summary form, so no research ethics board approval was required (CIHR et al. 2014).

I obtained three authorship metrics using the Web of Science Author Search (Beta version): current H-Index, the total number of publications, and total number of OA publications over a 5-year span

starting the year the grant was awarded. The 5-year period was chosen as it reflects the standard length of a NSERC DG award. Each individual's primary affiliation was collected and designated as a small (<10 000 full-time students), medium (>10 000 but <20 000 full-time students), or large university (>20 000 full-time students); government; or other. Both curated and algorithmically generated author records were used. All records were collected independently by two paid student researchers in May 2020; any discrepancy I attempted to resolve and only those with exact matches were retained.

I predicted gender of each award recipient using their first name and the R package gender (Mullen et al. 2015). Here I used the United States Social Security database between 1960 and 2012, with gender assignments based on the highest proportion. I then ran a series of models in R v.3.6.3 using the base and lme4 packages (Bates et al. 2006). In the first set of linear models, I examined the proportion of OA articles relative to award year and the number of OA articles relative to award amount. The second set of models quantified the relationship between gender and H-index and proportion of OA articles using a *t*-test. The final mixed model had the total number of OA publications as the response variable; gender x amount of award per year (scaled), institute type (factor), and H-index were treated as fixed effects. I treated the award year as a random effect to reflect possible shifting attitudes towards publishing OA articles. Note, to use a proportion in the last model (effectively a rate), I assumed a Poisson model with the total number of OA publications on the left side of the equation, and total number of papers (log transformed) as an offset variable (see R script for formula (Data availability section)).

There are aspects and assumptions with the data worth addressing. I make the general assumption that most award recipients, largely made-up of University professors, support OA models to some degree—meaning no one actively avoided publishing OA articles. I acknowledge that in many cases state-funded researchers might be required to make articles OA, but there is currently minimal enforcement and thus OA rates are highly variable among researchers. Gender is not binary, but it is treated as such in the model due to limited available information. Gender could also be misassigned, but reported error rates for this method are low (Blevins and Mullen 2015). The web of science algorithm generates citation metrics that might contain errors; there is no reason to suspect this systematically biased the model and records were collected independently twice. Not all NSERC DG awards are five years, but I viewed this as reasonable window to assess the impact of the DG on OA publishing. An individual might receive a second DG over this period for a variety of reasons; in such instances I took the most recent award date. Despite critiques of the H-index (e.g., Egghe 2006), this citation index was selected for consistency with other Canadian studies (i.e., Wei et al. 2020). Lastly, it is likely that any given award recipient does not pay for all the OA articles they have published, and some OA articles do not require a fee (e.g., invited review or green road); I assume this influences all award recipients, regardless of their grant amount, equally.

Results

I collected information on 535 awards; after filtering data for completion, removal of repeated individuals, and matching records among the two collectors ($n = 90$); a total of 409 individual records with a gender assigned were retained for further analysis. Researchers in the data set on average had 38% of their papers OA (**Table 1**). The total number of publications and proportion that were OA were not correlated (Pearson's product-moment correlation 0.02, $p = 0.72$), and there was a positive trend over time in regards to proportion of OA articles individuals published (**Fig. 1**; $\beta = 0.13$, df = 408, $p < 0.01$). Award amount was positively correlated to the number of OA articles ($\beta = 0.18$, df = 408, $p < 0.01$).

Table 1. Mixed-model summary statistics looking at predictors associated with open access publishing.

	Incidence rate ratios	Confidence interval	*p*
(Intercept)	0.38	0.32–0.46	<0.01
Amount	1.00	0.92–1.08	0.94
Gender: male	1.02	0.95–1.10	0.61
Amount × gender	1.03	0.96–1.12	0.40
H-index	0.99	0.96–1.03	0.73
Medium-sized university	0.93	0.86–1.00	0.06
Small-sized university	0.84	0.77–0.93	<0.01
Other institutes	0.89	0.78–1.01	0.08

Note: Institute coefficients are relative large universities (>20,000 full-time students).

