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Measuring the prevalence of open access in Canada: A national comparison
Mesurer la prévalence du libre accès au Canada : une comparaison nationale

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See table of contents

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Article abstract

For two decades, open access (OA) has gained momentum worldwide. However, adoption of OA in Canada is lagging compared with other countries. Using data from Dimensions and Érudit, this paper provides an overview of OA dissemination in Canada, focusing on the effect of institutions, language, and funding. Papers in French, and from Quebec universities, are more likely to be OA, while papers from engineering-oriented institutions are less likely to be OA. Regarding funders, those in health sciences have higher OA compliance. The paper concludes discussing disciplinary differences in OA dissemination, low compliance to OA mandates in Canada, and the role of Érudit.

Measuring the prevalence of open access in Canada: A national comparison

Mesurer la prévalence du libre accès au Canada : une comparaison nationale

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Abstract: For two decades, open access (OA) has gained momentum worldwide. However, adoption of OA in Canada is lagging compared with other countries. Using data from Dimensions and Érudit, this paper provides an overview of OA dissemination in Canada, focusing on the effect of institutions, language, and funding. Papers in French, and from Quebec universities, are more likely to be OA, while papers from engineering-oriented institutions are less likely to be OA. Regarding funders, those in health sciences have higher OA compliance. The paper concludes discussing disciplinary differences in OA dissemination, low compliance to OA mandates in Canada, and the role of Érudit.

Keywords: Open access publishing, scientometrics, scholarly communication, research dissemination, Canada

Résumé : Au cours des deux décennies, le libre accès (LA) a pris de l'importance à travers le monde. Toutefois, son adoption au Canada est à la traîne par rapport à d'autres pays. À l'aide des données de Dimensions et d'Érudit, cet article donne un aperçu de la diffusion en LA au Canada, en se concentrant sur l'effet des institutions, de la langue et du financement. Les articles en français et ceux des universités québécoises sont plus susceptibles d'être en LA, tandis que les établissements axés sur le génie sont moins susceptibles. En ce qui concerne les bailleurs de fonds, ceux en sciences de la santé ont une conformité plus élevée au LA. L'article conclut en discutant des différences disciplinaires dans la diffusion en LA, de la faible conformité aux mandats de LA au Canada et du rôle d'Érudit.

Mots clés : Publication en libre accès, scientométrie, communication savante, dissémination de la recherche, Canada

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Introduction

Researchers have long been aware of the importance of open access (OA) (Albert 2006; Tennant et al. 2016), although compliance to openly sharing their work is still limited (Larivière and Sugimoto 2018). The COVID-19 pandemic has shown that scientists can make their work available quickly, provided they are motivated to do so, thus leading observers to suggest that the pandemic could be the beginning of a radical—and long awaited—transformation in scholarly communication (Callaway 2020). In March 2020, UNESCO made a call to mobilize 122 countries to promote Open Science and reinforced cooperation in the face of COVID-19 (UNESCO 2020a). Then, in April, it stated that Open Science is critical to the fight against COVID-19 and offered resources to help scientists and institutions disseminate their materials (UNESCO 2020b). Canada was part of this movement for Open Science, and the Office of the Chief Science Advisor made a call for OA for COVID-19 publications (Government of Canada 2020).

In Canada, research articles funded by the main research councils are already supposed to be made accessible in OA since May 1, 2015, the effective date of the *Tri-Agency Open Access Policy on Publications* (TAOAPP). The TAOAPP requires all their grant recipients to ensure that results arising from agency-supported research are freely accessible online within 12 months of publication. One study considered general compliance with OA mandates and took an interest in Canada's case, showing that Canadian policies had little effect compared to those of American or British agencies (Larivière and Sugimoto 2018). Moreover, the European Commission (EC) website *Trends for open access to publications* (Directorate-General for Communication of the European Commission n.d.), which analyses data about the 28 member states of the EC, and all countries from the G8, ranks Canada 32 of 36 countries for the overall percentage of open access publications for the period 2009-2018, lagging behind the majority of its peer countries.

This paper aims at quantifying the importance of OA diffusion in Canada. Specifically, we will present, for the period 2015-2019, the proportion of OA articles by researchers of Canadian institutions according to the language of publication (English or French), and we will quantify the proportion of articles funded by the major Canadian granting agencies available in OA. We will try to determine if OA publishing practices in Canada are linked to province or territory, institution, funder, language, or a combination of these variables. We will take a closer look at the situation in Quebec, where particularities related to the language of publication in social sciences and humanities have been observed in the past (Larivière and Macaluso 2011).

Literature review and research questions

Typology of OA

Multiple routes to OA exist that allow authors to be compliant with funder mandates. We adopt the classification used in *The State of OA* (Piwowar et al. 2018, Table 1).

Gold	Published in an open-access journal, indexed in the Directory of Open Access Journals (DOAJ).
Hybrid	Free under an open license in a toll-access journal.
Bronze	Free to read on the publisher's page, but without a clearly identifiable license.
Green	Toll-access on the publisher page, but there is a free copy in an OA repository.
Closed	All other articles, including those shared only on an Academic Social Network (ASN) or in Sci-Hub.

Table 1: Types of OA, inspired from Piwowar et al. (2018).

Of the four types only Gold OA has nearly universal support (yet issues remain concerning megajournals and predatory publishers, discussed below), while the others may be more controversial (Piwowar et al. 2018). Hybrid OA, a model of financing frequently adopted by commercial publishers, has been disapproved for being overly costly, as both authors, through *article processing charges* (APCs), and subscribers are charged. Whether Bronze OA can be considered proper OA is subject to debate: the absence of a licence makes journals adopting Bronze OA incompatible with major OA databases, such as the Directory of Open Access Journals (DOAJ). Unlike Gold, Hybrid and Green OA, Bronze OA does not necessarily reflect an intention by the author to make a publication accessible. Instead, articles may become Bronze OA 'retroactively', for example upon decision by the publisher and several years after initial publication. Similarly, publishers may decide to return Bronze OA articles behind a paywall at any point. Globally, Bronze OA may represent a majority among OA publications, which is surprising since this category of OA is still little discussed in the literature (Piwowar et al. 2018). In addition, even though Bronze OA allows papers to be read for free, it does not permit the reuse of the content, which is critical, as the right to reuse, for example for crawling purposes (indexing), was one of the main aspects of the Budapest Open Access Initiative which paved the way for OA publishing in the early 2000s. As is the case with Bronze OA, reuse permission is not guaranteed when resorting to Green OA.

Other key issues: Megajournals and predatory publishers

In addition to the need to fully understand the different options available when publishing in OA, there are additional challenges such as the proliferation of megajournals (Siler, Larivière, and Sugimoto 2019) and predatory publishing (Siler 2020), which can greatly complicate the situation for teams of researchers who arrive at the publication stage and wish to make their article available in OA.

