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Author Index

A

Expanding GeoCapes usefulness for research

The majority of the science and technology research conducted in Brazil takes place within a national system of research and graduate education (SNPG) (SBPC and ABC, 2020b). This system has been designed as the object of public policy from the 1950s, through a series of actions such as the launch of a national campaign to prepare highly qualified personnel (BRASIL, 1951) and then through the Sucupira Report, a document that shaped the SNPG into a model close to the one that exists today (CFE, 1965). Since its conception, an evaluation system has been an integral part of the SNPG, with a periodic evaluation of graduate programs in continuous operation since the 1970s (Brasil, 2020).

The original campaign in charge of training higher education personnel became the Brazilian Agency for Support and Evaluation of Graduate Education (CAPES), today a public foundation that has been in charge of evaluating the SNPG for nearly five decades (Brasil, 2020). To perform the central assessment of graduate education, CAPES has consistently implemented strategies to collect data from graduate programs (PPG) and higher education institutions (HEI). The first time the agency conducted its collection was in 1975, and data from the first few years served as evidence for the first evaluation of graduate programs in the country, which took place in 1978 (Siqueira, 2019).

The initially paper-based data collection was replaced in 1987, when CAPES launched its first information system for that purpose: DataCapes. According

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to R. J. Ribeiro (2008), from the collection of annual information on the performance of all graduate programs in Brazil, DataCapes held one of the most detailed databanks of higher education in the world, with available information that caters to the evaluation needs of all fields of knowledge.

Over the next few years, CAPES' information systems followed the technological evolution, leading to three iterations of a new system designed to gather data from graduate programs. The new "Coleta CAPES" was operational from 1996 to 2013, moving from an initial offline system to an online one, eventually connecting to other databases such as the national Lattes curriculum. From 2013, the system was replaced by the more robust Sucupira Platform, which has been the subject of several studies over the years, including Maciel et al. (2019), Siqueira (2019), and Maia (2020).

Information systems designed to collect data from the SNPG have evolved considerably over time, providing evaluation committees with unprecedented information to assess the quality of research in Brazil. Despite that, for many years, "Coleta CAPES" was considered a black box, as its data was made available mainly to the evaluation committees. Neither society nor graduate programs could access the information supporting the evaluations. That started to change in July 2009, with the launch of CAPES' Georeferenced Information System (GeoCapes). This system was designed to bring the public a series of datasets around graduate education, presented with various levels of aggregation, and included a dashboard to explore the available information from different perspectives (CAPES, 2009; Cardoso, 2015; Maia, 2020).

From its launch, GeoCapes has been valuable for the accountability of invested resources and as a tool for interested users to understand and analyse Brazilian graduate education. Today, the system remains relevant, including around two decades of data on graduate programs, student body, faculty members, international cooperation, research funding, and even institutional access to scientific publications (from the Brazilian Portal of Journals). Nevertheless, GeoCapes presents a series of limitations when users need to perform more than fundamental analyses (Cardoso, 2015; Maia, 2020).

This paper introduces a GeoCapes R package developed to address some of the limitations seen in the original system. These include the need for further data standardisation and cleaning, the lack of tools for proper longitudinal analyses, and the need to enrich datasets with information to broaden potential research.

Additionally, the presented R package also addresses the language barrier of GeoCapes data, offering a curated translation of necessary content into English, making the datasets ready for international research as well.

A.1 GeoCapes benefits and limitations

CAPES introduces its GeoCapes system as a georeferenced tool with information on graduate education. Accessible at http://geocapes.capes.gov.br, the interface offers geographical and analytic visualisations of data for select indicators, including choropleth maps for a distribution perspective. Figure A.1 shows GeoCapes main page, displaying a map with the distribution of graduate programs in 2020. On the right side, visualisations provide information by broad area, course levels offered, and type of institution. Map selections filter the information displayed on the rest of the dashboard (CAPES, 2021e).

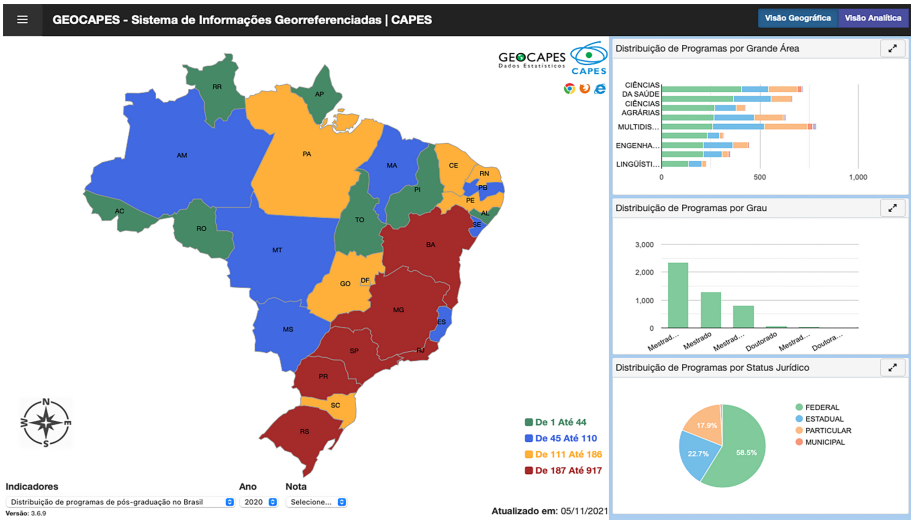
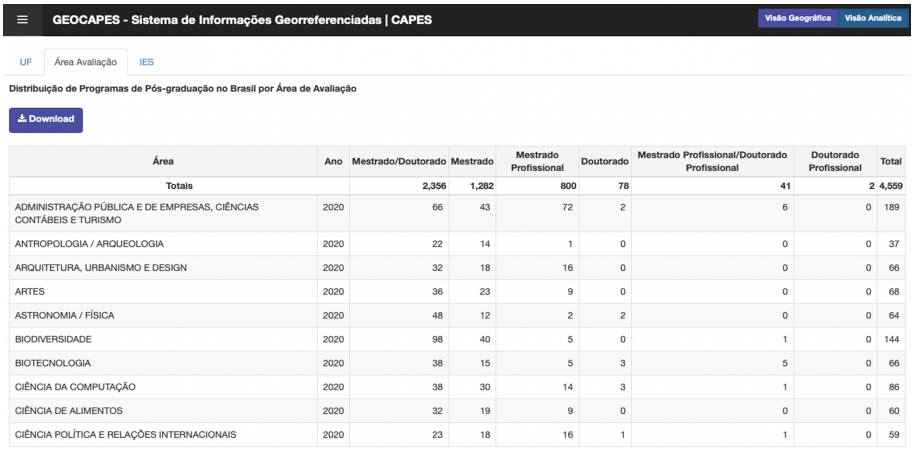


