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

Brasil Varandas Pinto, A.L.

Part I

The what, the why and the how

2

Building a national system of research and graduate education

> *While higher education in Brazil is plagued by many known problems, graduate education is a token of national pride recognised as such by the entire Brazilian society.*
>
> **— Balbachevsky & Schwartzman**

The ancient Greek philosopher Heraclitus once said: "there is nothing permanent except change". The idea of transformation has been a recurrent object of interest for thousands of years, as the cyclical process of birth, growth, decline, and decay has not only determined the course of human life, but has also been a driving question for scholars everywhere (London, 1996). As described by de Biasi (2019), change is ubiquitous, undeniable, inevitable, and irresistible.

In the modern world, resisting change has often been a fast path to failure. Numerous examples exist in the business context, but those of Blockbuster and Kodak have become somewhat emblematic. Both companies were leaders in their domains, but failed to adapt to changing times. Blockbuster refused a partnership with Netflix in 2000, as it considered the new company business model to be profitless; Kodak would not risk its lucrative photography film business and, despite having invented the first megapixel-camera back in 1986,

This chapter was published as: Brasil, A. (2020). Building a national system of research and graduate education: how did the university become the house of science in Brazil? *Revista NUPEM*, 12(27), 222–253. DOI: 10.33871/nupem.2020.12.27.222-253.

fell behind in the digital race. Both companies filed for bankruptcy in the last decade mainly because they could not change, as their organisational culture had become too rigid (Gershon, 2013).

The evolutionary nature necessary to remain relevant also applies to scientists, research centres, and whole science systems (Fealing et al., 2011). The COVID-19 crisis has confirmed this need for continuous change. Although the call for a fast response to fight the pandemic has reaffirmed the importance of science & technology worldwide, scientists had to redefine concepts of collaboration, scientific publishing, influence over policy, etc. (Serafim and Dias, 2020). As a consequence, notions of change that are well-established in business are increasingly present in the scientific environment (de Biasi, 2019).

Despite being so evident at this very moment, the understanding of the dynamics of science and innovation activities, as well as the way they change over time, is not something new. For decades, they have been studied by core social science disciplines such as Economics, Philosophy, and Sociology. On top of that, there is an emerging interdisciplinary field that is trying to establish itself as a recognised academic subject: Science of Science Policy (SoSP). This research area already contributes to the frameworks that provide an understanding of institutional structures that promote or impede scientific progress. Among its core concepts is the idea that science is not divorced from politics, as demands from the political system have been, for decades, the main drivers of science investment and advancement (Fealing et al., 2011; Marburger III, 2011).

Serafim and Dias (2020) argue that alliances between the State and scientific community can positively impact on the advancement of science. SoSP builds on that idea, claiming that governments play a crucial role in this progress, despite often lacking the necessary evidence for the proper design and implementation of S&T policies. As a result, policymakers usually cannot predict how best to manage science investments, much less design or reform science systems within their countries (Marburger III, 2011; Sapolsky and Taylor, 2011).

Brazil is such a country. As this chapter will show, the nation has an extensive research and graduate education system whose design has been the result of firm public policy initiatives over several decades. As the core of Brazilian science, this system has become very peculiar, as it integrates research and education in such an indivisible manner that it became determined even by the country's federal constitution (BRASIL, 1988; M. H. d. M. Castro, 2015). The successful

result is knowably expressed by Balbachevsky and Schwartzman (2010, p.87), who state that "while higher education in Brazil is plagued by many known problems, graduate education is a token of national pride recognised as such by the entire Brazilian society".

The aim of this chapter is mainly to provide a contextual understanding of the system mentioned above. The task was conducted from the study of primary sources – including original legislation and policy documents – as well as the analysis of archival interviews and literature exploring the system's history. The intended result is to reach a proper knowledge of: i) what is the Brazilian National System of Graduate Education (SNPG) and how representative it is in the face of the science conducted in the country; ii) how did this system evolve as a result of policy decisions over several decades; iii) why were such decisions made, and how they relate to a broader picture of public policy in Brazil.

After tracing back the history and evolution of the SNPG, this chapter will also provide a panorama of what it has become: how large is the system; how is it organised and distributed across the country; what is the demography of the faculty and student body, etc. Hopefully, understanding the SNPG today, as well as the complexities behind its development, may assist policymakers in their continuous efforts to advance the science system in Brazil.

Despite the main goal of bringing scientific evidence to the policy-making environment, this chapter also aspires to provide a comprehensive understanding of the Brazilian science system to the international academic community. Few studies on the SNPG have been published in English, and none of them is as complete as this one proposes to be. As will be clear, the public policy approach to science and high-level education in Brazil can serve as an inspiration to every country, both from its successes and failures.

2.1 The late start of higher education in Brazil

Higher education was a late phenomenon in Brazil, even compared to other Latin American countries. There were many reasons for this, but two of them were of particular importance: first, the Portuguese colonisation policy presented absolute resistance to this kind of initiative; second, the Brazilian elites

would rather pursue their education abroad, mainly in European higher education institution (HEI). Such determinants led not only to inaction, but also to the active establishment of obstacles to those interested in bringing higher education to the colony. One of the first known records of this comes from the 16th century, when the Portuguese Crown denied authorisation for the Jesuits to open the first HEI in Brazil (Fávero, 2006; C. B. Martins, 2018; Moacyr, 1937).

Over the next centuries, other attempts were made without success. An example comes from the Minas Conspiracy, a separatist movement at the end of the 1700s that had the first Brazilian university as part of its independence plans. The conspiracy was foiled, and the hope for higher education was put on hold until the Portuguese Court was transferred to Brazil, escaping the French invasion in 1807. Within a year of their arrival, two medical schools were created: one in the state of Bahia and another in Rio de Janeiro, where a polytechnic school soon followed. (Cunha, 2007; Fávero, 2006; Rothen, 2018).

Within a couple of decades, a few more courses and institutions were created, but all of them with a very applied nature. They were mainly designed to qualify professionals to work for the government or to provide technical training to a select group of the ascending elite. After the country's independence, in 1822, the new Brazilian Empire started to make room for a more academic mentality, and by 1828 two legal courses were installed: one at the Saint Francis Convent in the city of São Paulo and the other at the Saint Benedict Monastery in Olinda. Although these courses had a significant influence on the development of political mentality in the country, the promise of higher education in Brazil would not materialise for several decades (Fávero, 2006; Rothen, 2018).

At the end of the Brazilian imperial times, in 1889, the country had just six HEI and all attempts to create universities were unsuccessful. With the advent of the Republic, although the number of higher education institutions increased to 24, these were mostly professional schools, devoid of scientific research. The dream of a university continued to slip away (Fávero, 2006; C. B. Martins, 2018).