A megajournal is usually defined by three main characteristics: 1) it has broad coverage of different subjects; 2) it accepts articles based primarily on scientific soundness, opposed to novelty or originality; and 3) it offers full OA via APCs (Siler, Larivière, and Sugimoto 2019; Björk and Catani 2016; Domnina 2016). *PLOS One* and *Scientific Reports* are often cited as examples of megajournals.

According to Siler's article on predatory publishing (Siler 2020), predatory publishers are usually characterized by the fact that they charge high APCs without providing robust editorial services (Clark and Smith 2015) and, according to Jeffrey Beall—a now-retired University of Colorado-Denver librarian who used to maintain a controversial blacklist of "predatory" publishers, they generally exploit the model of OA publishing for their own profit (Elliott 2012). Predatory publishers often "mimic longstanding legitimate journals online" and are very creative in their ways to try and appear to seem legitimate (Siler et al. 2021).

As mentioned, megajournals generally offer full OA funded via APCs (Siler, Larivière, and Sugimoto 2019). Though innovative and legitimate, this way of publishing may enhance the prevalence of predatory publishers and could lead researchers to pay high APCs to publish in OA, without questioning the legitimacy of the journal or the selection process, only to make sure they publish in Gold OA. According to a knowledge synthesis on scholarly communication, predatory practices by journals and publishers are on the rise worldwide, and "the relative importance of predatory publishers is even greater at the Canadian level" (Larivière and Sugimoto 2020). Data from this report shows that nine out of fourteen Canadian organizations which created four or more journals during the 2006-2015 period are on the Beall's list of predatory publishers. These issues increase the threshold for OA publishing and complicate the options researchers face when choosing for one of the several routes to OA.

Advantages of OA publishing

Previous research has provided evidence that there are multiple advantages to OA publishing that benefit the entire scientific community. Of course, OA is beneficial to the general public, who can access freely the most up-to-date scientific knowledge, but OA is also beneficial to worldwide knowledge equity amongst researchers (Evans and Reimer 2009). Research for countries with fewer resources is often locked behind paywalls, preventing scholars access to many scientific articles important to their field. A lack of resources also prevents them from disseminating their own research in more prestigious and expensive journals. Thus OA offers an interesting and economically sustainable route to share their work (Iyandemye and Thomas 2019). It is also proven and widely discussed that a more diverse conversation in science leads to better science ("Science Benefits from Diversity" 2018; Philipps 2014; Gibbs 2014).

Also, publishing in OA provides advantages to individual authors since OA publishing is likely to contribute to their citation impact. According to a comprehensive review (Zhu 2017) "regardless of the cause for OA articles' citation advantage, most studies suggest that OA status may contribute to a higher visibility and more readerships." A debate persists on the importance of a citation advantage, with percentages varying from 8% to 40% (Piwowar et al. 2018), but researchers agree that

it exists, including in Canada (Archambault et al. 2014; McCabe and Snyder 2014; Ottaviani 2016). With the Canadian academic system being increasingly performance-based (Peters 2021; Spooner 2021), having a bigger readership and a highest citation rate is a big advantage to researchers, since it is associated to a higher symbolic capital and can possibly enhance funding and access to resources.

OA in Canada

In Canada, the two main goals of the TAOAPP are: 1) to improve access to the results of Agency-funded research; and 2) to increase the dissemination and exchange of research results (Government of Canada 2016). This policy applies to all research funded by one of the three federal granting agencies: the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council (SSHRC). A similar policy previously existed for CIHR since 2008, which was modified, harmonized, and jointly adopted in 2015 to include NSERC- and SSHRC-funded research. It now requires grant recipients to ensure that any peer-reviewed journal publication arising from Agency-supported research is freely accessible within 12 months of initial publication. As for compliance, the policy states that "grant recipients are reminded that by accepting Agency funds they have accepted the terms and conditions of the grant and award as set out in the Agencies' policies and guidelines" (Government of Canada 2016) and it is mentioned that the Agency could take steps in case of breach of the Agency policy. Nevertheless, the consequences of not complying with the policy remain vague. We did a manual scan on the websites of the major private funders for Canadian research to see if they mentioned OA and if so, to verify the nature of their policy. Without necessarily having a strong incentive to publish in OA, most have at least a statement that encourages their grant recipients to make their publications accessible. This would theoretically mean that a clear *majority* of research coming from Canada should normally be available in OA.

In Quebec, in addition to the federal agencies, the *Fonds de recherche du Québec* (FRQ) is the main provincial funder. The *Fonds de recherche du Québec open access policy for the dissemination of research* was adopted on April 15, 2019 and requires all FRQ funding recipients to provide OA to their scientific publications no later than 12 months after initial publication. The compliance with the policy is considered an inherent condition for FRQ funding and the institutions recognized to manage FRQ funding are expected to help researchers and their students to comply with the requirements of the policy (Fonds de recherche du Québec 2019). Before the adoption of this policy, there was no harmonized policy for the three FRQ constituents, and only the FRQ – Santé (FRQ-S) was subject to the *Policy regarding open access to published research outputs – FRQS.* This policy stated that FRQ-S awardees were expected to "make every possible effort to have their peer-reviewed publications posted on open-access Web sites as soon as possible, ideally, no later than six months after publication or presentation" (Fonds de recherche du Québec - Santé 2012). Though more severe in appearance, this policy did not specify who was required to ensure its implementation, as is the case with the policy recently adopted in 2019. In May 2021, FRQ announced

its endorsement of Plan S by joining cOAlition S, thus demanding publications resulting from funded research will be immediately OA, starting March 2023.

Finally, the development of the non-profit platform Érudit has contributed to the prevalence of OA publishing, mainly in the social sciences and humanities. Initially launched as a pilot project for digital publishing from *Presses de l'Université de Montréal* (Beaudry et al. 2009), Érudit now plays an important role in the valorization of national journals, especially those publishing in French, and its mission explicitly mentions the support of OA (Cameron-Pesant 2018); including its data thus appears crucial to a holistic portrait of OA in Canada.

Compliance with OA policies

In 2018, the first large-scale analysis of compliance with OA mandates revealed that rates varied greatly with funders and countries (Larivière and Sugimoto 2018). Of more than 1.3 million articles analyzed, around two-thirds were indeed freely available. Larivière and Sugimoto (2018) also noted that "funders that allow authors to deposit papers after publication see lower rates of compliance, presumably because authors lose track of this obligation." In Canada, this applies to CIHR, which slacked its requirement from immediate OA to a 12-month delay in 2015. Meanwhile, compliance with OA attained around 60% in 2014, but dropped to around 40% in 2017. This decline was probably related to the change in policy (Larivière and Sugimoto 2018). Even if data concerning compliance with this policy is available (Larivière and Sugimoto 2018), no thorough research has been done to compare it to other factors such as the author's affiliation, the field of research or the language of publication. Moreover, the Larivière and Sugimoto (2018) article aims at tracing the general portrait of OA publication worldwide, but it did not aim to provide a detailed portrait of OA in Canada.

