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Advancing the evaluation of graduate education: towards a multidimensional model in Brazil

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The impact of graduate education on academic publishing

“ *Our graduate education system is a source of national pride, a model that has been recognised throughout the world.*

— Helena Nader

During his first year in office, Brazilian president Jair Bolsonaro (2019–2022) wrongly stated that few of the country’s universities conducted research and that most of those engaged in science were private institutions. The nation’s academic community responded immediately. For instance, the Brazilian Academy of Sciences (ABC) stated that it was of utmost importance to provide the president with correct information about the country’s science system, highlighting findings from [Clarivate Analytics \(2019\)](#) that showed that more than 95% of Brazilian scientific production comes from public universities ([Moura, 2019](#)).

In the debate that followed, various actors in the Brazilian science system contributed with relevant information to better inform politicians and avoid misguided policy design, reporting that: (i) the country had more than 400 higher education institutions (HEI) engaged in research; (ii) the 30 universities that published the most in Brazil were public; (iii) predominantly public graduate education played a significant role in the country’s research, with 93.167 new

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researchers graduating in that year: 24.290 PhD and 77.795 masters (Brasil, 2020; CAPES, 2021e; CGEE, 2019; Moura, 2019; SBPC and ABC, 2020b).

Much of the information publicised at that time was grounded in evidence, and the numbers helped support the correct narrative on the reality of the science of the country. However, recurring statements on the substantial contribution of graduate education to scientific production were largely accepted, but rarely supported. For example, in a seminar organised by ABC and the Brazilian Society for the Advancement of Science (SBPC), it was reported that approximately 95% of Science & Technology research in the country is carried out within its graduate programs (PPG), which are composed of master's and doctoral courses (SBPC and ABC, 2020b).

Extensive research on the literature and official data provided by the Brazilian Agency for Support and Evaluation of Graduate Education (CAPES) revealed that there are no concrete data to support these claims. Therefore, departing from the hypothesis that such empirically accepted claims properly reflect the reality of the Brazilian system, this study was carried out to verify, through a bibliometric analysis, the extent of the role of graduate education in the Brazilian science system. A comparative exploration of international practises was also carried out to verify how different the Brazilian graduate experience is from that of other countries.

5.1 Additional Background

As reported by Herculano-Houzel (2013), the “scientist” profession does not exist legally in Brazil. Legislation to regulate the profession was proposed in 2015 in the national parliament, arguing that the country's science would not reach its potential impact since it relied on professors who teach as a main activity and research in spare time, or by masters, PhD and postdoctoral students who are not paid or who are awarded a scholarship with a value that is incompatible with their level of education or the expected work regime (Tenório, 2015).

Despite the parliament initiative, science was not regulated as a profession in Brazil. Not only did the proposed law not receive enough public support to advance in the legislative process, but it also faced what appeared to be unexpected opposition. In a public hearing at the parliament, representatives

from HEI and scientific societies, such as SBPC and ABC, expressed concerns that regulating the profession could lead to serious negative consequences. The main fear is that strict labour regulations could lead to bureaucratization of the activity, affecting the training of highly qualified human resources. On the occasion, the SBPC's president also highlighted the graduate model as a source of national pride, being one of the most prominent determinants of growing scientific production in the country. Once again, the role of graduate education was central to the discussion (Monteiro, 2015; Tenório, 2015).

The mid-20th century design of the Brazilian National System of Research and Graduate Education (SNPG) has been comprehensively described by Brasil (2020), who reported how the country's science system was the object of public policy linking research and education in nearly inseparable ways. One of the direct consequences of this fact has been reflected in the work of Balbachevsky and Schwartzman (2010). Inspired by Burton R. Clark (1993) "The research foundations of graduate education", the authors discussed the Brazilian case with an alternative title: "The graduate foundations of research in Brazil". The name change was intentional, as it reveals how the Brazilian account differs from most, if not all, other experiences worldwide.

However, is the historical design of the SNPG and its empirical perception by academics reflected in the scholarly publication practises in the country? This research in progress aims to find bibliometric answers to that question.

5.2 Methods and Data

The first approach adopted to verify the contribution that graduate education in Brazil makes to the overall scientific output of the country was to match publications from the Web of Science with the reported output from Brazilian graduate programs. For this, the CWTS internal version of the WoS Core Collection (Clarivate Analytics, 2022) was used, as the Centre for Science and Technology Studies makes significant investments to enrich the data set with improved affiliation data, which makes a more robust country identification of authorships possible.