2.1.1 The first universities

Legislation from the newly proclaimed Brazilian Republic would start to pave the way for a university system in the country. The first step came from the 1891 Constitution that, despite maintaining higher education as an attribution

of the Federal Government, stated it was no longer its sole jurisdiction (BRASIL, 1891). Also, Law 173/1893 and other legal provisions created the possibility of private ownership of higher education and scientific establishments, including those linked to associations (BRASIL, 1893; Rothen, 2019).

Once the Federal Government lost its exclusive power over matters of science and higher education, the first research institutes were founded (C. B. Martins, 2018). At the time, there was a great need to better understand Brazilian biodiversity, tropical diseases, and other topics relevant to the country (Schwartzman, 1989). This led to the creation of institutions such as the Emílio Goeldi Museum (1885), the Agronomic Institute of Campinas (1887), the Butantan Institute (1899), and the Oswaldo Cruz Foundation – Fiocruz (originally founded as the Manguinhos Institute in 1900). These and other research centres were created isolated from educational institutions and would play an essential role in the building of the country's scientific community (C. B. Martins, 2018).

Parallel to the creation of research centres, several higher education institutions were founded, including the first universities in the country: one in Manaus (1909), another in São Paulo (1911) and the third in Paraná (1912) (Cunha, 2007). As a direct reaction to this movement, the secondary and higher education systems were reorganised by Decree 11.530/1915, which determined the Government would move to establish the first federal university in Brazil "when possible" (BRASIL, 1915). This would take place in 1920, as another decree instituted the University of Rio de Janeiro (BRASIL, 1920).

Despite having a federal university as one of the positive effects of Decree 11.530, the educational reform would have a much more substantial impact on the Brazilian science system. The reason was that it established the university as the home of research and education; and these should be integrated (Rothen, 2019). The drawback is that the approach might have been taken in a very normative and absolute way, and the resolution would become an obstacle for the founding of new research institutions outside of universities.

2.1.2 Early concepts for a graduate system

While Brazil mobilised to build its first universities, prominent organisations emerged in the country. Among them was the Brazilian Academy of Sciences

(founded originally in 1916 as the Brazilian Society of Science); and the Brazilian Education Association (ABE) in 1924 (Fávero, 2006). These institutions would play a fundamental role in the design of the country's universities and in how they integrate teaching and research activities (C. B. Martins, 2018). For example, in the document "The problem of the Brazilian university", ABE (1929) stated "the university, to be worthy of that name, should become a focus of culture, of disseminating acquired science and creating new science".

The viewpoint of ABE represents the dominant belief in Brazil at that time: the defence of the university's role in the development of scientific research, in addition to the training of professionals (Fávero, 2006). This belief becomes reality with yet another reform of the higher education system in 1931 (Sucupira, 1980). Francisco Campos, the Minister of Health and Education at that time, led the initiative that included the creation of the National Education Council (Decree 19.850, 1931a), the promulgation of the Statute of Brazilian Universities (Decree 19.851, 1931b), and the creation of the University of Rio de Janeiro (Decree 19.852, 1931c).

Although there had been records of institutions that had already provided doctorate degrees through simple thesis defence (Sucupira, 1980), the comprehensive university project that was launched in 1931 marked the formal beginnings of graduate education in the country (Balbachevsky and Schwartzman, 2010). The project not only created the first regular doctoral courses in the areas of law, exact, and natural sciences (BRASIL, 1931c), but defined the idea of a university that "transcends the exclusive purpose of teaching, involving concerns of pure science and disinterested culture" (BRASIL, 1931a). Even though inspiring, this core belief would not be strong enough for science to find its true space in the university at that time (Schwartzman, 1991).

2.2 The first steps of the SNPG

In the years following the university reform of 1931, the advancement of science through graduate education in universities was extremely limited (Cunha, 2007). Brazil's priority at the time was to implement what turned out to be a successful national development policy. The initiative was quite effective from 1930 to 1945 and focused mostly on industrialisation. In the first years, the

country was able to put its idle industrial capacity to use, but the expansion of national production pressured imports and led to inflation and unattractive exchange rates. The result was a reduced interest in private and foreign investment in Brazil (Cano, 2015).

What followed contributed to shaping the primary *modus operandi* of the Brazilian Government in terms of state matters. Since it was not possible to rely on the market to act, the State stepped up to continue to develop, which meant founding its own industries, such as the National Steel Company (1941) and the Rio Doce Valley Company (1942, known today as Vale) (Cano, 2015; Gouvêa, 2012).

While all this happened, few steps towards scientific development were taken. Among the relevant was the creation of the University of São Paulo (USP), in 1934. The institution was conceived as an ambitious project to produce a new intellectual elite in Brazil and, for almost two decades, it would graduate most of the scientific workforce in the country. Furthermore, the HEI was the first in Brazil to really strengthen its research capacity through international outreach, as it became the new home for various European scientists who moved to Brazil to escape the threat of war (da Fonseca, 2015).

Still, World War II erupted, and so did a movement to take science out of its academic isolation to serve economic and social development. Such ideas had been spreading in Europe for the best part of a decade, counting with strong advocates such as J. D. Bernal and his book "The social function of science". In the inevitability of war, those ideas had to be put into practise, as scientists played critical roles in cracking the German secret code, improving radar, and many other relevant activities, including the development of the atomic bomb (Schwartzman, 1989).

As World War II ended, Brazil was sparked by the idea of scientists focused on solving concrete problems, and the country sought inspiration in the success stories of the war (Cano, 2015). As an example of that, physicists and mathematicians who arrived from Italy in the 1930s had helped educate a group of competent researchers in high-energy physics at USP. This group was then called to develop the country's nuclear policy, a project that would lead to the creation of the Brazilian National Council for Scientific and Technological Development (CNPq), in 1951 (Schwartzman, 1989).

Despite the eventual failure of the nuclear project, in part because of the United States veto (Schwartzman, 1991), the initiative integrated a substantial evolution in the Brazilian political, economic, and social progress in the early 1950s. In this new phase of the development project, the State continued to push forward, founding new institutions such as the Commission for Industrial Development (CDI), the National Bank for Economic Development (BNDE), and the Brazilian Agency for Support and Evaluation of Graduate Education (CAPES) (Gouvêa, 2012). The last one would be of extreme significance for the birth of the Brazilian National System of Graduate Education (SNPG) (Rothen, 2018).

Created by Decree 29.742/1951, CAPES started as a commission in charge of a national campaign for "ensure the existence of specialised personnel in suitable quantity and quality to meet the needs of public and private efforts aimed to develop the country" (BRASIL, 1951). For that, a mixed group of policymakers, academics, and even representatives of the financial sector received unprecedented autonomy to implement pioneering programs for graduate education in Brazil (CAPES, 2010).