Methodology

The data we used was extracted from the Dimensions database, a source with better coverage of national scientific production than the databases generally used in scientometrics (Basson et al. 2021), as of January 2021. Dimensions indexes more than 5 million articles annually and, unlike Clarivate Analytics' Web of Science, covers a significant portion of the literature published in national journals (Herzog, Hook, and Konkiel 2020) and has a better coverage of non-English-language literature. It is worth mentioning that document types in Dimensions are relatively general and do not have the same level of detail as those in the Web of Science. We considered the document type *article*, which covers any type of document published by a scholarly journal. An initial query aiming to obtain all scholarly articles having a first author affiliated to a Canadian institution appeared to lack 11,220 articles disseminated by Érudit. To resolve the absence, the initial query was adjusted to obtain only articles not disseminated by Érudit from Dimensions, retrieving 1,002,913 articles, and internal data from Érudit on 26,925 articles was added subsequently. The final dataset contained a total of 1,029,838 articles by Canadian researchers published between 1995 and 2019, with a focus on the period 2015-2019, for which 309,103 articles were available. Érudit

disseminates less than 3% of the total number of articles published between 1995 and 2019, but its platform represents 62% of the articles in French published by Canadian institutions, and this proportion increases to 72% when just the period 2015-2019 is considered.

Dimensions links publications and citations with grants and allows for a more holistic review of the research landscape (Digital Science & Research Solutions Inc. 2020). In addition, we extracted the discipline for each article from Dimensions, as identified by the field *Research Categories*. Not all articles added from Érudit had a discipline associated by Dimensions and therefore we did not aim to analyze these in detail.

We focused on the five-year period of 2015-2019 to avoid potential unusual year-to-year fluctuations. The year 2019 is the latest complete year for which we could obtain data and going back five years allowed us to evaluate numbers from after the implementation of the TAOAPP, which was adopted in 2015. In our data, the type of OA is mutually exclusive. This means that an article that has been identified as Gold OA will not be counted a second time, even if it is also available in Green OA. In addition, the OA status assigned to a paper is the status identified as of spring 2021 and does not necessarily reflect the OA status at the time of publication. This effect is present particularly for Green and Bronze OA.

Finally, an acknowledgement issue may well be present with some of the articles in the database. The number of articles that mention their source of funding is lower than the real number of articles backed by some type of funding, and we can assume that this is because some researchers do not mention it in the acknowledgements or that they are poorly indexed by Dimensions or Érudit.

Results

The Canadian portrait of OA

At the national level, 44% of the articles published between 2015 and 2019 were available in OA, varying with the province or territory (Figure 1). The numbers for the three territories are statistically markedly different but given the low absolute numbers of publications (less than 40) for each of these, it would be risky to try to deduce anything from this and we will exclude these numbers from our interpretations. The dominant OA type varies between Gold and Bronze OA, while Hybrid OA accounts for the smaller part of OA articles in each province (Figure 1).

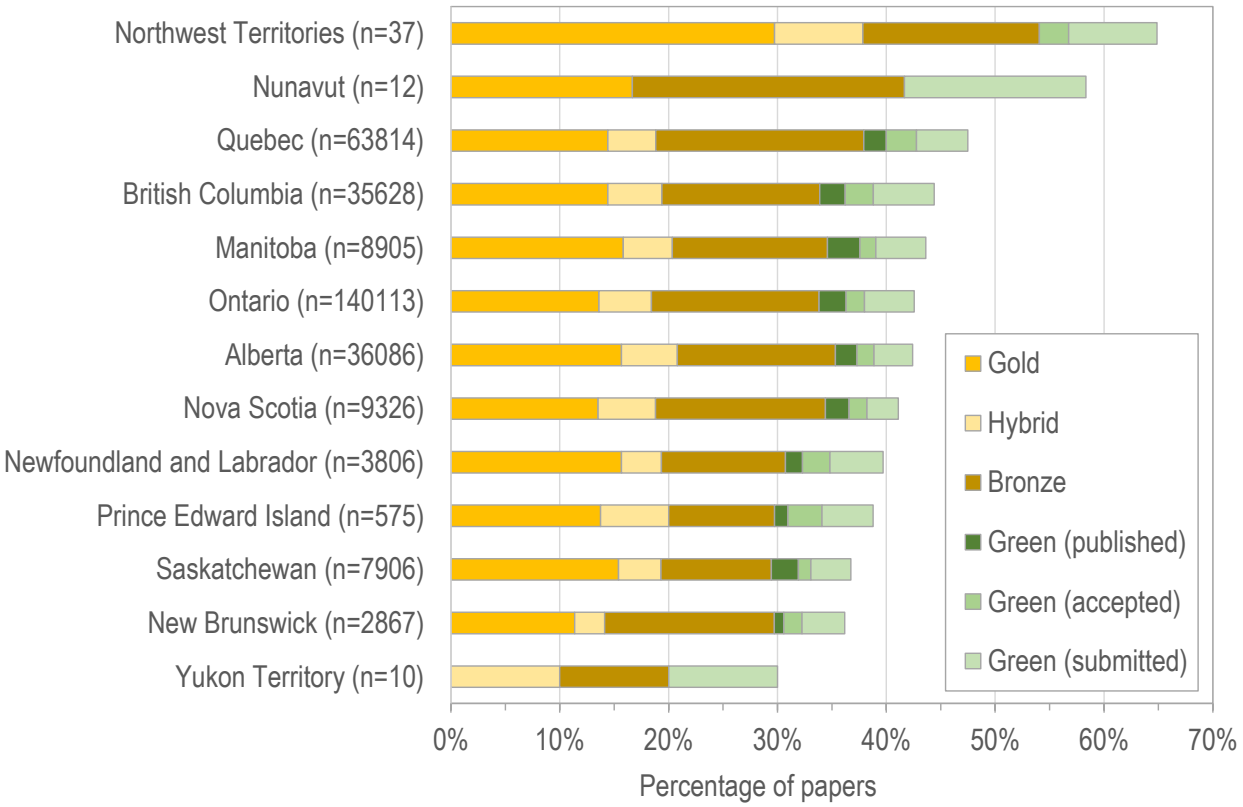

Figure 1: Proportion of articles available in OA (by province, 2015-2019). The total number of articles, including non-OA, is shown for each province/territory in parentheses.