Figure A.1.: Geographical view of the GeoCapes system, displaying the distribution of graduate programs in Brazil in 2020

Figure A.2 shows GeoCapes analytical view, where the dashboard's underlying data is shown in a table format. For the selected dataset, three levels of aggregation are offered: state, evaluation area, and higher education institution (HEI).

To explore the panel, users can choose different years and even download data according to the desired level of aggregation.



Área	Ano	Mestrado/Doutorado	Mestrado	Mestrado Profissional	Doutorado	Mestrado Profissional/Doutorado Profissional	Doutorado Profissional	Total
Totais		2,356	1,282	800	78	41	2	4,559
ADMINISTRAÇÃO PÚBLICA E DE EMPRESAS, CIÊNCIAS CONTÁBEIS E TURISMO	2020	66	43	72	2	6	0	189
ANTROPOLOGIA / ARQUEOLOGIA	2020	22	14	1	0	0	0	37
ARQUITETURA, URBANISMO E DESIGN	2020	32	18	16	0	0	0	66
ARTES	2020	36	23	9	0	0	0	68
ASTRONOMIA / FÍSICA	2020	48	12	2	2	0	0	64
BIODIVERSIDADE	2020	98	40	5	0	1	0	144
BIOTECNOLOGIA	2020	38	15	5	3	5	0	66
CIÊNCIA DA COMPUTAÇÃO	2020	38	30	14	3	1	0	86
CIÊNCIA DE ALIMENTOS	2020	32	19	9	0	0	0	60
CIÊNCIA POLÍTICA E RELAÇÕES INTERNACIONAIS	2020	23	18	16	1	1	0	59

Figure A.2.: Analytical view of the GeoCapes system, displaying the distribution of graduate programs in Brazil aggregated by evaluation area

In addition to the distribution of graduate programs, GeoCapes includes six other datasets, all listed in Table A.1 alongside the respective data coverage and aggregation levels present in the analytical view. The availability of such diverse data sets contributes to the transparency of the Brazilian graduate system and serves as an essential source of information for higher education institutions, students, researchers, and policymakers.

Table A.1.: Datasets available in GeoCapes, including coverage period and available aggregation levels

Datasets	Coverage	State	Countries	Broad Area	Area	HEI
Distribution of graduate programs	1998–2020	✓			✓	✓
Distribution of faculty members	1998–2020	✓			✓	✓
Distribution of graduate students	1998–2020	✓			✓	✓
CAPES scholarship holders in Brazil	1995–2020	✓		✓	✓	✓
CAPES scholarship holders abroad	1998–2020		✓		✓	
CAPES investment in scholarships and funding	2002–2020	✓				
Access data to the Portal of Journals	2001–2020	✓				✓

The levels of aggregation provided by GeoCapes reveal limitations that could impact research interests. For instance, the Brazilian graduate system classifies

its programs into 49 evaluation areas, grouped into nine broad areas and three upper groups. As an example, "Economics" is one of the evaluation areas in the broad area of "Applied Social Sciences", which is part of the "Humanities" upper group. GeoCapes lists evaluation areas for five datasets, but broad areas are only available for domestic scholarship holders. Therefore, if a researcher hopes to analyse graduate program growth in relation to scholarships granted in the upper group of "Life Sciences", GeoCapes' interface is not enough. For that study, it would be necessary to download the underlying datasets, enriching them with information on broad and upper groups of areas.

Since most datasets include the microlevel classification of evaluation areas, enriching the data would be straightforward if GeoCapes provided unique identifiers for the 49 areas. However, since that is not the case, users need to rely on the area names, which are not standardised. For instance, the graduate programs dataset includes 106 distinct evaluation areas, and most are duplicates from either trailing and inconsistent spacing or capitalisation issues. While cleaning the data could solve these, another problem comes from renaming evaluation areas over the years. The current area of "Journalism and Information", for example, was known as "Applied Social Sciences I" until it was rebranded, alongside two other areas, by Ordinance 234 (CAPES, 2016b).

Similar inconsistencies are seen across higher education institutions, cities, countries, and other fields. Those problems can be partially explained by the fact that GeoCapes does not seem to be based on a relational database, compiling visualisations from a structured source. Instead, the underlying information appears to be built from appending new aggregated data every year, imposing limitations that need to be addressed to conduct rigorous research.

A.2 Introducing the GeoCapes R package

R is an open-source language and environment for statistical computing and graphics, popular among researchers and data analysts across multiple fields of knowledge. The language's algorithms are powerful to work with large volumes of data, automating the tedious and error-prone manual work associated with spreadsheet use while also being shareable in public repositories, thus fostering openness and reproducibility (R Core Team, 2021; Sarmento and Costa, 2017).