2.2.1 CAPES: the first years

The decree that created CAPES (BRASIL, 1951) established a series of objectives for the initial campaign. They can be summarised in three points:

i) Study the country's needs in terms of the highly qualified personnel necessary to work towards social and economic development;

ii) Address such needs by mobilising, in cooperation with public and private institutions, existing resources to provide training opportunities to the most capable individuals, in particular to those without their own financial means;

iii) Promote the expansion of graduate education and research centres in Brazil;

The study by Gouvêa (2012) described how CAPES was organised in order to carry out the proposed objectives. At the core of the campaign, a Technical and Scientific Program (PQTC) was implemented, with the support of a Statistics and Documentation Service (SED). Their job was to map the research infrastructure already installed in the country and to understand its deficiencies with

respect to scientific personnel. To do so, a University Program (PgU) was also implemented, counting with the support of a Scholarship Service (SBE).

The strategy adopted by PgU was to search for talented people in academic institutions and provide them with direct support in research infrastructure and staff (Balbachevsky and Schwartzman, 2010). Such support would include hiring foreign visiting professors, assistants, and even technicians to work in Brazilian institutions, as well as granting scholarships for select national researchers to study abroad (Gouvêa, 2012). Although the statistical data for that period seem not to be completely reliable, C. B. Martins (2018) estimates that, from 1953 to 1959, an average of 1.200 students moved abroad every year.

As a result of these policies, a new generation of Brazilian researchers was formed. Many of them graduated abroad, often in the United States, and most were back in Brazil to assume the scientific leadership in universities by the early 1960s. From their international perception of what a research program could be, they would actively participate in the design of the new master and doctoral courses so needed in the country (Balbachevsky and Schwartzman, 2010; Gouvêa, 2012; C. B. Martins, 2018).

2.2.2 The persistent design of Brazilian graduate education

In the first decade of its existence, CAPES was able to both strengthen the few research departments in Brazilian universities and contribute to the development of a critical mass to advance science in the country (Gouvêa, 2012). Now, the international experience of the researchers who graduated abroad would challenge the established design of the national institutions to achieve the once planned result: the university as an educational and research environment (Sucupira, 1980). According to Fávero (2006), this modernisation movement was clearly seen in 1961, with the creation of the University of Brasília (UnB).

Brasília is the current capital of Brazil. Founded in April 1960, the city was built in just 41 months, in the very centre of the country. Designed in the shape of a plane and erected on the margins of an artificial lake with 80 km of shore length, Brasília was a symbol of progress. Its first university should reflect this modernity, and that was made clear in the HEI's original plan, which stated UnB was "projected on the same bases as the teaching and research centres that are revolutionising the modern world" (D. Ribeiro, 1961).

The plans that led to the structure of UnB included innovations that would soon be reflected in broader legislation: Law 4.024 (LDB), which sets the guidelines and bases for national education. The LDB decentralised the educational system; gave freedom for each institution to organise its curriculum; provided academic, administrative, financial, and disciplinary autonomy to universities; and so on. For this study, the most significant contribution was that graduate education became a permanent task of the university. It constituted a system of regular courses to deepen the training received during undergraduate studies and could lead to academic degrees (BRASIL, 1961; D. Ribeiro, 1961; Sucupira, 1980).

Despite the conceptual advances of UnB and the LDB in graduate education, the lack of accumulated tradition in research at Brazilian universities hindered the expected growth of the system (Balbachevsky, 2004). 1965 would bring a decisive milestone for the change, as the Minister of Education and Culture, Suplicy de Lacerda, asked the Federal Education Council (CFE) to further define and regulate graduate courses, given the imprecise understanding that still reigns about their nature and purposes (C. B. Martins, 2018).

The resulting document, Report 977/1965 (known today as the Sucupira Report in honour of its lead author, Newton Sucupira), was approved by CFE to become the most important document in the history of graduate education in Brazil. Among its core ideas and definitions, we can find (CFE, 1965):

i) Although graduate education might refer to any course that follows an undergraduate degree, specialisation and improvement courses focus on professional development and are to be considered as *sensu lato*. They are not included in the scientific policy initiative at hand;

ii) Graduate education *sensu stricto* is intended to train researchers and professors for higher education courses; to stimulate the development of scientific research; and to prepare high-level personnel to meet the needs of national development in all sectors. It consists of two successive cycles, "equivalent to the master and doctor of the American system";

iii) The master's degree is not a necessary prerequisite for enrolment in a doctoral course. Certain fields of knowledge may even offer only doctoral programs, with direct access after an undergraduate course;

iv) The master's course can be more than a mere preliminary stage in the path to the doctorate. It may also be seen as a terminal degree;

v) The master's candidate must produce a dissertation revealing mastery of the chosen theme and the ability to systematise; the Doctoral candidate must defend a thesis that represents research work, making a real contribution to the knowledge of the subject;

vi) In addition to the thesis or dissertation, candidates must follow a certain number of courses, participate in seminars and research works, and submit to a series of exams;

vii) The master's degree would take at least one year to complete, while the doctorate would take a minimum of two years (the "ideal" duration would soon be established as two and four years, respectively).

The proposed model was strongly influenced by the American graduate system at that time. The Sucupira Report (1965) recognised the inspiration, citing the Robbins Report (1963) to support the decision. Such a document presented research on the conditions for the expansion and improvement of British higher education, recommending the adoption of techniques and processes from the North American system in British graduate studies. Furthermore, it is possible to infer that the choice for the American model would also be grounded on its familiarity to the new generation of Brazilian researchers with international experience, as most of them had graduated in the USA.

By the time the Sucupira Report was approved, there were only 38 graduate courses active in Brazil, 27 of them master's and 11 doctorates. In the decade that followed, the growth was enormous, and by 1975 this number jumped to 429 master's and 149 doctorates (Balbachevsky, 2004; C. B. Martins, 2018). The results came from the direct impact of Report 977/1965, as the document provided a precise shape for graduate education; one that higher education institutions could use as a guide to implement real change in the Brazilian science system (Sucupira, 1980).

From the observed growth, it is relevant to note the significant number of master's courses. At the time, they were seen as the most efficient way to quickly address the pressing need to form new scientists in Brazil. Although the Sucupira Report (1965) recounts objections among its authors on the adoption of the master's level in Brazil, the courses were not only embraced but also shaped resembling a short doctorate. As the model endures today, one may argue that the master's degree is still of high relevance to Brazil, both from the formative and scientific perspectives.