For the Brazilian data set, the country conducts a high-stakes national evaluation through a government agency, CAPES. The agency implemented a data

collection system to support its evaluation process, and the resulting data set is robust and reliable due to the impact evaluation has on funding and the renewal of accreditation of PPG; it is in their interest to provide accurate and comprehensive information (Brasil, 2020). At the time of this research, the most recent microdata available from CAPES included publications up to 2018, so that year was selected for the matching process.

With the WoS and CAPES datasets available, all publications from 2018 with at least one author of Brazilian affiliation were extracted from the first and matched to the second. The process was based on an algorithm described in detail in a previous study, considering DOI, author names, titles, ISSN of the journal, volumes, issues, and page numbers (Brasil, 2021b). The matched publications were then analysed according to a broad area classification adopted by CAPES and detailed by Brasil (2022).

Although the first approach identified the percentage of WoS-indexed papers reported as graduate program output in Brazil, a second approach investigated the rate publications from different countries in relation to their PhD graduates per year. The CWTS in-house version of WoS was used once again, and data on PhD graduates per country were collected from Eurostat (2022) and OECD (2021), complemented with information from CAPES (2021e), the Ministry of Education: People's Republic of China (2022), and the US Census Bureau (2020). Due to the range of data available on PhD graduates per country, this analysis was conducted for the period 2013-2020. A limitation of this approach is that master's courses contribute significantly to the development of the Brazilian science system (Brasil, 2020), but the number of graduates at this level was not considered in the analysis, as there is a lot of heterogeneity in the modality between countries, especially since the changes in Europe sparked by the Bologna Declaration (European Ministers of Education, 1999).

5.3 Results and Discussion

The Web of Science indexes 53.604 articles and reviews published in 2018 by authors with Brazilian affiliation. When these individual publications are matched to the country's database of graduate programs' scholarly output, 40.634 records coincide. That means that more than 75% of the Brazilian

publications indexed by WoS in that year are reported by PPG as results of their research. That is a significant share of the indexed output, which is potentially even higher, as CAPES records sometimes lack detailed information on publications (e.g., DOI, ISSN, journal issue).

Considering that [Brasil \(2021b\)](#) showed that coverage of Brazilian academic publishing in the Web of Science is unbalanced between different research areas, an additional analysis of the publications was performed comparing WoS papers according to the major classification of the Organisation for Economic Cooperation and Development (OECD) with the broad area classification system adopted by CAPES for the country's graduate programs.

[Figure 5.1](#) displays the results of this analysis, using fractional counting on both sides of the visualisation. For the OECD classification, this means that the weight recorded in WoS was considered in the distribution seen on the left of the figure. For the right side, authorships from different PPG were also considered (e.g., a publication coauthored by an author from a multidisciplinary program with another from an engineering one has been counted as 0,5 for each broad group).

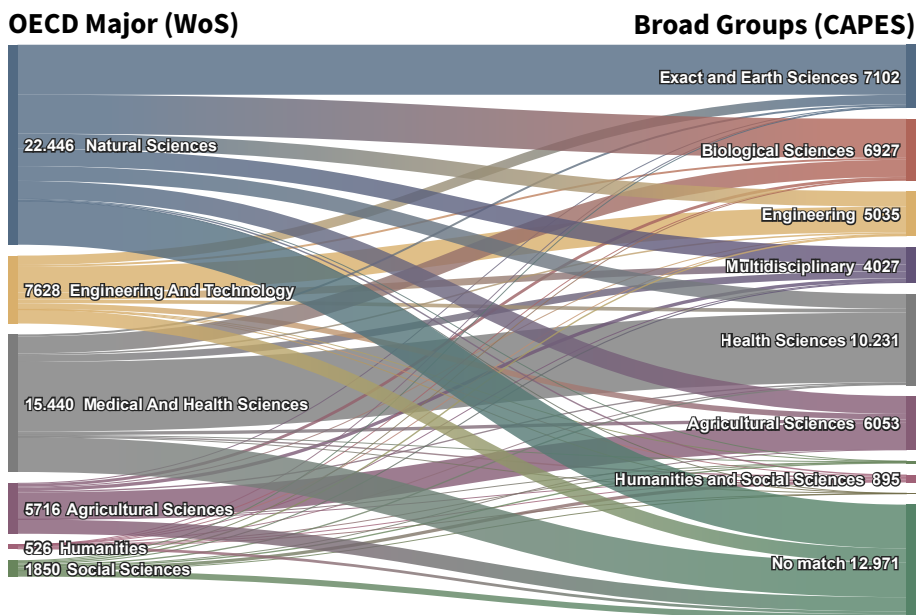


Figure 5.1.: Articles of Brazilian authors in WoS matched to PPG in the country, organized by CAPES broad group classification (2018).