The benefits of the R language make it valuable to deal with GeoCapes data, in part because the system's datasets are updated annually, but not simultaneously. Algorithms can seamlessly download and process the most recent data, saving users from handling new tables for every study. Additionally, the approach is more suitable to address new research questions that may arise from the data, as the code can be adapted and expanded as needed. Of course, the code complexity grows with the design of multiple usage scenarios, limiting its use to those users proficient in the chosen language. For that reason, this paper introduces an R package compiling a series of algorithms designed to work with GeoCapes data. In a package, thousands of lines of code are transformed into simple and easy to use functions, significantly improving accessibility.

To demonstrate its simplicity, Algorithm A.1 shows the commands to install and load GeoCapes for R; download and process the most recent version of the graduate program dataset; export the cleaned and enriched results to a CSV file; and even produce visualisations from the data. To use the code, R should be installed on the user's computer, and the software download with necessary instructions is available at https://www.r-project.org/. It is also recommended to install RStudio Desktop, an integrated development environment (IDE) that enhances the use of many R features (https://www.rstudio.com/).

Algorithm A.1: GeoCapes R package: installing, loading and operation example

```
# Install and load the latest version of the GeoCapes R Package
install("devtools")
devtools::install_github("AndreBrasil/geocapes")
library(geocapes)

# Download and clean the GeoCapes dataset of graduate programs
get_grad_programs()

# Exporting the dataset as a local file
save_grad_programs()

# Plots from the processed dataset
prog_year()
prog_hei()
```

The resulting data set from running the `get_grad_programs()` function is a table with 65.599 observations[1] of 16 variables, including the 13 originally

[1] The information considers the dataset made available in November, 2021.

provided by GeoCapes and three additional ones: evaluation area id, HEI id, and upper area groups. Cleaning algorithms are applied to fields such as city, HEI and institution type. A series of arguments are included in the download function to filter the dataset: *start year*, *end year*, *state*, *region*, and *HEI*. From that, `get_grad_programs(2010, 2015, region = "North")` retrieves records from 2010 to 2015, from the North region of Brazil, while `get_grad_programs(state_code = "SP")` limits the resulting table to PPG in the state of São Paulo. As the package is thoroughly documented, help files with descriptions, arguments, and examples are available for every function.

After downloading the chosen data set, the `save_grad_programs()` function can be used to export the resulting table as a CSV file. Those familiar with R can continue using the environment for data analyses, and the package also includes ready-made functions for that. Figure A.3, for instance, shows the plot created with the `prog_year()` function, which consists of a line graph of the number of graduate programs active per year in the 1998–2020 period.

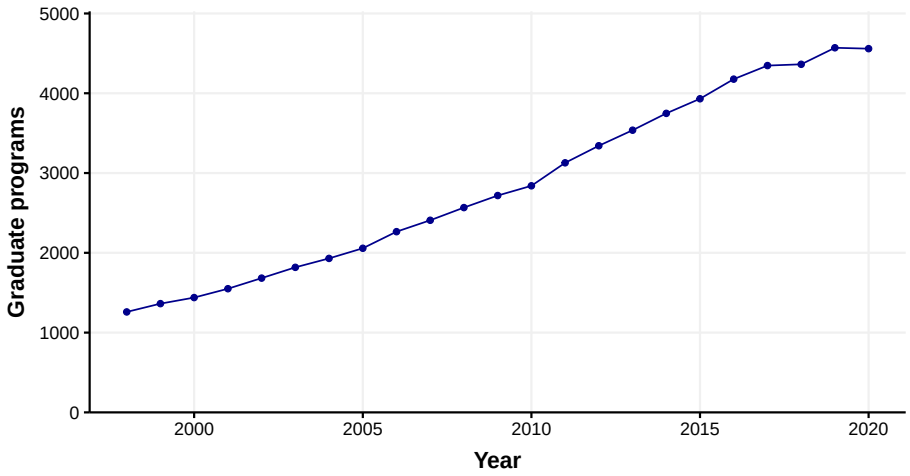


Figure A.3.: Line chart created by `prog_year()`, showing graduate programs per year

As happens with the download function, `prog_year()` includes arguments to filter the starting and end years displayed, but it can also detail the plotted line according to different variables. Figure A.4, for instance, shows the output of `prog_year(per_region = TRUE)`, a line chart of PPG revealing the asymmetrical distribution of graduate education across the five Brazilian regions.

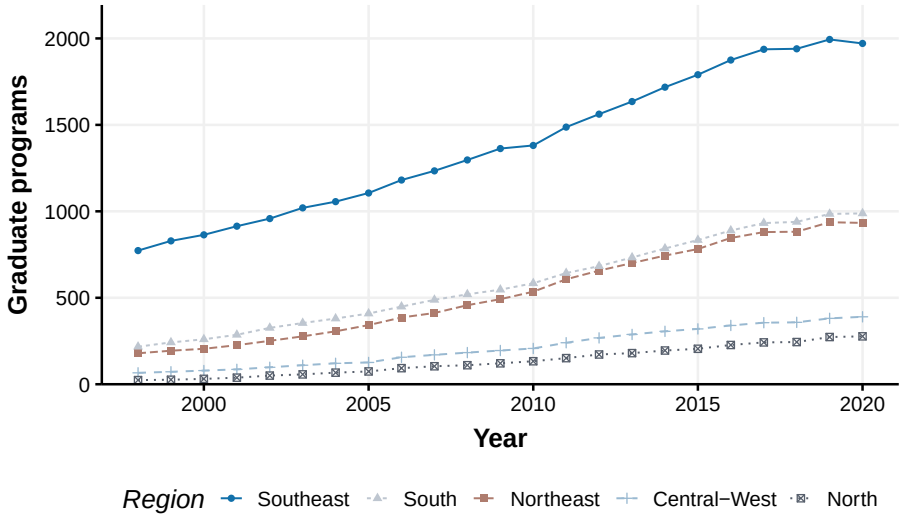


Figure A.4.: Line chart created by `prog_year(per_region = TRUE)`, showing graduate programs per year and region

Another example is seen in Figure A.5, which displays the result of running `prog_year(per_region = TRUE, per_level = TRUE)`. This command outputs a line chart for each region, detailing the number of programs according to the level of courses offered. The legend shows master's degrees (MA), doctoral degrees (DO), and the respective professional categories (MP and DP).