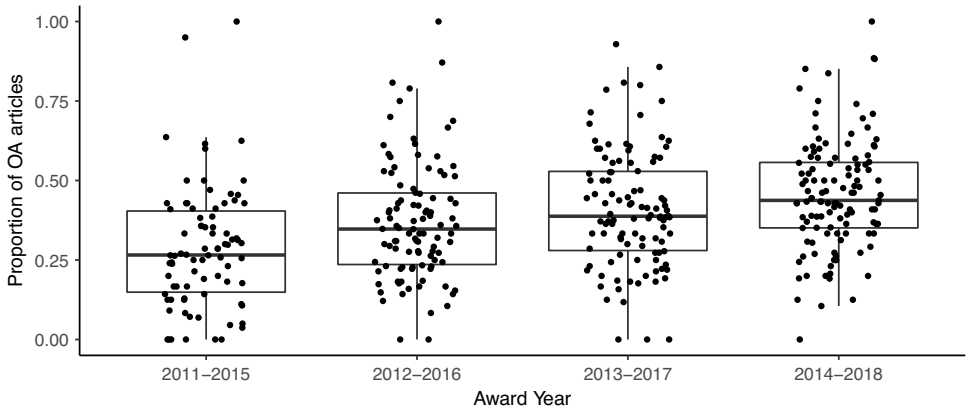

Fig. 1. Boxplots showing proportion of open access (OA) publications by Natural Sciences and Engineering Research Council funded researchers over the selected funding period. The proportion of OA publications significantly increased over time.

There were clear differences between gender and award amount (Fig. 2a; $t = -3.99$, df = 359, $p < 0.01$), but not the proportion of published OA articles (Fig. 2b; $t = -0.30$, df = 234, $p = 0.76$). In the mixed model I showed that medium and small universities, and other institutes (primarily government), published proportionately less OA articles on than researchers at large universities (Table 1). H-Index and gender did not have a clear effect in the model (Table 1). When I removed the offset variable and simply examined the number of OA publications, only H-index had an effect in the full model (incidence rate ratio = 1.44 (CI 1.39–1.49), $p < 0.01$).

Discussion

There is a clear shift towards OA publishing in science (Severin et al. 2018) and more specifically ecology and evolution (Fig. 1). A portion of OA publications involve a financial cost to the authors, and often this does not come solely from research grants (Solomon and Björk 2012). Journals with higher APCs have higher impact factors (Solomon and Björk 2012), and nefarious publishers have started exploiting the OA model (Beall 2012). Collectively, this led to the primary question: do individuals with more (grant) money, publish more OA articles?

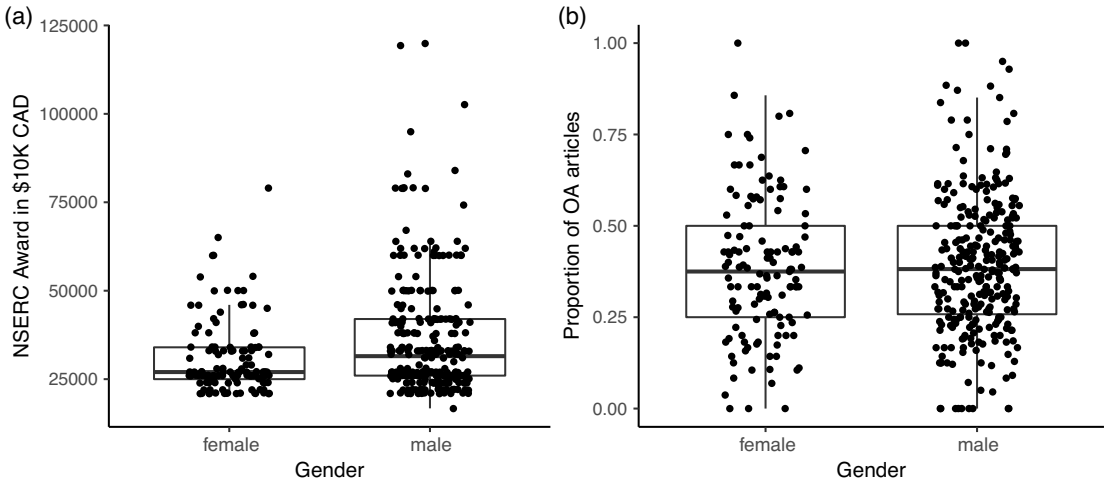

Fig. 2. (a) Natural Sciences and Engineering Research Council (NSERC) award (in 10s of thousands $CAD). (b) Proportion of publications that are open access (OA). There was a significant difference between gender and NSERC award amount, but not the proportion of OA articles published.

While I focused only on Canadian grants in ecology and evolution, there was no evidence funding influenced the rate of OA publishing in terms of the proportion of articles (**Table 1**). Individuals with more grant money and higher H-indices had more total OA articles on average: this suggests that total publications and OA articles scaled co-linearly with award amount, but the OA publishing tendency of Canadian researchers did not change with increased funds. This data set had a mean grant amount of $34 467 (min. $16 746; max. $120 000); this might not be a large enough spread to shift an individual's publishing behaviour, and it would be interesting to quantify the effect of really large grants in this regard.