At the level of the institution, the proportion of articles available in OA ranges from just over 54% for UQAM to 27% for Ryerson University (Figure 2). Overall, Quebec universities have a higher-than-average percentage of OA articles, with Université de Montréal (n=10,040; 53% OA), Université Laval (n=8,634; 51% OA), Université de Sherbrooke (n=3,957; 50% OA) and McGill University (n=16,483; 47% OA) being respectively second, fourth, fifth and sixth for their OA availability among the top publishing universities in Canada. This is mainly due to their higher percentage of Bronze OA. Institutions more active in the natural sciences and engineering, including University of Waterloo, Concordia University, Polytechnique Montréal and Ryerson University, have a much lower overall proportions of OA. Polytechnique Montréal and University of Waterloo, however, have relatively high proportions of Green OA, irrespective of its type. These results appear consistent with disciplinary differences in the adoption of OA, but they also suggest an additional influence reflected by Quebec institutions consistently ranking higher than the universities in the rest of Canada.

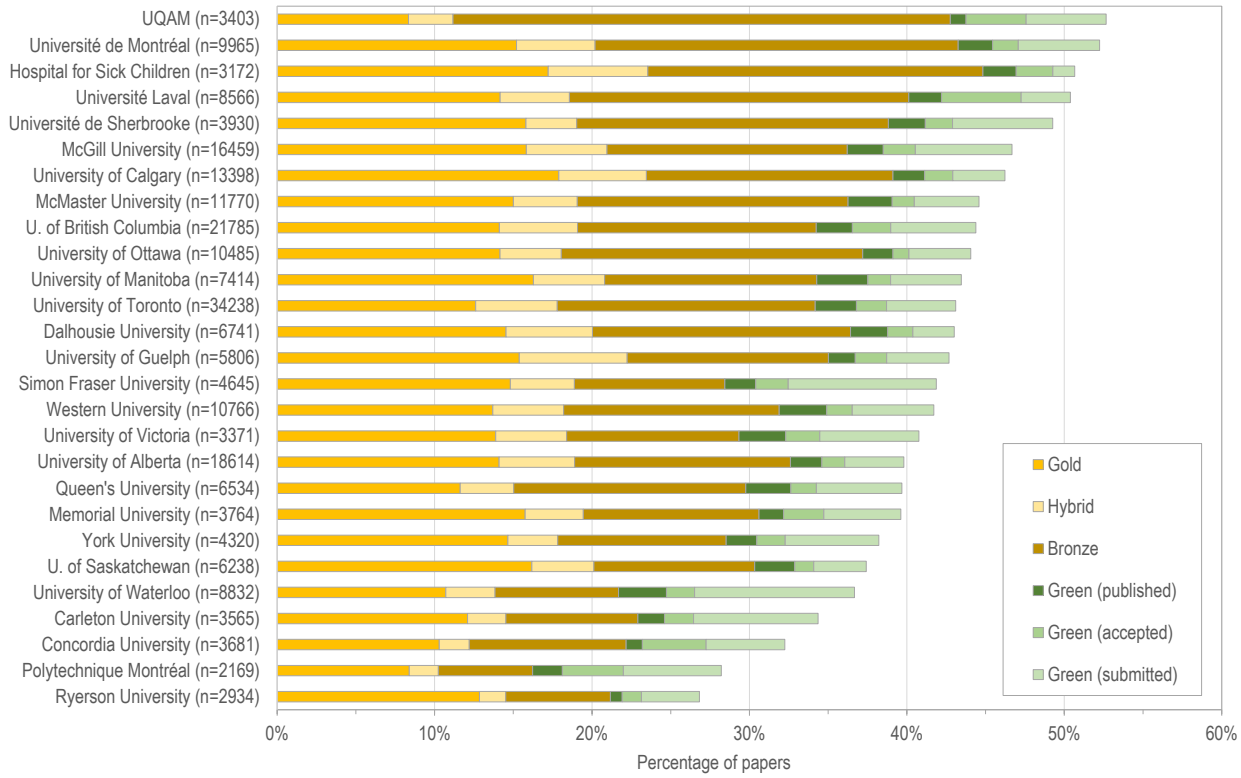

Figure 2: Proportion of papers available in OA (2015-2019), for universities having authored at least 2000 articles.

Disciplinary variations

The adoption of OA is highly variable according to the funder (Figure 3), yet comparing proportions across the various levels of government, we observe that variations are also associated with the discipline, with the health field clearly leading the way in OA publishing. While more than half of the articles funded by the health granting agencies (Public Health Canada, Genome Canada, Michael Smith Foundation, CIHR and FRQ-S) are available in OA, a majority of those in the natural sciences and engineering, and the social sciences and the humanities remain closed. At the federal level, 61% of CIHR-funded papers published between 2015 and 2019 are OA, while only 39% of NSERC-funded papers and 27% of SSHRC-funded papers are OA. The Quebec funders show a similar pattern, with 55% of articles funded by FRQ-S being OA, 40% OA for articles associated with funding from FRQ-Nature et technologies (FRQ-NT) and 31% OA for those funded by FRQ-S.

In the context of the COVID-19 pandemic, we made sure to include the Public Health Agency of Canada in our analysis, even though we can observe that the Agency is not a major funder, having funded 901 papers. Still, we can see that the Agency takes seriously its role to disseminate science and make it widely accessible, with 69% of their published articles being available in OA. It is rather surprising that Genome Canada is showing a higher rate of OA (66%) than two public organizations with OA policies that include incentives to comply (CIHR, at 61% and FRQ-S, at 55%). Although these proportions are relatively similar, in the long run it makes an important difference

in the number of articles being effectively (un)available in OA, since CIHR has supported 34,780 articles over a five-year period, compared to 1,604 articles for Genome Canada.

OA appeared to be rising overall, with an increase from 43% in 2005 to 63% for CIHR (2017), from 24% to 41% for NSERC (2017) and from 14% to 30% for SSHRC (2016) (Figure 4). Temporal trends for Quebec funders were not evaluated, because of the short timespan since the establishment of the mandates.