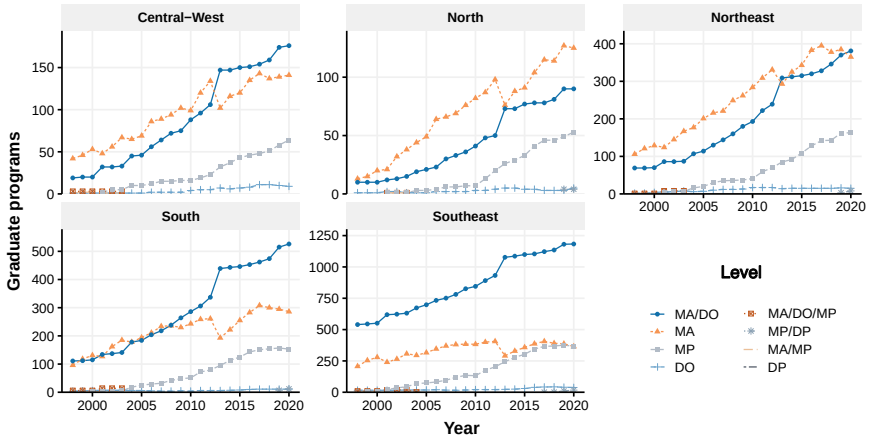


Figure A.5.: Line chart created by `prog_year(per_region = TRUE, per_level = TRUE)`, showing graduate programs per year and level, grouped by region

Figure A.5 reveals how graduate programs offering academic courses at the master's and doctoral levels have been the majority for decades in the Southeast of Brazil, but a more recent development in the South and Central West regions. In the case of the Northeast and North regions, the proportion of programs offering only the academic master's is still significant. The data support the arguments presented in Brasil (2020) for the valorisation of the master's course in its current format in the country – resembling a short doctorate – as it is still the primary alternative for scientific training in a substantial part of Brazil.

Still working with the PPG dataset, the GeoCapes package for R offers the `prog_hei()` function, which analyses the data from the perspective of HEI. The bar graph produced can be seen in Figure A.6, where the top 15 HEI in the number of graduate programs are shown (using the most recent year available in the dataset). Each bar is detailed by grade, which starts at *2* for this set of institutions and goes up to the maximum of *7*. Grade *A* represents programs that were recently accredited, but have not yet gone through a periodic evaluation. The available arguments allow the selection of reference years and the number of institutions to be shown, as well as the filtering of HEI from selected regions. Users are also allowed to visualise the results as a percentage stacked bar chart.

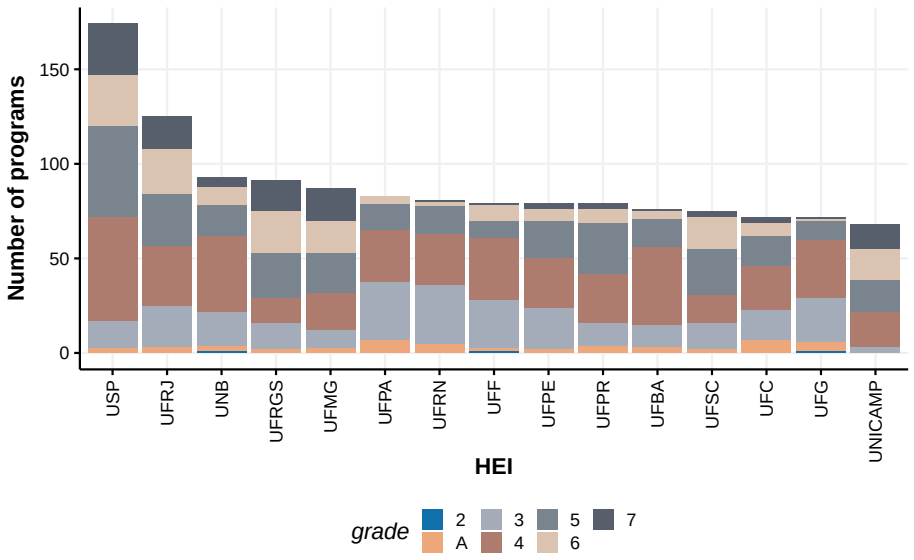


Figure A.6.: Top 15 HEI in number of graduate programs in Brazil, detailed by grade

A different example of the GeoCapes R package application comes from the function `get_funding()`, which downloads data on annual CAPES investment per state. While relevant, the original dataset has no information on region, and expenditures are only provided in Brazilian real (BRL), without any monetary correction over the years. As Brazil is not a country free of inflation, deflating investments would improve comparisson capabilities and converting values to US dollars (USD) would make the dataset useful for an international audience. With that in mind, internal functions were embedded into `get_funding()`, adding the following columns to the resulting dataset:

i) Brazilian geographical regions;