Across universities, small- and medium-sized institutes published less OA proportionally than larger institutes (**Table 1**). There are clear differences in grant amounts by institute size (Murray et al. 2016), but I did not see an effect of award amount in the full model. A German survey showed that working where publication output was viewed as an essential metric of achievement increased the likelihood of publishing OA articles (Eger et al. 2015). Certainly, in Canada expectations of research output vary by university, with smaller institutes generally placing more premium on teaching, which could partly explain this relationship. Larger institutes often also have more discretionary pools of money that researchers can tap into for APCs. In addition to the institutional differences in funding, there are clear systematic biases against women when it comes to peer-review (Fox and Paine 2019) and funding (Urquhart-Cronish and Otto 2019). These biases do not appear to have affected OA rates (**Table 1**; **Fig. 2**). However, I would be concerned that OA discrepancies between institute size, combined with funding amount differences (Murray et al. 2016; Urquhart-Cronish and Otto 2019), has the potential to create a synergistic negative feedback loop that could have negative real consequences if left unchecked. Pointedly, this could limit the research (i.e., amount of money) and impact (i.e., OA publishing rates) of female and ECRs at small and medium-sized universities.

Almost 80% of articles published in the 100 largest publishers can be made OA via the green road (Laakso 2014). Yet fewer than 10% of biologists report self-archiving (Eger et al. 2015), which Björk (2017) suggested meant researchers simply could not be bothered with it. It is surely not a coincidence that once the National Institutes of Health (NIH) in the United States threatened to withhold funding to enforce its pubic accessibility policy, compliance followed immediately and NIH researchers now have among the highest archiving rates (Van Noorden 2013; Larivière and Sugimoto 2018).

NSERC requires all grant recipients make the supported articles OA within 12 months; however, compliance appears to be around 40% (Larivière and Sugimoto 2018; this study). With current levels of APCs more than $3000 CAD on average (Morrison 2018), this is just under 10% of the average grant in ecology and evolution. Publishing in gold road journals, despite the noted benefits, presents an ethical dilemma of using public funds to cover the APCs of publicly funded research (though again, this should not detract from green road). APCs also come at a cost to other research projects, student recruitment, and student financial support. Given this, novel OA models need to be explored (Fruin and Rascoe 2014; Speicher et al. 2018) and self-archiving facilitated by institutes should be enforced to maximize access to research.

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Author contributions

ABAS conceived and designed the study. ABAS performed the experiments/collected the data. ABAS analyzed and interpreted the data. ABAS contributed resources. ABAS drafted or revised the manuscript.

Competing interests

The author has declared that no competing interests exist.

Data availability and supporting information

The final data set with identifying personal information removed and full R scripts are available online at gitlab.com/WiDGeT_TrentU/Open_Access.

References

Bates D, Sarkar D, Bates MD, and Matrix L. 2006. The lme4 package [online]: Available from cran.r-project.org/web/packages/lme4/.

Beall J. 2012. Predatory publishers are corrupting open access. Nature, 489(7415): 179. PMID: 22972258 DOI: 10.1038/489179a

Björk B-C. 2016. The open access movement at a crossroad: are the big publishers and academic social media taking over? Learned Publishing, 29: 131–134. DOI: 10.1002/leap.1021

Björk B-C. 2017. Gold, green, and black open access. Learned Publishing, 30(2): 173–175. DOI: 10.1002/leap.1096

Blevins C, and Mullen L. 2015. Jane, John … Leslie? A historical method for algorithmic gender prediction. DHQ: Digital Humanities Quarterly, 9(3).

Brugger KK. 2020. White House formally invites public comment on open-access policies [online]: Available from sciencemag.org/news/2020/02/white-house-formally-invites-public-comment-open-access-policies.

Canadian Institutes of Health Research (CIHR), Natural Sciences and Engineering Research Council of Canada (NSERC), and Social Sciences and Humanities Research Council of Canada. 2014. Tri-council policy statement: ethical conduct for research involving humans.

Davis PM, Lewenstein BV, Simon DH, Booth JG, and Connolly MJL. 2008. Open access publishing, article downloads, and citations: randomised controlled trial. BMJ, 337: a568. PMID: 18669565 DOI: 10.1136/bmj.a568

Eger T, Scheufen M, and Meierrieks D. 2015. The determinants of open access publishing: survey evidence from Germany. European Journal of Law and Economics, 39(3): 475–503. DOI: 10.1007/s10657-015-9488-x

Egghe L. 2006. An improvement of the H-index: the G-index. ISSI Newsletter, 2: 8–9.

Evans JA, and Reimer J. 2009. Open access and global participation in science. Science, 323(5917): 1025. PMID: 19229029 DOI: 10.1126/science.1154562

Eysenbach G. 2006. Citation advantage of open access articles. PLoS Biology, 4(5): e157. PMID: 16683865 DOI: 10.1371/journal.pbio.0040157

Fox CW, and Paine CT. 2019. Gender differences in peer review outcomes and manuscript impact at six journals of ecology and evolution. Ecology and Evolution, 9(6): 3599–3619. PMID: 30962913 DOI: 10.1002/ece3.4993

Fruin C, and Rascoe F. 2014. Funding open access journal publishing: article processing charges. College & Research Libraries News, 75(5): 240–243. DOI: 10.5860/crln.75.5.9120

Government of Canada. 2016. Tri-Agency Open Access Policy on Publications [online]: Available from ic.gc.ca/eic/site/063.nsf/eng/h_F6765465.html.