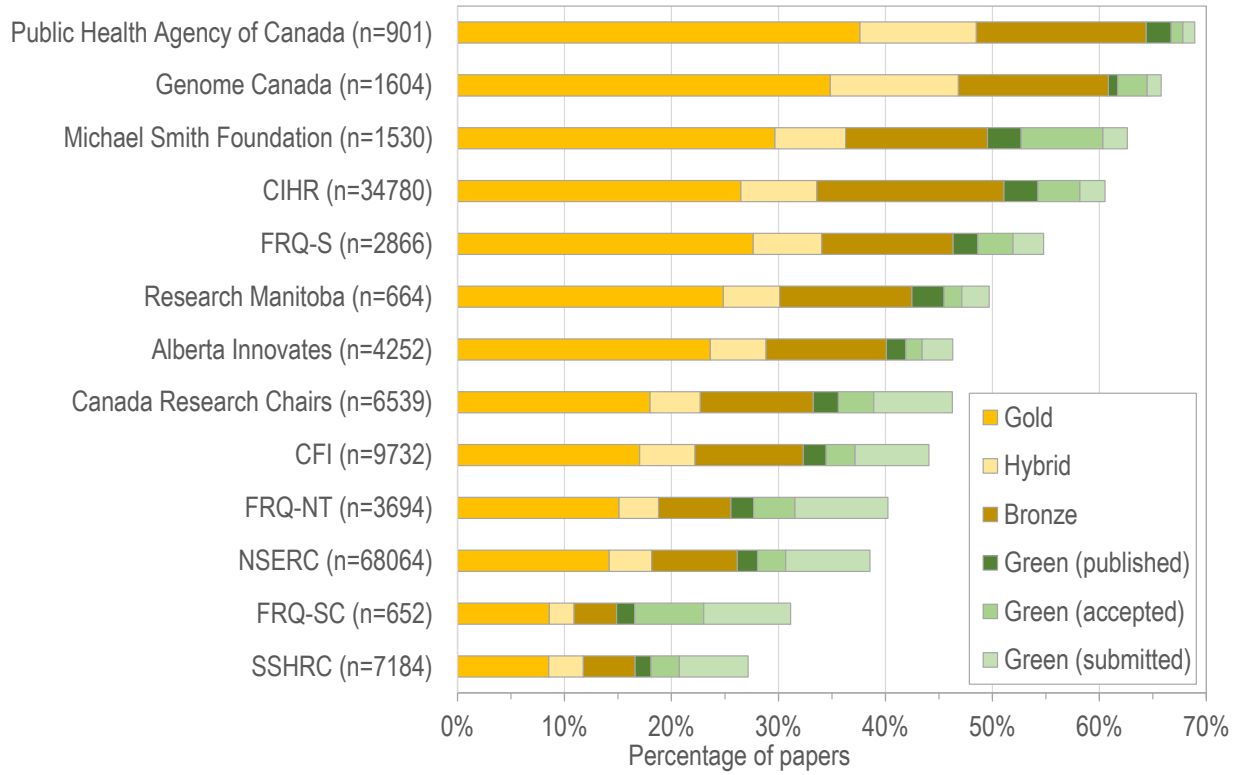

Figure 3: Proportion of papers available in OA (by major Canadian funders, 2015-2019).

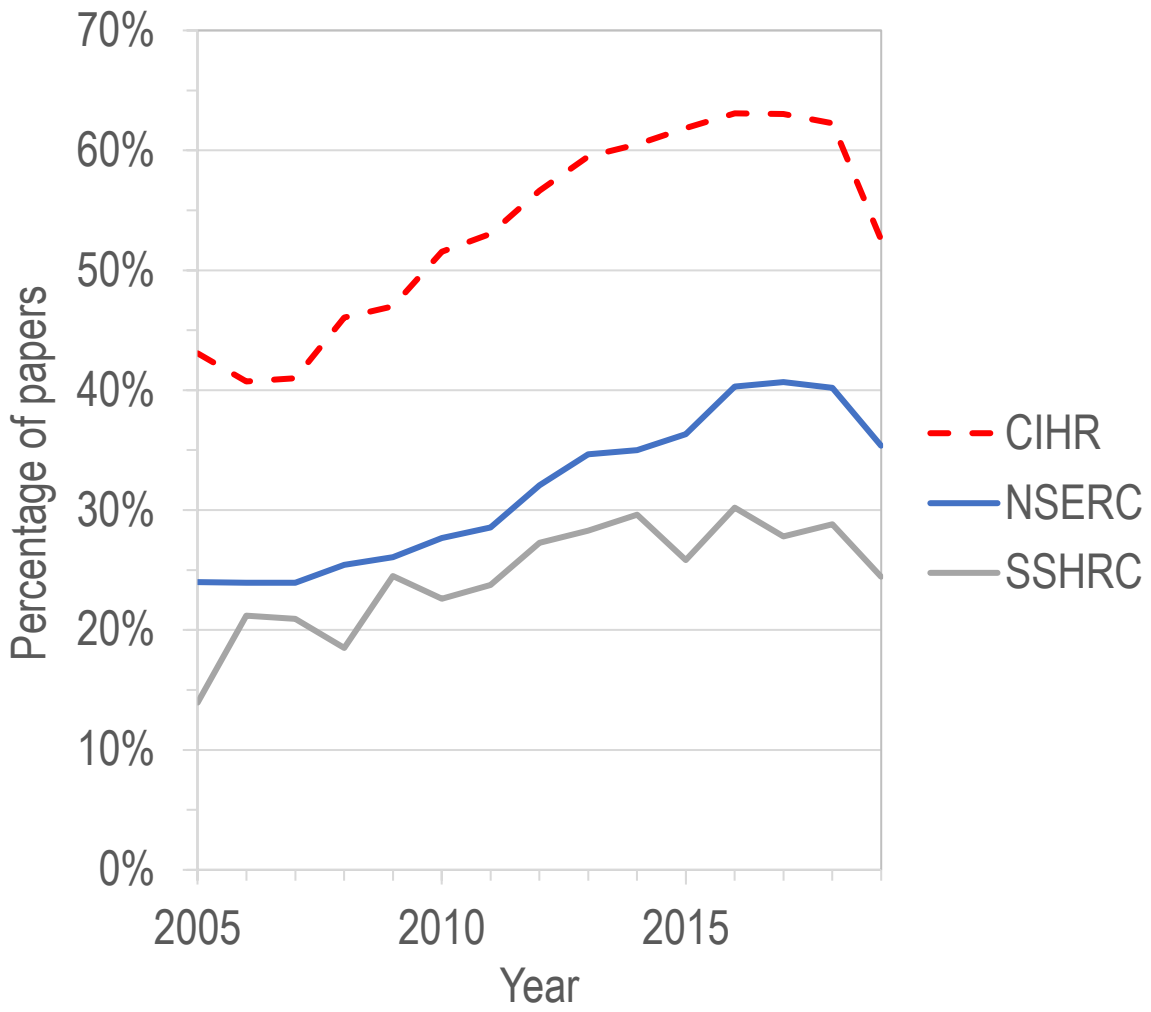

Figure 4: Proportion of papers available in OA for the three federal granting agencies.

In health sciences, OA availability is higher for articles originating from federal or provincial (Quebec) funding than for those without, which is not surprising given the associated OA mandates (Figure 5). However, this effect was not found for natural sciences and engineering and social sciences and humanities, where funded research was *less* frequently found to be OA than non-funded research. This suggests a highly limited effect of mandates, specifically those of NSERC, FRQ-NT and SSHRC. As the indexation of disciplines was incomplete for the articles from Érudit, a vast majority of which are associated with the social sciences and humanities, the results for non-funded research articles on this platform are shown in a separate graph (Figure 5).