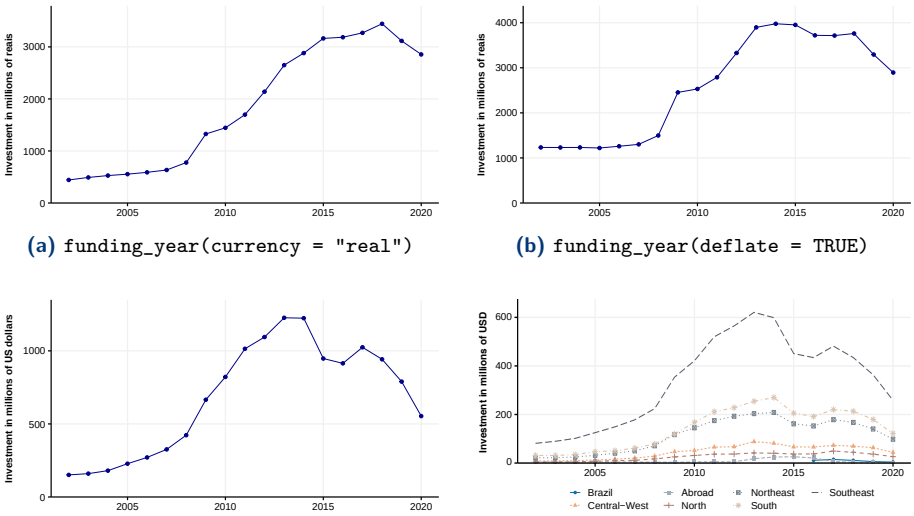
ii) The corresponding US dollar exchange rate for each record, obtained through the Application Programming Interface (API) of the Brazilian Central Bank;

iii) The informed investment converted to the corresponding dollar rate;

iv) Deflated values in BRL, corrected using the Extended National Consumer Price Index (IPCA), which is collected through the API of the Brazilian Institute of Applied Economic Research (IPEA).

As with any of the download functions provided by the package, the resulting data set can be saved as an Excel compatible CSV file, in this case by running `save_funding()`. Furthermore, a visualisation function is available – `funding_year()` – which can be used to plot a line graph of CAPES investment over time, as can be seen on Figure A.7. Arguments available allow users to select the start and end years plotted, choose the desired currency (either BRL or USD), and whether the monetary correction should be applied for investments in Brazilian real. It is also possible to plot the data according to region, as shown on Figure A.7d.

The GeoCapes funding dataset is quite valuable for observing the rise and fall in investments made by CAPES over nearly two decades. It helps researchers and general users identify the asymmetry in funding distribution, see the impact of devaluation of the Brazilian real on the dollar, and more. Combining funding information with data on scholarship holders in Brazil or abroad, growth of the graduate system, and details on students makes GeoCapes an even more powerful resource for answering relevant research questions about the Brazilian National System of Graduate Education.



(a) `funding_year(currency = "real")`

(b) `funding_year(deflate = TRUE)`

(c) `funding_year(currency = "dollar")`

(d) `funding_year(currency = "dollar", per_region = TRUE)`

Figure A.7.: Line charts generated by the `funding_year()` function

A.3 Available functions in the R package

The initial release of the GeoCapes for R package includes more than 60 functions, of which 50 are available to the user. The remaining are internal functions created for tasks such as monetary correction, defining visualisation templates, and dataset translation. They are activated when necessary, without the need for user intervention, and the package documentation includes details about their operation.

The user-accessible functions are presented in two sets: one in Portuguese and the other in English. Both download, clean, and enrich datasets; save results to CSV files; and provide visual output for simple analyses. The only difference is that the first set does all that in the original language of the datasets, while the second applies a series of algorithms to translate column names and content such as countries, regions, evaluation areas, and groups, etc.

The GeoCapes R package does not use machine-generated translations. Instead, it relies on lookup tables curated from the author's previous research and inter-

national publications. For instance, the translation applied to evaluation areas, broad areas, and groups resulted from analysing the classification adopted by CAPES against those of the Organisation for Economic Co-operation and Development (OECD) and the International Standard Classification of Education (ISCED). The corresponding lookup table has been made available on a public repository (Brasil, 2021c).

The following subsections will present the user-accessible functions included in version 1.0 of the GeoCapes R package.

A.3.1 Downloading

The GeoCapes R package can download all the data sets listed in Table A.1. The available functions are shown in Table A.2, focussing on the English versions, but showing the Portuguese alternatives below them. Running any of those functions will make the corresponding dataset available in the R environment, cleaned and enriched. Arguments are available to allow users to pre-filter the original datasets to fit particular needs. For example, all functions accept the `start_year` and `end_year` parameters, while others may be used to get information for a single higher education institution or for a region or state.

Table A.2.: GeoCapes R package functions to download, clean, and enrich datasets

Function	Description
`get_grad_programs()` `baixar_ppg()`	Retrieves the complete dataset of active graduate programs (PPG) in Brazil, with information per year and according to HEI, city, evaluation area, etc. The full enriched table includes 65.599 records of 16 variables, which can be filtered by *start year*, *end year*, *state*, *region*, and *HEI*.
`get_faculty()` `baixar_docentes()`	Downloads the dataset with information on the distribution of faculty members aggregated by PPG, and detailed by affiliation type (permanent, contributor or visiting professor). The full dataset includes 77.655 observations of 19 variables, and the same filters as above apply.
`get_students()` `baixar_discentes()`	Similar to the previous function, the final table includes the number of graduate students per year and level across each individual PPG. The full dataset includes 137.820 observations of 20 variables. The same five filters remain available.

Continue...

Table A.2 Continued

Function	Description
`get_grants()` `baixar_bolsas()`	Downloads the dataset with grants awarded to each PPG, detailling level (masters, doctorate, postdoctorate, etc.) and funding program. The complete data set includes 154.916 observations of 28 variables. While the filters mentioned above also apply, users have the additional option to filter by *funding line*.
`get_international()` `baixar_internacional()`	Retrieves the dataset of scholarships granted for studies abroad, aggregated according to foreign institution and funding program. The resulting data set has 117.914 observations of 21 variables. Available filters are: *start year*, *end year*, *country*, *funding program*, and *HEI (foreign)*.
`get_funding()` `baixar_fomento()`	This function gets the table with information on CAPES' funding per year and state, enriching the data with columns on monetary correction (IPCA), currency convertion (from BRL to USD) and region. The resulting table contains only 538 observations of 8 variables, but can still be filtered by *start year*, *end year*, *state*, and *region*.
`get_pub_portal()` `baixar_portal()`	Retrieves information regarding usage of the Brazilian Portal of Journals, including access to reference databases and the number of full-text downloads, aggregated by HEI. The data set of 5603 observations of 11 variables can be filtered by *start year*, *end year*, *state*, *region*, and *HEI*.
`get_geocapes()` `baixar_geocapes()`	This function downloads all GeoCapes datasets, running the respective algorithms to clean and enrich them. All the filters mentioned above can be used here.