2.3 The research system as public policy

The Sucupira Report (1965) was able to advance previous efforts to develop Brazilian graduate education. Further initiatives recognised its value, either by confirming or strengthening its main concepts (Sucupira, 1980). The university reform of 1968–1969, for instance, established that academic degrees would be among the main criteria for admittance and progression in the teaching career. The same reform also stipulated that universities should institute programs to improve teaching staff, creating a demand that would further stimulate the growth of the graduate system (C. B. Martins, 2018).

Another relevant initiative to advance science in Brazil came with the foundation, within the structure of the Ministry of Education and Culture, of the National Council of Graduate Education (CNPG). Created by Decree 73.411 (BRASIL, 1974a), the council was formed by two ministers (education and planning); presidents and directors of institutions such as CAPES, CNPq, BNDE and CFE; and by presidents from two public and one private universities. These distinguished members were in charge of: i) elaborating a National Plan for Graduate Education (PNPG), ii) proposing the necessary measures to execute and regularly update such plan.

2.3.1 The National Plans for Graduate Education

According to the initial diagnostics of the National Council of Graduate Education, the observed expansion of the Brazilian science system had been partially spontaneous, somewhat unbalanced, and pressured for conjunctural reasons. This differed from the intended coordinated form, although CAPES had been making efforts, from its very foundation, to understand and act on the needs of the country. Changing this scenario to one of stable and balanced growth would require graduate education to move up in the national agenda, by becoming the object of state planning. For that, the idea was to issue continuous and subsequent National Plans for Graduate Education (PNPG) that should be recognised as guides for future initiatives and efforts on the issue (CNPG, 1974).

The PNPG 1975–1979 was then published in 1974, containing contextual analyses of the graduate system and a series of goals established according to the

priorities at the time. The document included measures to be taken at all institutional levels of coordination, planning, execution, and regulation of graduate activities. Mostly, the first PNPG reinforced main concepts already presented in this study, such as the need for graduate courses to address development demands; the aim to better train university teachers, highly qualified personnel for all sectors, and researchers for scientific work; and the need to keep education and research integrated within all levels. Nevertheless, some major policy decisions from the PNPG 1975–1979 (1974) would continue to shape the Brazilian National System of Graduate Education:

i) Graduate students are trained professionals who could choose the job market instead of continuing their studies, so the path to master's and doctorate degrees must be attractive. Most students should work full-time on a scholarship robust enough to meet their needs. CAPES, CNPq and other agencies should design a harmonious policy to meet these demands and the funding requirements of research programs;

ii) The primary funding for research and graduate education should come from the higher education institutions themselves. This involves costs with infrastructure, personnel (professors' salaries included), expenses with teacher training programs, etc. Resources from government agencies such as CAPES and CNPq should be seen as complementary;

iii) The expansion plan for graduate education should be based on efficiency. This meant the general rule for new courses was to prioritise established universities, rather than isolated research centres, as these presented only a subset of the activities in the educational-scientific work matrix. From the perspective of investment, the criteria were to consider the greatest possible multiplier effect, meaning that smaller budget increases for universities would probably yield larger results. Finally, the PNPG considered the costs of graduate education too high to be maintained with resources from school fees, while maintaining good quality levels. Thus, government support for graduate courses in private institutions would be considered only for particular fields and situations;

iv) The accreditation of graduate courses had been a plan since the Sucupira Report (1965), which believed it was necessary to guarantee the quality level within the system. At the time of the first PNPG, the Federal Education Council was in charge of this process, but it was carried

out *a posteriori*, lacking the appropriate mechanisms and procedures to be successful (Balbachevsky, 2004). The plan identified this limitation and called for an analysis of future alternatives, leading to a transfer of responsibility to CAPES.

In the complexity of a PNPG, some goals and consequent actions were significant for the design of a national science policy. For example, the section about the current state of SNPG will show that items (ii) and (iii) have led the system to a scenario where the majority of graduate education is concentrated in a few institutions, mostly public universities. Additionally, as much as item (iv) has led to immediate action, pushing for a new evaluation system within CAPES, item (i) is a goal yet to be achieved, as only about half of the master's and doctoral candidates have got access to a scholarship, even today.

2.3.2 CAPES, evaluation and the future of the PNPG

From 1964 to 1985, Brazil was under the rule of an authoritarian military dictatorship. While similar regimes in Argentina, Chile and Uruguay dismantled public universities (Hostins, 2006), in apparent contradiction, Brazil strengthened science, technology and higher education (Schwartzman, 1991). The first National Plan for Graduate Education came in 1974 as a critical step in this direction, but that was also an important year for CAPES. At that time, the agency was restructured, acquiring a new level of administrative and financial autonomy that would help carry out its new mission of evaluating graduate courses (BRASIL, 1974b).

In an effort to improve the quality assessment conducted by the Federal Education Council, CAPES conducted the first general evaluation of graduate courses in 1976. At the time, the agency had to decide on the allocation of student scholarships, and, instead of focussing on individual level assessments, it evaluated the quality of graduate programs as a whole, providing block grants to research units according to their achievements. By connecting performance with funding from the very beginning, the evaluation system was built as a powerful science policy instrument in Brazil, capable of steering the SNPG in the direction proposed by the national plans. To this day, a good performance in evaluations improves the chances of substantial support in student scholarships, research infrastructure, and funds (Balbachevsky and Schwartzman, 2010).

The evaluation system launched by CAPES at that time became a periodic, widely publicised process that has been improved at every cycle. Although it has acknowledged shortcomings, the system engages the academic community in committees using mixed methods to determine quality levels considering differences between fields of knowledge (Balbachevsky, 2004; Rothen, 2019).

The complexity of such evaluation cannot be briefly captured, and we shall dedicate a whole study to investigate its evolution and current perspectives, in a similar way to what we have done for this chapter. The important message that should remain for now is that CAPES' evaluation was converted into one of the most effective instruments to build the foundations of the Brazilian scientific community and guide its growth in the decades to come (Schwartzman, 1991).

In addition to the recently acquired evaluative role, by 1981 CAPES experienced yet another progression in its strategic importance in science policy (Hostins, 2006). At the time, Decree 86.791 extinguished the National Council of Graduate Education, transferring all of its responsibilities to CAPES, including the formulation of the new National Plan for Graduate Education (BRASIL, 1981).

The II PNPG was then published for the 1982–1985 period. The document expanded and updated the goals presented in the first plan, but now emphasises the need to further assess the quality of graduate education. The evaluation system under development would then become more expressive with increasing participation of the scientific community. Furthermore, the new plan would provide additional support for research infrastructure, more financial stability, and autonomy for graduate courses, and, for the first time, would contemplate strategies to reduce institutional and regional asymmetries (CAPES, 1981).