The [Figure 5.1](#) distribution of publications according to OECD's major classification aligns with the findings of [Brasil \(2021b\)](#), showing that the coverage of Brazilian output in WoS is high in the natural and life sciences, but below average in the social sciences and humanities (SSH). The results also reinforce the findings in [Brasil \(2023b\)](#), which shows that the classification system adopted in the country needs to be reviewed, as many graduate programs appear to conduct research in areas not aligned with the local classification.

Taking into account the 12.971 publications without a match in [Figure 5.1](#), a disproportionate distribution according to the OECD classification could indicate that scientific publishing occurs outside of academia. For instance, if numerous papers come from engineering and technology, that could include publications from industry authors. However, the distribution seems proportional in all areas, so two further steps are planned for future analysis: an improvement of the matching algorithms, and a sample analysis of the unmatched ones to identify additional authorship sources (e.g., from within universities but originating from outside graduate programs).

Complementing the perspective of the matching analysis, [Figure 5.2](#) shows the average publication rate per country in relation to the number of PhDs they graduate each year, from 2013 to 2020. The interactive visualisation available at <https://tabsoft.co/3i6XJES> can be filtered to display the results per year, so any fluctuations can be observed.

[Figure 5.2](#) reveals that most countries have a rate of 0,1 to 0,2 graduating PhDs per publication. For instance, the USA had a per-year average of around 430k papers indexed by WoS, and of 55k graduated PhDs. The respective numbers for China are 360.000 and 58.000; for the UK they are 130.000 and 27.000; and for the Netherlands they are 43.000 and 4600. These and most countries included publish four to ten articles per PhD graduating each year.

However, the situation in Brazil is substantially different. As can be seen, the rate for the country is above 0,4, with an average number of 49.000 indexed papers and around 20.000 new PhDs graduating every year. [Figure 5.2](#) also shows that Mexico and Russia have an even higher rate of graduates per publication, reaching nearly 0,8 in the Russian case (38.000 publications for 28.000 graduates). The graduate systems of both countries are already being studied to understand their dynamics, and the results will be reported in the final version of this study.