A.3.2 Saving

After running any of the download functions, the corresponding datasets will be made available in R's global environment. These can be explored by users – who can further clean, enrich, and analyse the tables – or just be exported as CSV files. Table A.3 lists the available functions to save data sets.

Table A.3.: GeoCapes R package functions to export downloaded datasets

Function	Description
`save_grad_programs()` `salvar_ppg()`	Exports the complete dataset of active graduate programs in Brazil as `geocapes_grad_prog.csv`.
`save_faculty()` `salvar_docentes()`	Exports the dataset on the distribution of faculty members per PPG as `geocapes_faculty.csv`.

Continue...

Table A.3 Continued

Function	Description
`save_students()` `salvar_discentes()`	Exports the dataset on the distribution of graduate students per PPG as `geocapes_students.csv`.
`save_grants()` `salvar_bolsas()`	Exports the dataset on CAPES scholarship holders in Brazil as `geocapes_grants.csv`.
`save_international()` `salvar_internacional()`	Exports the dataset on CAPES scholarship holders abroad as `geocapes_international.csv`.
`save_funding()` `salvar_fomento()`	Exports the dataset on CAPES investment in scholarships and funding as `geocapes_funding.csv`.
`save_pub_portal()` `salvar_portal()`	Exports the dataset on the use of the Brazilian Portal of Journals as `geocapes_pub_portal.csv`.
`save_geocapes()` `salvar_geocapes()`	Checks which datasets were downloaded by the user and runs the respective functions to export everything at once.

Each of the functions presented in Table A.3 will perform all saving operations on the datasets locally available. Thus, any filters applied during the download process will be reflected in the exported files. To represent the content of each CSV file, users can include a different filename to the functions. For instance, `save_international("geocapes_international_USA.csv")` can better reflect the output of scholarship holders if the download was filtered to show only grants awarded for studying or conducting research in the United States.

A.3.3 Visualising

The GeoCapes R package includes a series of functions to help users understand and visualise the downloaded data. Table A.4 lists those available in version 1.0, including the arguments users can apply to adjust the visualisations to reflect their needs.

Table A.4.: GeoCapes R package functions to visualise downloaded datasets

Function	Description
`prog_year()` `ppg_por_ano()`	Creates a line chart on the number of graduate courses active in Brazil, as seen on figures A.3 to A.5. Users can define *start year* and *end year* to show and choose to plot the lines by region and level.

Continue...

Table A.4 Continued

Function	Description
`prog_hei()` `ppg_por_ies()`	Creates a stacked bar chart on the distribution of graduate programs per HEI, detailed according to grade (Figure A.6). By default, the function plots the most recent data for the top 15 institutions in the number of PPG, but users can choose to visualise previous years and change the number of HEI to display. It is also possible to filter the data to show one or more regions and to output the results as a percent bar chart.
`faculty_year()` `docentes_ano()`	Creates a stacked bar chart of the number of faculty members over time, detailed by affiliation type. Users can change the range of the data displayed, and filter by region, state, or HEI.
`enrolled_year()` `matriculados_ano()`	This function creates a stacked bar chart similar to the previous one, but plots the number of enrolled students, detailed by level. All filters from `faculty_year()` apply.
`graduates_year()` `graduados_ano()`	Also similar to the previous function, including the available filters, but producing a stacked bar chart of the number of students graduated each year, again detailed by level.
`save_grants()` `salvar_bolsas()`	Creates a line chart on the number of scholarship holders in Brazil. The visualisation can be filtered by region, state and HEI, and users can select the desired range to display.
`international_year()` `internacional_ano()`	Creates a line chart on scholarship holders abroad, detailed for the top 10 countries. Users can select the period to be shown (defining *start year* and *end year*), change the number of countries to display, or even choose the ones to be shown. Two boolean filters are also available to exclude either undergraduate scholarships or the Science Without Borders program from the visualisation.
`funding_year()` `invest_ano()`	Creates a line chart on the evolution of CAPES funding over time, as seen in Figure A.7. Users can visualise investments in USD or BRL (nominal or deflated) and can detail the results by region. It is also possible to select the years to display.
`pub_portal_year()` `portal_ano()`	Creates a stacked bar chart on the annual use of the Brazilian Portal of Journals, detailed by type of access (database and full paper download). Once again, users can select the desired range to display, as well as filter by region, state and HEI.

For experienced R users, it is worth mentioning that the functions listed in Table A.4 rely on the ggplot2 data visualisation package designed by Wickham (2016), so the resulting objects can be further manipulated. For instance, running `prog_year() + geom_smooth(method = "lm")` will add a linear model to the original plot. Likewise, wrapping any of the visualisation functions in `ggplotly()` – from Plotly Technologies (2015) – will convert the figures into interactive ones, ready for embedding into web applications.

A.4 Conclusion and next steps

The launch of CAPES' Georeferenced Information System (GeoCapes) was a significant step towards a transparent system of research and graduate education in Brazil. Opening data on graduate programs, faculty members, student body, and different funding initiatives has made the system very valuable over the years, both for accountability and research purposes. However, significant limitations exist both in the system's public interface and in the underlying data, including language restrictions imposed by its Portuguese only approach. Therefore, this paper introduced a GeoCapes R package designed to share a series of algorithms developed to increase the value of CAPES' system for Brazilian researchers and an international audience.