By the end of the II PNPG coverage, Brazil had once again become a democracy. That was a time of stability for CAPES, without any significant direct impact from the regime transition. As a consequence, the PNPG 1986–1989 was, as its predecessor, built mainly on a base of updated and incremental goals. The III PNPG hardened the criteria for the accreditation of new courses, while proposing inductive action in strategic areas. It recognised shortcomings of the original scholarship policy, both in coverage and in the loss of purchasing power over the years. The plan also enhanced the role of the evaluation system to fight high student dropout rates, long graduation times, low overall performance, etc. On top of that, evaluation should also guide an increase in investments in the best courses, with the aim of improving their productivity (CAPES, 1985).

In addition to such incremental ideas, the plan registered a concern that would become quite influential in shaping the SNPG: there was an undesired dependency of short-term extra-budgetary resources for research within HEI. According to the PNPG, the issue created instability for research groups, often leading to temporary or permanent interruption of their work. In addition to that, institutions and researchers had spent too much time on the continuous development of fund-raising projects. The proposed solution was to highlight specific funds for research and graduate studies in institutional budgets.

The result was a reinforced idea of research centres within HEI, without base funding concerns, and counting with dedicated resources, infrastructure, and personnel. Additional investments, including scholarships, would come from agencies such as CAPES and CNPq, and were usually linked to the centre's performance. These research centres must include a master's or doctorate degree, often both, and are officially known as graduate programs (PPG).

One of the characteristics of such graduate programs is the overall absence of the "researcher" figure. As peculiar as it seems, one of the consequences of the ever-present integration between education and research is that, in PPG, researchers invariably fit into two categories: students or professors. Considering that most of these programs in Brazil are within public universities, the most common path to become a professor is through public tenders.

The idea that every citizen could have the ability to work for the government solely on the basis of "talents and virtues" was first introduced by the Imperial Constitution of 1824. This concept would be refined over time to determine that access to public employment would depend on prior approval in an open selection based on exams and academic degree analysis, whenever relevant. According to the current constitution, from 1988, such tenders are mandatory for most government jobs, except office nominations or select positions of trust. This process aims to eradicate any gender, race, social, or age discrimination in government hiring. In addition, to ensure security in the face of potential political influences, public servants acquire stability after an evaluation period, usually of three years (BRASIL, 1988). Although not perfect, the process allows professors to be hired according to explicit criteria, with the possibility of gaining tenure after a short period of time.

The constitution of 1988 also formalised other relevant concepts. First, article 207 confirmed that i) "universities enjoy didactic-scientific, administrative,

financial and patrimonial autonomy"; and ii) "they will obey the principle of inseparability between teaching, research and extension". Then, article 209 established that iii) "the private initiative can offer educational services, but are required to a) comply with the general rules of national education, and b) submit to authorisation procedures and quality assessment by the Government".

2.4 The latest chapters in designing the SNPG

The 1980s were very prolific for the evolution of the science system in Brazil. The military government had a nationalist ideal of turning the country into a world power, which motivated the push for a Science & Technology agenda (Rothen, 2019). This plan advanced in the first years of the democratic regime, but Latin America had been experiencing what became known as "the lost decade", a period of successive economic crises that dominated the region. In Brazil, that was actually one of the reasons for the political impasse that ended the military dictatorship, and the effects of such crises would eventually reach the science system as well (Ferreira and Moreira, 2002).

A significant sign of that came with the 1990 federal government restructuring, in which CAPES was extinguished (BRASIL, 1990b). Due to the negative repercussions within universities and the decisive action of the academic community, the agency was re-established in less than a month (BRASIL, 1990a) and later acquired public foundation status (BRASIL, 1992). Despite this renewal that even improved CAPES' standing in the federal structure, in the early 1990s Brazil was facing hyperinflation, reaching the mark of 80% a month, at one point. That was a time for restraint and, although the main characteristics of the current SNPG had already been shaped, the next chapters of this history would be put on hold for a few years.

The IV PNPG, for example, would only come into development in 1996. The new document would try to resume the evolution of the system, deal with structural factors hampering its performance, focus on the identification of asymmetries that need to be addressed, push for greater integration among S&T organisations. Despite the extensive discussion around a preliminary version, the enduring crisis and the lack of articulation among the funding agencies at the time would lead the final plan to be abandoned (CAPES, 2004).

Although no official PNPG would be published until 2004, CAPES acted on a series of recommendations from the plan's draft (Hostins, 2006). Among them, the proposal to diversify the graduate education model would lead to one last significant addition to the PNPG before the turn of the century: the professional master's courses (CAPES, 2004).

2.4.1 The professional modality of graduate courses

The Sucupira Report (1965) determined master's courses could be seen as a terminal degree, helping to advance the abilities of professionals, or as a preliminary stage in the path to the doctorate. After performing an analysis of how such courses developed over three decades, CAPES was concerned that the dynamics of graduate education had led these courses predominantly to the second category, and the master's degree was not fulfilling their whole intended purpose (CAPES, 1995b).

After three years of discussion within the agency and with the academic community, CAPES issued legislation creating a new type of graduate course: the professional master's. The modality was designed to apply the high-quality level *stricto sensu* approach to the training of professionals interested in problem solving by advancing existing knowledge (CAPES, 1998). To understand the different perspectives of academic and professional modalities, the Stokes (1997) quadrant model of the relations between basic science and technological innovation, seen on Figure 2.1, can be applied.

		Considerations of use	
		No	Yes
Quest for fundamental understanding	Yes	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)
	No		Pure applied research (Edison)

Figure 2.1.: Quadrant model of scientific research, as proposed by Stokes (1997, p.73)

Stokes (1997) categorises research according to the search for fundamental understanding and by considerations of use. From this perspective, academic graduate courses in Brazil can be classified in Bohr's Quadrant, as they strive for the advancement of scientific knowledge without pressing concern with immediate application. On the other hand, the professional master's were designed to actively pursue knowledge toward immediate application, thus existing within Pasteur's Quadrant. The final quadrant, Edison's, might be appropriate to describe the *latu sensu* courses, as they focus on the training of professionals based on already established knowledge.

Over the years, there has been much debate in academia about the validity of the professional modality, with advocates on both sides of the discussion (Ferreira and Moreira, 2002). Despite the opposition, these courses have become quite representative within the SNPG, even in their role of producing more applied research outputs (Brasil, 2018). As a consequence, in 2017, the Ministry of Education authorised the professional modality at the doctoral level (MEC, 2017). By August 2020, CAPES had already accredited 53 of these courses, complementing the 873 professional master's in the system. (CAPES, 2021c).

2.4.2 Centralising access to scientific literature

From what has been presented so far, it becomes evident that the Brazilian SNPG is organised in a top-down structure, where government institutions have the power to enact their ideas by controlling the budget, the evaluation system and the legislative authority to promote changes. A significant example of the potential and dangers of such reality may be found in the Portal of Journals.