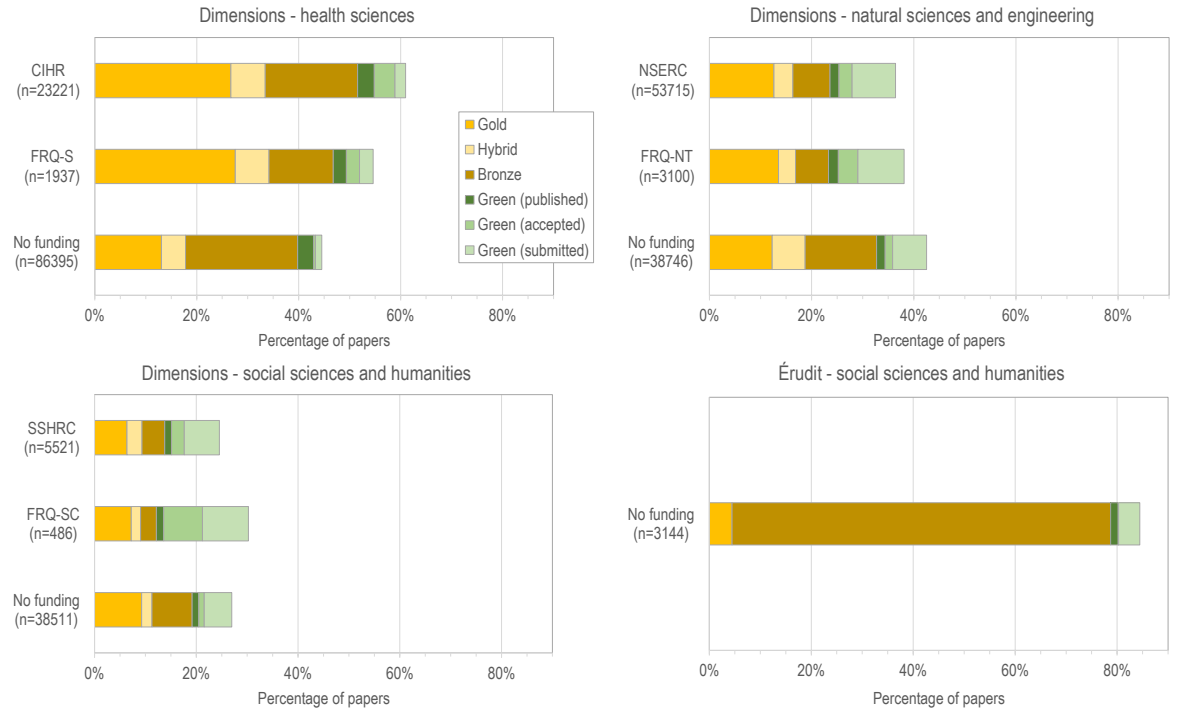

Figure 5: Proportion of papers available in OA for the federal granting agencies and those not linked with funding. Disciplines were obtained from Dimensions. Health Sciences includes papers indexed as Medical and Health Sciences; Natural Sciences and Engineering includes papers indexed as either Biological Sciences, Chemical Sciences, Earth Sciences, Engineering, Environmental Sciences, Mathematical Sciences, Physical Sciences and Technology; Social Sciences and Humanities includes papers indexed as Built Environment and Design, Commerce, Management, Tourism and Services, Economics, Education, History and Archaeology, Information and Computing Sciences, Language, Communication and Culture, Law and Legal Studies, Psychology and Cognitive Sciences, Studies in Creative Arts and Writing and Studies in Human Society. Disciplines were incomplete for papers from Érudit, shown separately. Only a marginal number of papers from Érudit had funding associated.

The adoption of various subtypes of OA varies with discipline and funding (Figure 5). Irrespective of disciplines, Green OA is more frequent for funded articles than for articles lacking financial support, suggesting this route is often chosen even when funding may be available for covering APCs for Gold or Hybrid OA. Nevertheless, there is a high variation in the repartition of Green OA, and we can observe that it is generally a more popular choice within the fields that publish less frequently in OA, whether research is funded or not, such as the social sciences and humanities. Linking funding and the use of different types of OA may be complicated by a possibility that not all funders allow the use of funding for covering APCs for Gold and Hybrid OA; in other cases, the amount of funding may simply be insufficient to cover APCs.

Finally, disciplinary variations are also reflected in the OA proportions of Quebec's universities. For example, among the ten universities that publish the most articles associated with funding, the four universities with medical schools, McGill University, Université Laval, Université de Montréal and Université de Sherbrooke, show a much higher adoption of OA than the universities characterized by the social sciences and

humanities (Concordia University and UQAM) or engineering (Polytechnique Montréal and ÉTS) (Figure 6).

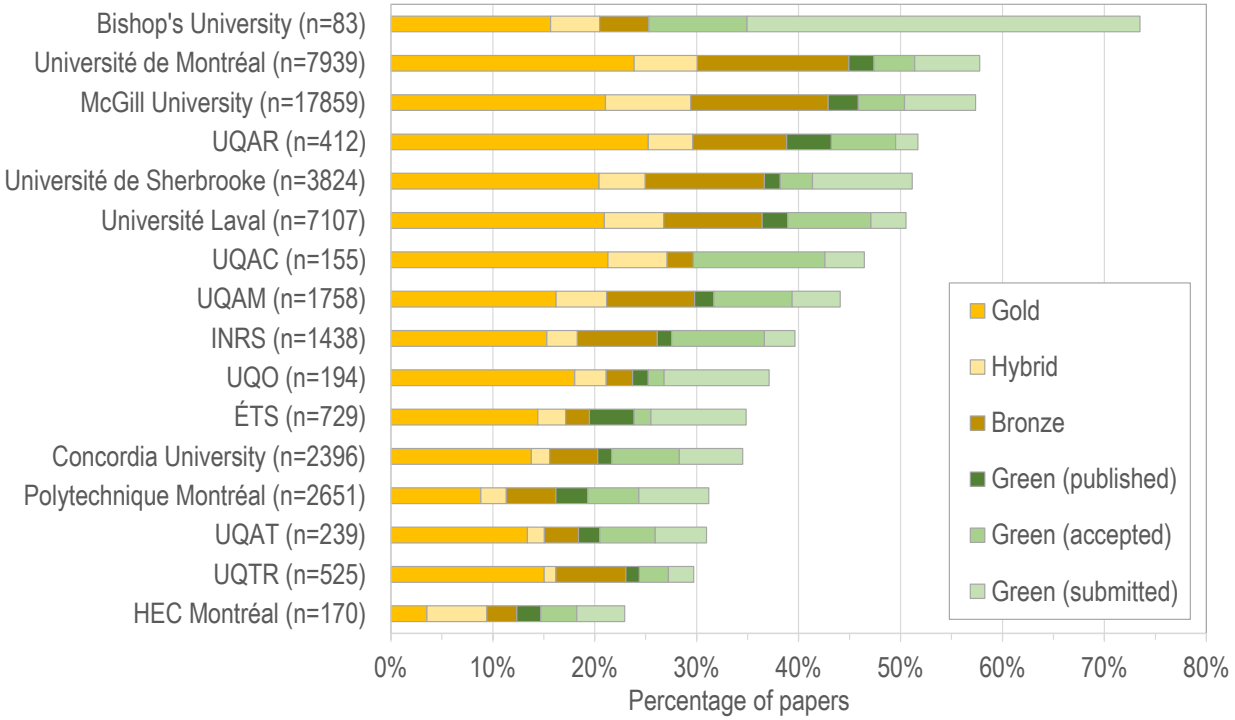

Figure 6: Proportion of funded papers available in OA (All Quebec universities; 2015-2019). The total number of funded articles, including non-OA, is shown for each university in parentheses.