Harnad S, Brody T, Vallières F, Carr L, Hitchcock S, Gingras Y, et al. 2004. The access/impact problem and the green and gold roads to open access. Serials Review, 30(4): 310–314. DOI: 10.1080/00987913.2004.10764930

Himmelstein DS, Romero AR, Levernier JG, Munro TA, McLaughlin SR, Tzovaras BG, et al. 2018. Sci-hub provides access to nearly all scholarly literature. eLife, 7: e32822. PMID: 29424689 DOI: 10.7554/eLife.32822

Laakso M. 2014. Green open access policies of scholarly journal publishers: a study of what, when, and where self-archiving is allowed. Scientometrics, 99(2): 475–494. DOI: 10.1007/s11192-013-1205-3

Larivière V, and Sugimoto CR. 2018. Do authors comply when funders enforce open access to research? Nature, 562(7728): 483–486. PMID: 30356205 DOI: 10.1038/d41586-018-07101-w

Li Y, Wu C, Yan E, and Li K. 2018. Will open access increase journal citescores? An empirical investigation over multiple disciplines. PLoS ONE, 13(8): e0201885. PMID: 30161156 DOI: 10.1371/journal.pone.0201885

Morrison H. 2018. Global OA APCS (APC) 2010–2017: major trends. *In* ELPUB 2018, Toronto, Ontario, June 2018. DOI: 10.4000/proceedings.elpub.2018.16

Mullen L, Blevins C, and Schmidt B. 2015. gender: predict gender from names using historical data. R package version 0.5.1.

Murray DL, Morris D, Lavoie C, Leavitt PR, MacIsaac H, Masson ME, et al. 2016. Bias in research grant evaluation has dire consequences for small universities. PLoS ONE, 11(6): e0155876. PMID: 27258385 DOI: 10.1371/journal.pone.0155876

Natural Sciences and Engineering Research Council of Canada (NSERC). 2020. 2020 Competition statistics, discovery grants, research tools and instrument and subatomic physics programs [online]: Available from nserc-crsng.gc.ca/_doc/DGP2020_e.pdf.

Nicholas D, Boukacem-Zeghmouri C, Xu J, Herman E, Clark D, Abrizah A, et al. 2019. Sci-Hub: the new and ultimate disruptor? View from the front. Learned Publishing, 32(2): 147–153. DOI: 10.1002/leap.1206

Rabesandratana T. 2018. European funders detail their open-access plan. Science, 362(6418): 983. PMID: 30498107 DOI: 10.1126/science.362.6418.983

Rabesandratana T. 2019. Will the world embrace Plan S, the radical proposal to mandate open access to science papers? Science, 3. DOI: 10.1126/science.aaw5306

Schiermeier Q. 2018. China backs bold plan to tear down journal paywalls. Nature, 564(7735): 171–172. PMID: 30542162 DOI: 10.1038/d41586-018-07659-5

Severin A, Egger M, Eve MP, and Hürlimann D. 2018. Discipline-specific open access publishing practices and barriers to change: an evidence-based review. F1000Research, 7: 1925. PMID: 32399178 DOI: 10.12688/f1000research.17328.1

Solomon DJ, and Björk B-C. 2012. Publication fees in open access publishing: sources of funding and factors influencing choice of journal. Journal of the American Society for Information Science and Technology, 63(1): 98–107. DOI: 10.1002/asi.21660

Speicher L, Bargheer M, Maryl M, Fund S, Mosterd M, Pinter F, et al. 2018. OPERAS white paper: open access business models.

Suarez AV, and McGlynn T. 2017. The fallacy of open-access publication. The Chronicle of Higher Education.

Suber P. 2006. Open access in the United States. *In* Open access: key strategic, technical and economic aspects. *Edited by* Neil Jacobs, Chandos Publishing. pp. 1–20.

Urquhart-Cronish M, and Otto SP. 2019. Gender and language use in scientific grant writing. FACETS, 4(1): 442–458. DOI: 10.1139/facets-2018-0039

Van Noorden R. 2013. Nih sees surge in open-access manuscripts. Nature News Blog.

Wei Q, Lachapelle F, Fuller S, Corrigall-Brown C, and Srivastava DS. 2020. Working groups, gender and publication impact of Canada's ecology and evolution faculty. bioRxiv. DOI: 10.1101/2020.05.12.092247