The Ministry of Education created, in 1990, a national program to support higher education institution libraries. Five years later, a funding program for journal acquisition was designed as a joint initiative of MEC, CAPES, CNPq and the Funding Authority for Studies and Projects (FINEP). The goal was to extend access to scientific literature for libraries related to graduate education. CAPES would deal with editors and subscribe to journals that would be sent directly to each participating institution (CAPES, 2020c; de Almeida et al., 2010).

Despite delays in journal acquisitions, mostly because HEI requests would often take longer than desired, the model worked well until 1999. At that time, a 53% cut in the program's budget enhanced challenges from the ongoing devaluation

of Brazilian currency against the US dollar. There was a need for reform, and the Internet became a possible solution, as most scientific publishers were already digitising their collections (de Almeida et al., 2010).

From the restructuring of the acquisition program, the Brazilian Portal of Journals was launched in November 2000. With it, the 72 institutions offering graduate education at the time gained access to 1.419 digital journals at first. The Portal adopted a centralised acquisition model to optimise processes, improve bargaining power over publishers, and generate economies of scale. In addition to that, it also helped reduce asymmetries, as institutions would have access to the same collections, regardless of their size, budget, or location (CAPES, 2020c).

By the end of 2019, the Portal already provided access to 426 HEI, covering 49.247 journals; 331.565 documents such as books and reports; hundreds of databases of publications, patents, statistics and media; and more (CAPES, 2020c). Data from Geocapes (2021e) show nearly 190 million accesses to the Portal in 2019 alone, including over 59 million full-text downloads; all that with a yearly budget of around 100 million US dollars (CAPES, 2020b). Despite this success, at the time of its launch, there was little support from academia, as only the Brazilian Society for the Advancement of Science favoured the idea (de Almeida et al., 2010). Without the centralised, top-down structure of the Brazilian science system, the Portal would probably never exist.

Although direct action from the government and its top agencies has been able to shape and develop the SNPG, experience shows that such power comes with risks. For example, high managers at CAPES have consistently reported how changes at various levels of government have led to questions about the very existence of the Portal of Journals (SBPC and ABC, 2020a).

An example of such threats came in 2015, with the announcement of budget cuts to the Portal in the following year. At the time, SBPC, ABC and seven other scientific entities sent a letter to the minister of education, stating "it would be inconceivable for the country to be devoid of an instrument so relevant to the regular functioning of our education, science, technology and innovation system" (Nader et al., 2015). Fortunately, such initiatives helped contain threats not only to the Portal of Journals, but also to several core components of the SNPG. Nonetheless, there is always the apprehension that misguided actions could change all that.

2.5 The SNPG today

The historical panorama shows that the evolution of the Brazilian National System of Graduate Education has resulted from decades of coordinated work from CAPES, CNPq, MEC, higher education institutions and other actors. Although they have continued to be active in the past twenty years, the core design of the graduate system was established, and most of the actions not covered in this study had only incremental effects on the evolution of the system.

For instance, in the 21st century, the PNPG have continued to give macro-political direction for research and graduate education, through diagnoses and the establishment of conceptual and practical goals. So far, two additional plans have been published, one for the period 2005–2010 (CAPES, 2004) and the other with a decade-long coverage of 2011–2020 (CAPES, 2010). Both have proposed strategies for the induction of vital research areas, to improve the performance of the system, to expand financial support to programs, to evolve evaluation for better quality assurance, etc.

Although the most recent PNPG did not play the same role in shaping SNPG as its predecessors, they have been essential to guide the impressive growth of the system presented in this section. Here, we examine information obtained from different national databases to see what the system has become. In particular, we will work with CAPES ' integrated system of graduate education data – Sucupira Platform (2021c); and the Georeferenced Information System of the Agency, Geocapes (2021e).

2.5.1 Graduate courses and programs

All basic research conducted in Brazil takes place within the realm of graduate education, and the same is true for around 95% of all S&T research in the country (SBPC and ABC, 2020b). As we have discussed, such a graduate system is organised around graduate programs (PPG): research centres offering either or both a master's and a doctorate, always in the same modality (academic or professional). Such PPG are necessarily part of higher education institutions.

As Figure 2.2 shows, this century has been quite significant for the growth of this system. From 2001 to 2020, the number of graduate courses has gone from

3.292 to 7.146: a 117% increase. At the time the data extraction took place, 4.601 of these courses were master's (3.728 academic and 873 professional) and 2.545 were doctorates, 53 of those in the professional modality.

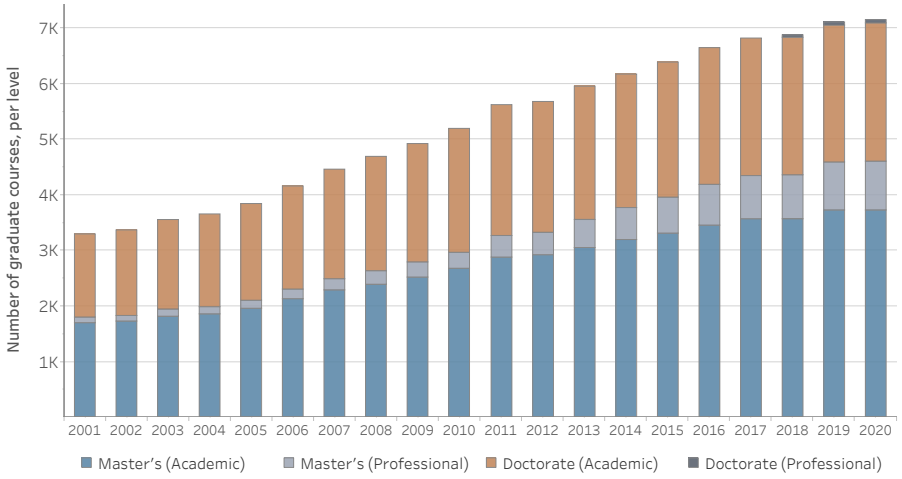

Figure 2.2.: Number of graduate courses active per year (2001 – 2020)

From the PPG perspective, the 7.146 courses active in 2020 are organised into 4.690 graduate programs, according to what is displayed in Table 2.1.

Table 2.1.: Organisation of active courses into graduate programs (2020)

Modality \ Level	**Master's**	**Doctorate**	**Master's & Doctorate**
Academic	1.322	86	2.406
Professional	823	3	50

Although the Sucupira Report (1965) established isolated doctoral courses to be acceptable, even desirable for specific fields, Table 2.1 shows that there are only 89 programs in this situation. On the other hand, the number of PPG with only master's courses is quite significant in the Brazilian National System of Graduate Education, serving as evidence of the importance of such courses for the development of science in Brazil.