Language and cultural variations

For the entire period between 1995 and 2019, articles in French are more likely to be OA than those in English (Figure 7). Likewise, the type of OA differs significantly according to language: almost all the French-language articles available in OA are of the Bronze type, whereas those published in English take several forms—in order of importance, Bronze, Gold, Green and Hybrid. This diversity of formats also reflects the fact that articles in English cover a broader disciplinary spectrum, while those published in French are primarily in the social sciences and humanities.

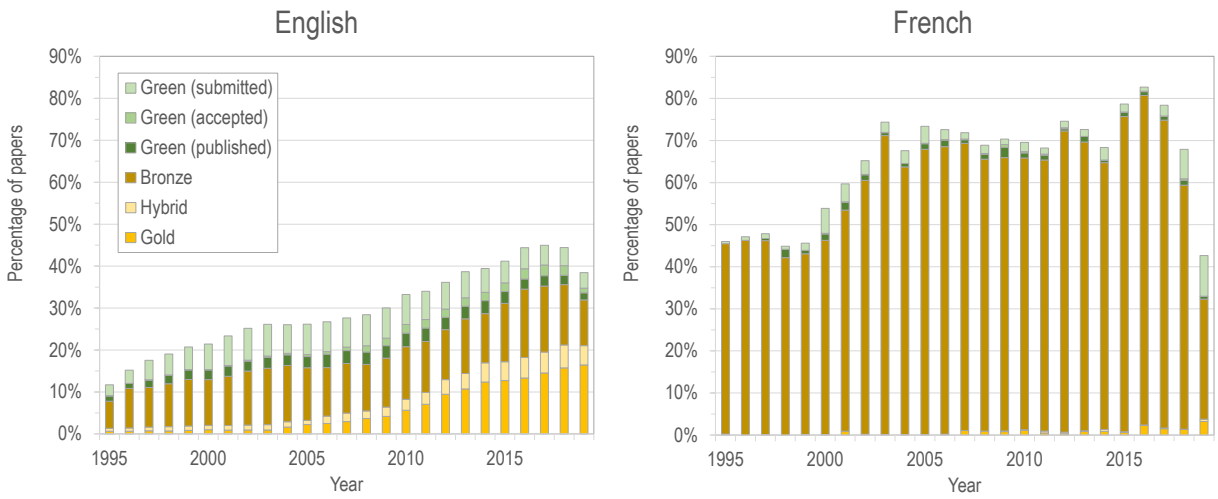

Figure 7: Proportion of articles available in OA by Canadian researchers between 1995 and 2019, by language.

The role of Érudit in OA publishing

Quebec's generally good posture is associated with the high proportion of articles that are published on the Érudit platform, where almost all articles are available in OA. Érudit disseminates almost 9% of Quebec articles, whereas only just over 1% of articles authored by Canadians outside of Quebec are disseminated by Érudit. There is no clear evidence of a geographical or cultural influence, as Quebec authors do not publish in OA more often than their colleagues from the rest of Canada when articles disseminated by Érudit are excluded (Figure 8). Likewise, excluding articles disseminated by Érudit, articles in English are more frequently available in OA than those in French, suggesting that countrywide, French language is not synonym for OA publishing.

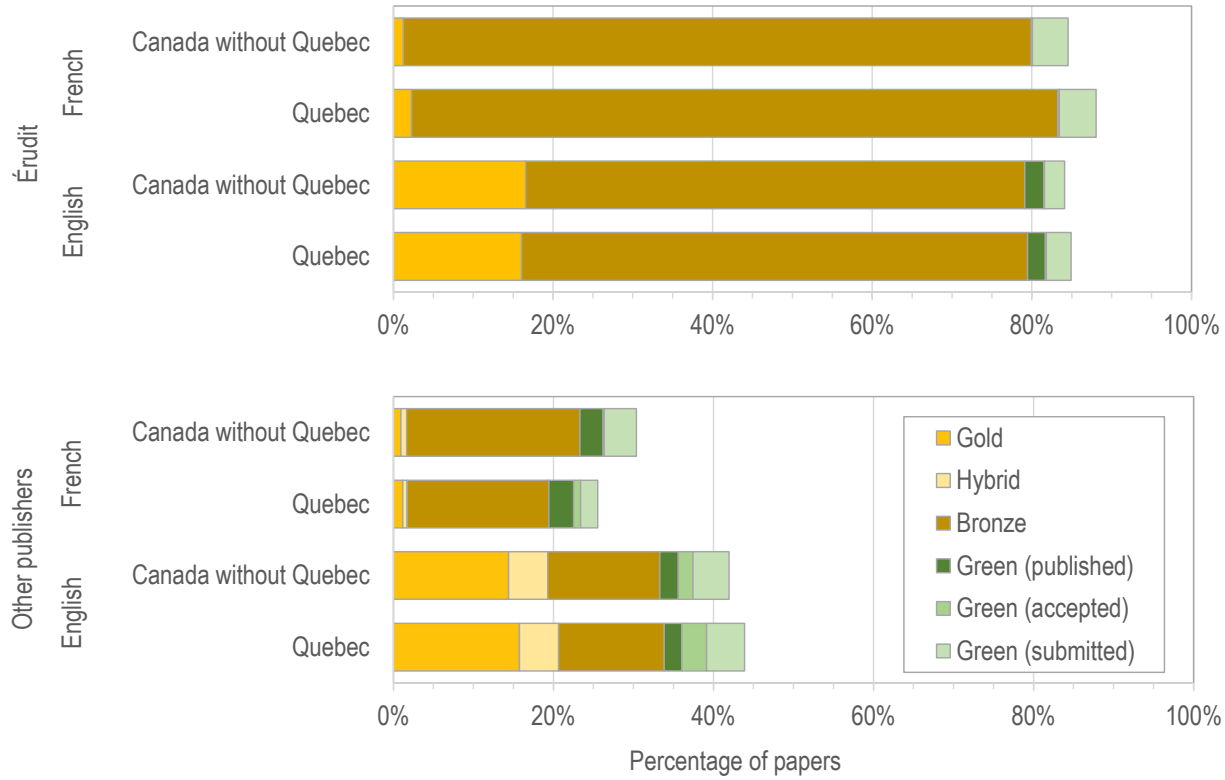

Figure 8: Proportion of papers available in OA (2015-2019), separated according to publisher, language, and origin.