In its initial release, the GeoCapes R package includes 25 user-accessible functions to deal with the original data in Portuguese and equivalent counterparts to perform the same tasks with additional translation into English. These functions download, clean, enrich, export, and plot data from GeoCapes, expanding the system's functionality and usefulness for researchers and other interested users. By providing simple access to complex data analyses, the functions are easy to use and are documented in the corresponding language.

Among the benefits of the GeoCapes for R package is the possibility of performing time series analyses as seen in A.3, A.4, A.5, and A.7. However, several other analyses are already possible with the package, and the arguments included in each function allow users to filter and adjust the various output files and visualisations. In that sense, an important next step in the package development is the expansion of potential usage scenarios, incorporating new analyses both from the author's perspective and from eventual user requests or collaboration.

Although expanding the package for R users may be relevant, it is crucial to acknowledge the steep learning curve associated with any programming language. Furthermore, researchers with a more qualitative profile usually adopt more intuitive statistical tools, such as SPSS. On the other hand, disciplines such as engineering favour the use of Python, in part because it is a general-purpose programming language (Muenchen, 2019). Thus, it is relevant to consider how to expand the scope of the package presented here in order to allow its use by groups of users who may benefit from the results offered, but who would have no interest or need to add R to their research toolset. In this sense, one of the

next steps planned for the development of GeoCapes for R is the design of a graphical web interface, based on the Shinny platform created by Chang et al. (2021). In this way, users will be able to operate the package without typing a single line of code.

For now, the open source version of the GeoCapes R package – including its documentation and a space for users to report bugs or send feature requests – is available on the GitHub repository at https://github.com/AndreBrasil/geocapes.

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Additional Resources

B

This dissertation is grounded in an applied research approach, with the aim of making it relevant and impactful on evaluation processes. It provides a variety of practical suggestions to improve Brazil's graduate evaluation system. Given its complexity, extensive nature, and English language, the work might not be easily accessible to everyone. Thus, a list of deliverables tied to this dissertation's core essence are provided here. This inventory is geared towards a more practical understanding and application of the research.

B.1 Policy brief series

In the realm of academic research, it is of paramount importance to ensure that the results and findings of studies are not limited to the walls of universities or the pages of scholarly publications. It is equally crucial to see these results translated into actionable insights, specifically tailored for policymakers who wield the power to promote change. To this end, a suite of policy briefs has been prepared to communicate some of the key recommendations derived from the various chapters of this dissertation.

Figure B.1 showcases the cover of the first policy brief in the series, developed from insights included in Chapter 9. This chapter advocates for the use of purchasing power parity (PPP) as a preferred index to negotiate transformative agreements for open-access publishing in Brazil. Other policy briefs within the collection available at https://doi.org/10.17605/osf.io/8jsvu explore a myriad of topics. These include, but are not limited to, the role of evaluation in the recognition of open-access publishing, and recommendations regarding the reconfiguration of the disciplinary classification currently upheld by CAPES.

PRÁTICAS DE NEGOCIAÇÃO DE APCS:

A PARIDADE DO PODER DE COMPRA COMO PARÂMETRO MAIS EQUITATIVO

Sumário Executivo

Este documento sugere que a CAPES utilize o índice de Paridade do Poder de Compra (PPP) como parâmetro normalizador da estrutura econômica brasileira ao negociar acordos de transformação com editoras científicas. As metodologias adotadas por muitas editoras para concessão de waivers de publicação empregam o modelo Research4Life ou a classificação do Banco Mundial com base no PIB. Ambas negligenciam as consideráveis disparidades econômicas nacionais, exigindo uma alternativa mais equitativa. Este resumo apresenta evidências de que o PPP pode ser usado como possível alternativa. No entanto, sua apresentação não descarta o valor de consultas com especialistas econômicos para explorar alternativas mais adequadas ao cenário de negociação.

Figure B.1.: Cover page of one of the policy briefs being prepared for CAPES

B.2 Website: BrScience

In conjunction with the outcomes delineated within this dissertation, a website has been designed to offer an extensive scientometric analysis of the strengths, weaknesses, opportunities, and threats of the Brazilian science system. The BrScience website (https://brscience.cwts.nl) includes information on scientific output, citation impact, international and industry collaboration, and more. The core data for the initial development came from the Web of Science, covering the period 2013-2022. However, additional databases have been subsequently added and the presented analyses now include information from Scopus, OpenAlex, and other relevant sources.

The primary objective of the effort is to offer an overview of the Brazilian scientific landscape from a scientometric perspective, while also providing policymakers with evidence for the effective allocation of investments and the recognition of past efforts. The development of this website is taking place in consultation with CAPES, and the initial single author approach for the development has been opened to include collaborations from many other researchers interested in sharing their analyses on the Brazilian scientific landscape.