Taking into account the perspective of graduate programs, Figure 2.3 shows the geographical growth of the system, contrasting the current distribution of PPG with that of 1975, the first year of coverage of the original PNPG.

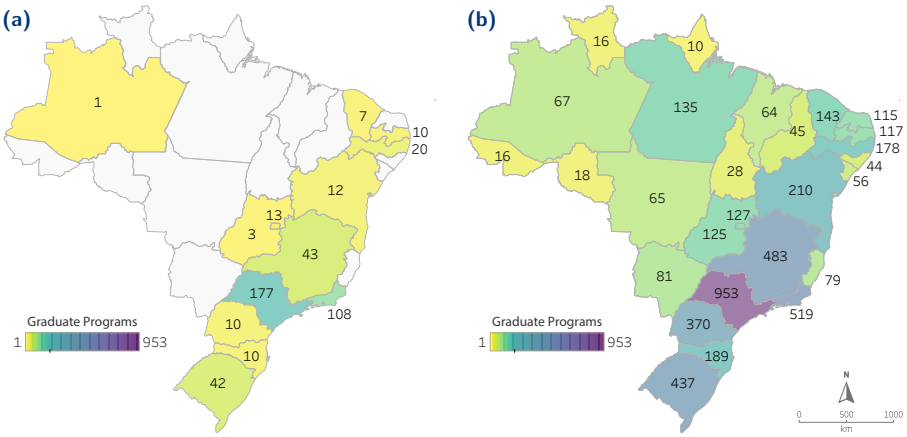

Figure 2.3.: State distribution of graduate programs in Brazil, in: (a) 1975; and (b) 2020. Data source: Sucupira Platform (2021c).

The contrasting maps included in Figure 2.3 show a considerable improvement in the distribution of graduate education. In 1975 (a), we can see that more than half of the Brazilian states did not count with a single program, and by 2020 (b) all of them were contemplated. If the dispersion of the population is considered, the current distribution is even more balanced, and we can use the state with the most PPG as an example: São Paulo hosts 953 programs (20,3% of the total), while containing 21,9% of the country's 210 million inhabitants, according to recent estimates from the Brazilian Institute of Geography and Statistics (2021). On the other extreme, at the north of the second map, we see the state of Amapá, with only 10 programs. Although a 0,2% representation is far from adequate, the discrepancy seems less extreme if we consider the fact that the state accounts for only 0,4% of the country's population.

Despite the scenario presented by a state-based analysis, a city-based distribution of graduate programs makes an unbalanced configuration apparent. In Brazil, out of 5.570 municipalities, only 307 count with graduate education, as can be seen in Figure 2.4. This distribution of courses reflects a concern that had already been highlighted by the PNPG 2011–2020: Research centres are still too concentrated in metropolitan regions, notably in coastal areas (CAPES, 2010). This new map makes the fact more noticeable because it shows how states with large numbers of courses have already achieved some interiorisation,

while the others register substantial concentrations mostly at the state capitals. So, it is possible to say that Figure 2.3b reflects how far asymmetry reduction policies have come, but Figure 2.4 shows how far they still need to go.

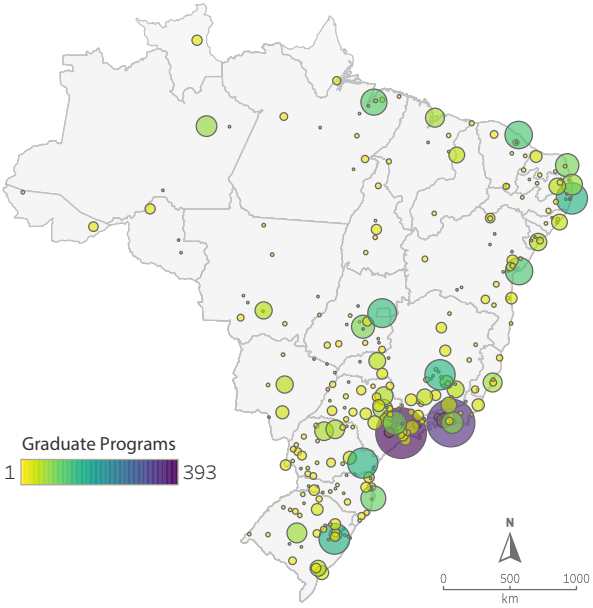

Figure 2.4.: Distribution of graduate programs per city

2.5.2 Higher Education Institutions

Higher education in Brazil had always been quite restrictive and only became a social priority in the 21st century. To increase access to the general population, a series of policies led to a tremendous growth in the number of higher education institutions, mostly through the expansion of private establishments (Rothen, 2019). In 2000, for example, Brazil had 1.180 HEI, but this number more than doubled by 2018, reaching a total of 2.537 institutions (INEP, 2020).

However, access policies that led to institutional expansion focused mainly on the undergraduate training of professionals, while the graduate system continued to be very meritocratic and restricted to a few HEI. As a result, only 432 of the 2.537 institutions currently offer graduate education. More than that, as a direct result of policies that prioritise investments to develop research

within universities and large institutions, there is a significant concentration of graduate programs in a small group of these already select HEI.

The Pareto chart in Figure 2.5 confirms such perception, showing the accumulative contribution of every one of the 432 higher education institution to the whole graduate system, in descending order. Each colour represents 20% of the total number of programs.

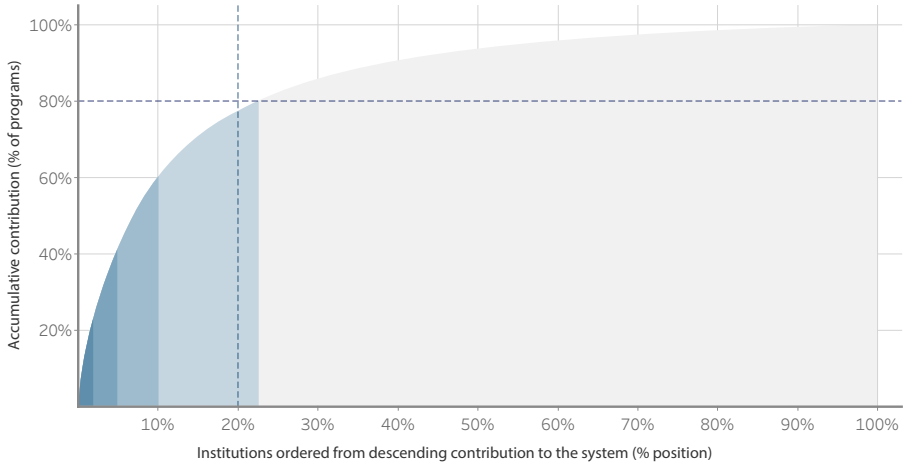

Figure 2.5.: Pareto chart on accumulative number of graduate courses, per HEI

From Figure 2.5, we can conclude that nearly 80% of all graduate programs are offered by 20% of the institutions. Looking at the first colour group, the situation is even more impressive, as 20% of the PPG can be found in just seven universities[1]: USP, UNESP, UFRJ, UnB, UFRGS, UFMG and UFPE.