Discussion

OA availability and funding policies in Canada

The portrait of OA in Canada is associated with a multitude of variables. We observe that generally, for each province, 40% to 50% of the published articles are available in OA, with an average of 44% at the national level. We also note that Quebec is in an advantageous position, having the highest proportions of all provinces. It should be noted, however, that it is an advantageous position within poor results, with a relatively modest 47% of articles published between 2015 and 2019 available in OA. Looking at articles associated with funding, the Canadian percentages are very scant, considering that all policies from the major public funders, and most of the private ones, encourage researchers to disseminate their papers in OA. Our results are very similar to those already observed by Larivière and Sugimoto in 2018, even with more comprehensive data from Dimensions and Érudit, and confirm that without any real consequence on their funding, researchers lose track of their obligation to comply with OA (Larivière and Sugimoto 2018).

Roles of funding and disciplines

The compliance with funders' OA mandates varies by disciplines. Excluding journals disseminated by Érudit, we observe that the health field has been the strongest adopter of OA publishing. This result corroborates the conclusions of Larivière and

Sugimoto in their 2018 large-scale analysis on compliance with OA mandates: "Although researchers cite norms and needs within disciplines as a reason not to comply with OA mandates, we believe that the funding agency is a stronger driver of OA than is the culture of any particular discipline" (Larivière and Sugimoto 2018). While this finding was particularly true for the United States—where the NIH mandate has strong negative consequences for researchers who do not comply—it does not resonate as much in Canada, where lack of compliance with mandates has little consequence. Despite that, our results show that articles in the health field are generally more frequently available in OA, yet funder and field culture effects—as well as effects of international collaboration with the United States—remain difficult to disentangle, as both CIHR and FRQ-S have had more aggressive and earlier OA publishing policies than their federal and provincial counterparts in the natural sciences, engineering, and the humanities and social sciences. The influence of field culture on the adoption of OA publishing practices has been addressed in previous studies, mainly through inquiries on researchers' perceptions of OA publishing. However, these were generally performed within a specific discipline, community, or timespan, which complicates broader comparisons. Regardless, we ought to acknowledge the fact that health researchers appear to have been relatively well aware of the importance of rapid diffusion of research results particularly within the context of the COVID-19 pandemic (Callaway 2020).

Our findings for the publications associated with the natural sciences and engineering, and social sciences and humanities, where, somewhat surprisingly, funded research is less frequently available in OA than non-funded research, may be explained by a funding bias. It may be possible that in these disciplines, funding is more frequently obtained by researchers having international collaborations or a certain prestige and a strong a priori preference to publish in high-impact, non-OA journals, and the presence of funding may not incite them to publish in OA journals. Nonetheless, our results suggest a highly limited effect of NSERC, FRQ-NT and SSHRC mandates on OA availability.

A major part of the literature of the social sciences and humanities is not supported by funding. Considering the field culture of these disciplines, generally weakly inclined to publish in OA (Larivière and Sugimoto 2018), Érudit's contribution in making the literature of these disciplines widely available in OA is not to be underestimated. These results reaffirm the importance of the Érudit platform for OA publishing in Canada.

Increasing OA publishing while choosing the right route

Our results raise the question of how policies could be adapted to encourage researchers to publish their results in OA. Should funding agencies reduce the compliance time? Could they consider publishing in OA as an essential condition when applying for funding? Should funders focus more on supporting national non-profit journals and platforms, enhancing their compliance to policies? Or should Canadian universities create or enhance incentives for making content Green OA, promoting the use of institutional repositories? Indeed, the FRQ seem to have chosen to focus on

university involvement when it reworked and harmonized its policy: putting the responsibility for monitoring on university administrations, acting as managers of research funds. Meanwhile, the FRQ have recently joined cOAlition S, which implies that all funded research should be immediately published in OA starting March 2023, in compliance with the Plan S policy. The effect of the 2019 reform of their initial policy cannot be observed yet in our data, but it will be interesting to see in the coming years whether the new policies will continue to widen the gap between Quebec and the rest of Canada.

As mentioned earlier, not all types of OA are equivalent, and important differences in the types of OA are present according to language and funder, the latter likely driven by differences in disciplinary cultures. Nationally, Gold and Bronze OA are the most common types and Hybrid OA accounts for the smaller part of OA articles. Gold OA is relatively common for funded articles in health sciences. Bronze was an emerging category of OA in 2018 (Piwowar et al. 2018) and our data suggests that research from Canada is available in Bronze OA more frequently, yet proportions of 'temporal', 'retroactive' or 'original' Bronze OA and trends in these cannot be quantified using our data. Green OA is more strongly present among the social sciences and the humanities and, to a lesser extent, natural sciences, and engineering.

Although Bronze OA accounts for a relatively high proportion of the OA articles in Canada, it is not compliant with the developing mandates and especially not with the more demanding Plan S. This noncompliance is primarily associated with the absence of a licence and the interdiction of reuse beyond reading. In order to ensure a viable Canadian publishing landscape, funders may need to enhance awareness among national journals on evolving mandate compatibility in general and the use of appropriate publishing licences in particular. Studies on the evolution of the different types of OA in Canada should therefore focus on both the quantity and the quality of OA publishing.

Conclusion

Canadian research published between 2015 and 2019 remains mostly inaccessible, with 44% of articles available in OA. Practices are heterogeneous and the presence of various disciplines, funders, and the role of Érudit has contributed to the rather intricate Canadian OA landscape that exists today. OA availability is generally high within the health sciences, where research is more frequently funded, highly internationalized and OA mandates have been established for a longer period. In the natural sciences, engineering and the social sciences and humanities, OA proportions are lower, mandates appeared later, and these have not significantly proven their effect, or at least not yet.

The data provided by Dimensions, which claims to have a rather comprehensive reading of national research by language, combined with internal data from Érudit, allowed us to emphasize the potential role of publishing platforms in OA publication, even at the national level. Indeed, Érudit seems to play an important role, as the vast majority of articles on this platform are OA, regardless of the language. Érudit has

allowed Quebec to position itself slightly ahead of the other Canadian provinces for all categories of OA publications and several of its academic institutions are placed ahead of their Canadian peers.

Since harmonized mandates for the federal and provincial granting agencies are very recent, it is to be hoped that their effects are simply taking time to show up. However, considering that CIHR and FRQ-S have both had OA mandates for well over a decade now, it appears more strict mandates and possibly repercussions in case of nonconformity may be necessary to ensure that researchers comply with policies. In short, the low rates of compliance with mandates show the long road ahead in convincing researchers to adopt OA publishing in their knowledge dissemination practices. Since the COVID-19 pandemic has shown us that, with the will to do so, teams of researchers are indeed able to make their work available in OA quickly, we can only hope that one of the beneficial effects of the crisis will be to raise awareness among them and their funding agencies on the importance of disseminating their research results in OA.

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