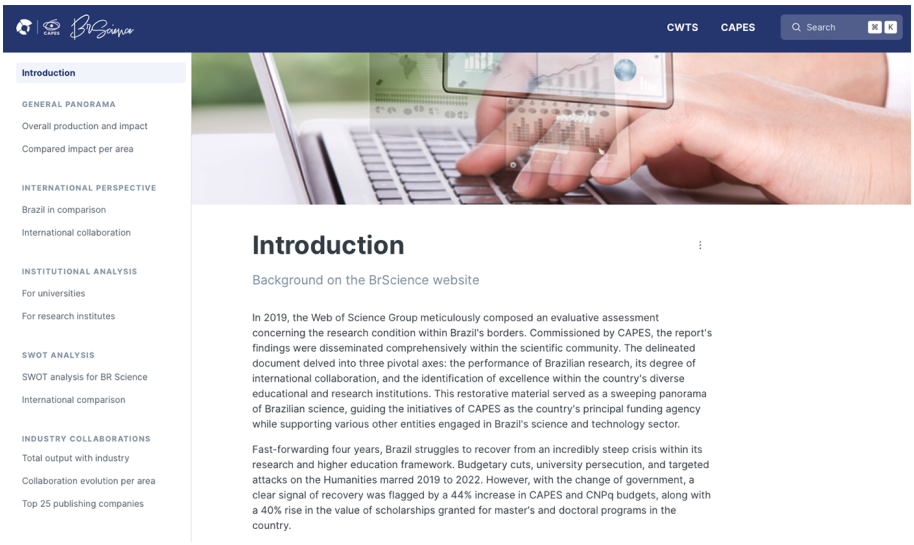

Figure B.2.: BrScience website, available at https://brscience.cwts.nl

B.3 Dashboard: Literature explorer

During this doctoral research, an exhaustive study was undertaken, encompassing the examination of close to 1500 research items. This large collection included articles, books, chapters, reports, and legislation, among other types of document. To facilitate the exploration of the cited works, each individual chapter in this dissertation includes a dedicated reference section. Furthermore, the end of the book also features a consolidated reference list of all cited works, followed by a complete author index.

However, for those who wish to gain a more detailed perspective of the entire literary landscape explored, an interactive dashboard has been created and made available at https://andrebrasil.github.io/viz/references.html. This resource enables users to dive into all the reviewed works, cited or not, and provides direct links to any content with a DOI or a permanent URL. The interface also offers multiple filter capabilities, including by author, publication type, language, and by the chapters in which the works were cited.

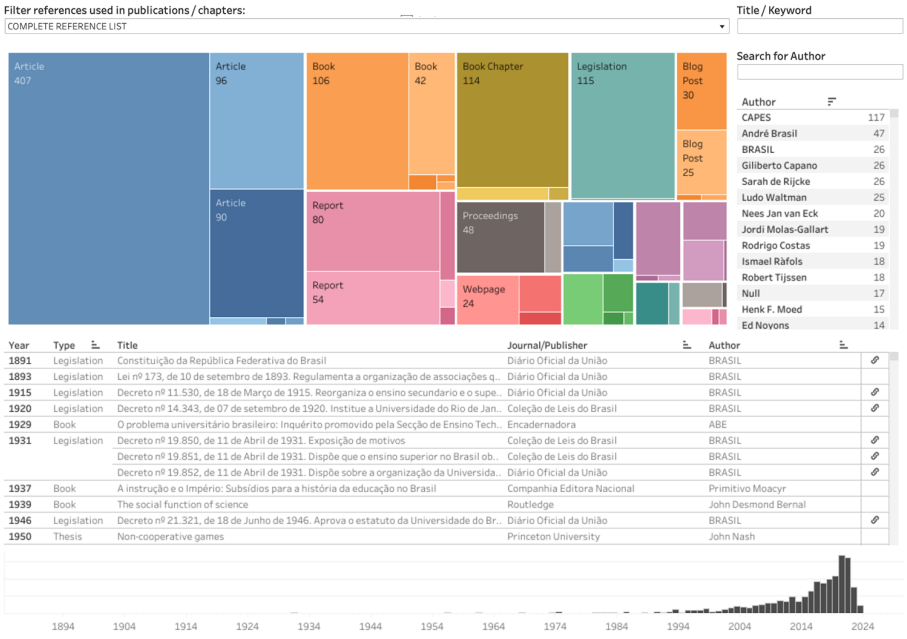

Figure B.3.: Main view of the bibliography explorer

B.4 Dashboard: Brazilian legislation on graduate education

Throughout this dissertation, more than 100 legislative items were examined, including laws, ordinances, and decrees. To assist those seeking to understand the construction process of the Brazilian National System of Graduate Education (SNPG) and its evaluation, a timeline has been prepared with these documents. The tool is available at https://andrebrasil.github.io/viz/timeline.html, and not only displays the researched legislation, but also provides direct access to the original texts.

It is crucial to note that the Brazilian National System of Graduate Education (SNPG) is predominantly regulated by the Ministry of Education and by CAPES. As such, the legislation mapped in this timeline at times serves to mould the system, while in other instances it plays a role in defining evaluation processes and standards. Therefore, its importance in understanding the Brazilian evaluation system is considerable.

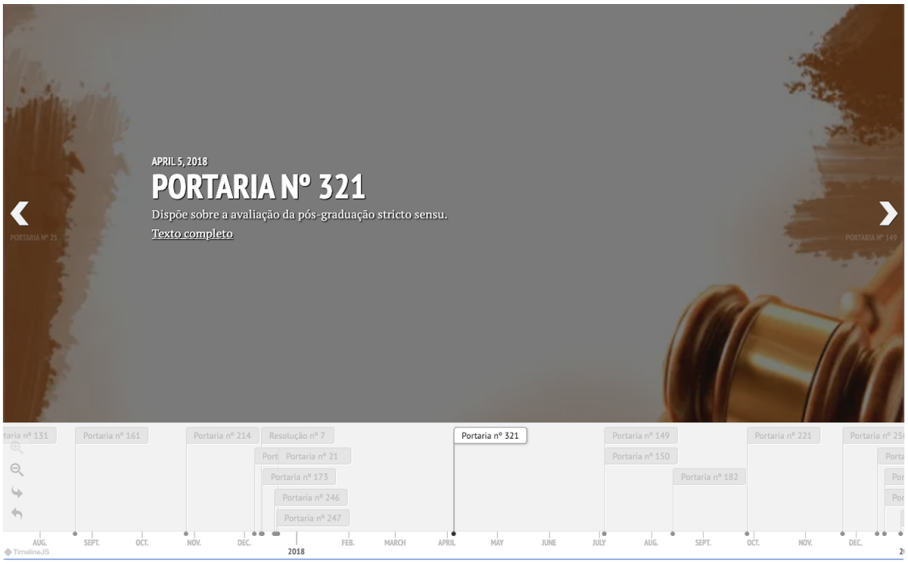

Figure B.4.: Legislation timeline available at https://andrebrasil.github.io/viz/timeline.html