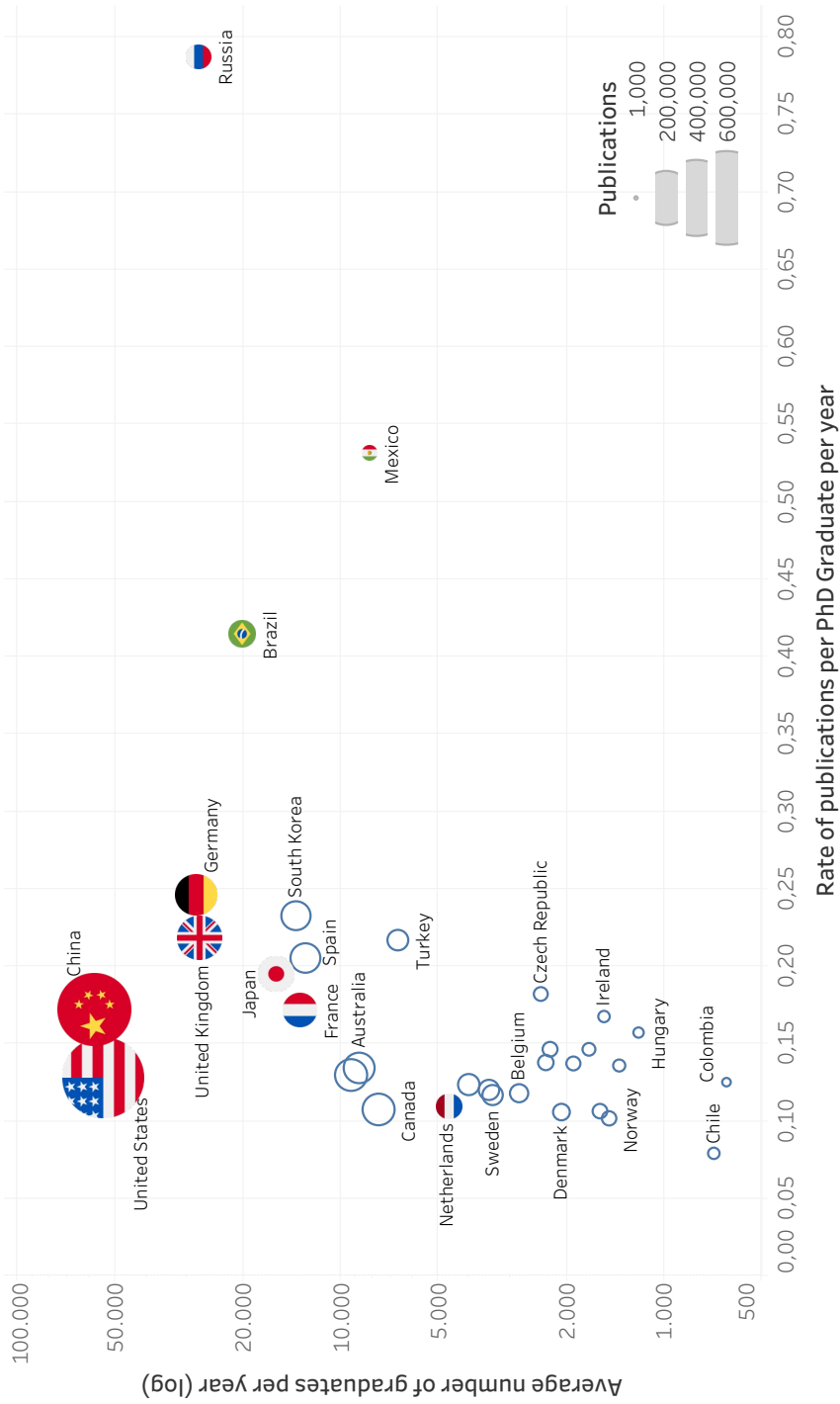


Figure 5.2.: Average number of PhD graduates per year in relation to the yearly rate of publications per PhD graduate (2013-2020).

In the case of Brazil, the analysis may suggest that graduate education has indeed a larger role in the national science system than what can be seen in most countries, supporting the empirical perception of Brazilian academics. However, the indication is still far from being considered a solid conclusion. Low levels of English literacy may make publishing in WoS harder for Brazilians, explaining partially the results. However, that same effect would probably be visible for some of the other Global South countries listed, which does not seem to be the case. The same reasoning could be used in regard to other challenges to publish in the WoS core collection, or regarding practices to publish in journals indexed by local databases such as SciELO.

5.4 Conclusion and next steps

This research in progress aims to produce evidence around a recurring argument of Brazilian academics who state that the country's graduate education can be considered the main or even the single pillar of the country's science system. A first analysis of legislation, policy documents, and related literature shows that the Brazilian research system was designed around a broader graduate education. That perception seems to be contrary to how graduate systems have been implemented around the world, where they are often one dimension of a broader research system. As an ongoing part of this study, a comprehensive literature analysis is being performed for a comparative perspective, including additional records from the Brazilian case, but also covering other countries such as China, Germany, Japan, Mexico, The Netherlands, South Africa, UK, USA (Bawa, 2008; Becher, 1993; Ben-David and Zloczower, 2009; Deem and Dowle, 2020; Gaughan and Robin, 2004; Gellert, 1993; Kobzar and Roshchin, 2020; Kyvik and Tvede, 2010; Lim et al., 2020; Nerad, 2008; Schwartzman et al., 2015; Westerheijden et al., 2008).

Regarding the bibliometric analyses, a first exploration has revealed that at least 75% of all WoS-indexed output from authors of Brazilian affiliation are reported as PPG research output. It was noticed that there appears to be no sign of research areas that register numerous contributions from authors outside of academia. The initial analysis was performed with 2018 data, but as algorithms are refined and more recent data become available, it will be possible to expand the full study data set over a four-year period (2017-2020).

Using data from the Web of Science and multiple international sources on PhD graduates per country, it was also possible to identify that Brazil has a high rate of graduates per publication, which may reinforce the idea that graduate education plays a central role, above world average, in Brazilian science. Preliminary results may indicate there is truth behind the claims, but further investigation is necessary, including the analysis of additional databases with broader coverage of Brazilian output (e.g., Scopus or Dimensions), addition of more Global South countries that may face similar challenges to publish in international journals, and also including master's students in the comparisons, as they are also a driving force in Brazilian graduate education.

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