Taking into account the policies that prioritised the expansion of graduates in public institutions, the top seven HEI were expected to be public. In fact, in the ranking of institutions with the most PPG, there is only one private university within the top 10%, and it comes in the 40th position in the list: The Pontifical Catholic University of Rio de Janeiro (PUC-Rio), which offers 34 distinct programs. For a better understanding of the public versus private dimension of graduate education, Figure 2.6 details the higher education institutions according to type.

[1] Explore the interactive dashboard at https://andrebrasil.net/publication/building-the-snpg/

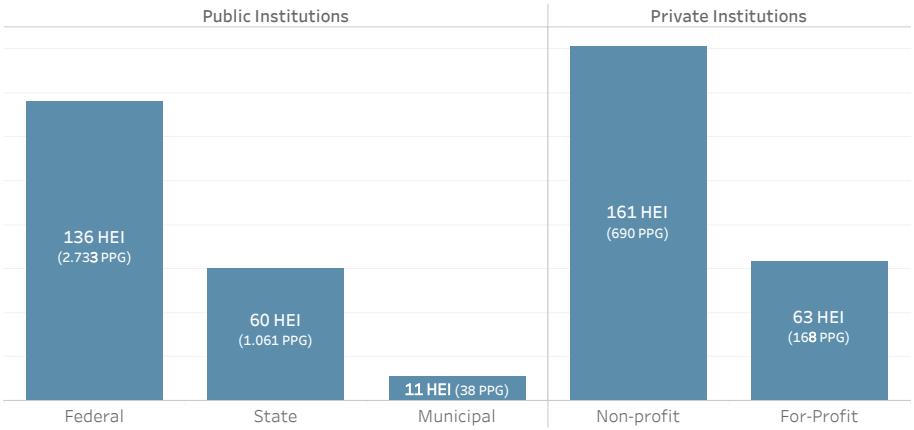

Figure 2.6.: Higher Education Institutions (HEI) in Brazil with active graduate programs in 2020, and the total number of PPG offered.

Of the 2.537 Brazilian HEI active in 2018, 2.238 (88,2%) are private (INEP, 2020). Figure 2.6 shows a different scenario for those involved in research, as this percentage drops to 52%. Although the number may still seem significant when considering the research policies discussed throughout this chapter, it is important to note that only 18,3% of all courses are found in private institutions. Besides that, 69% of all public HEI in the country offer at least a master's or doctoral course, while only 10% of private ones do the same.

The first PNPG stated that the costs to offer graduate courses are too high for institutions that rely on student tuition (CNPG, 1974). In Brazil, these are private organisations subdivided into two categories: non-profit and for-profit. The first group includes philanthropic and community HEI, as well as those with some religious orientation. They hold 80,4% of the programs offered by private institutions: an average of 4,28 per HEI, versus 2,7 in the for-profit group. In addition to the financial aspect, another element that could contribute to the minor involvement of private institutions in research and graduate education is their faculty profile, as discussed in the following.

2.5.3 Faculty

According to the 2018 educational census (INEP, 2020), the Brazilian higher education system counts with 384.474 faculty members, 173.868 working for

public institutions and 210.606 for private ones. The workforce in the private sector is relatively smaller, averaging 95 faculty members per institution, while 581 are recorded in the public sector. Another difference is that the public side prefers full-time employment contracts (86,4%), while the private side prefers part-time (42,4%) and hourly contracts (30,1%). Finally, most of the faculty in public higher education institutions hold doctoral degrees (64,3%) while in private ones the master's degree is the predominant higher level (50,1%, against 25,9% with a doctorate). As the workforce available for research activities in private HEI appears to be smaller than in public ones, this can be an obstacle to implementing new graduate programs.

Considering faculty members active in graduate education, data from the Sucupira Platform (2021c) show there were 81.639 professors working in Brazilian PPG during the 2017–2018 biennium. Of these, 99,1% held doctoral degrees, and their distribution by gender and age group can be seen on Figure 2.7.

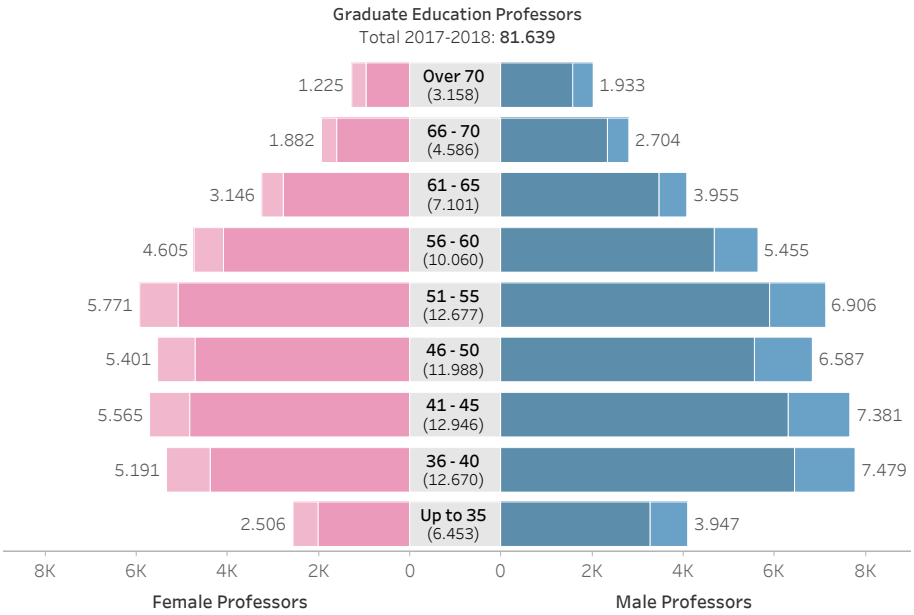

Figure 2.7.: Age and gender distribution of graduate education professors in Brazil (2017 – 2018). Lighter colours highlight those working for private HEI.

One of the first things we notice from the pyramid of faculty members is that the lighter parts of the bars, representing professors working for private institutions,

are much smaller than the darker colours. In the 2017–2018 period, 85,7% of all faculty members worked for public institutions (which is not far from their 82% share of courses).

Another evident perception from Figure 2.7 is the skew towards the male side, which represents 56,8% of the total number of professors. The reasons for this are undoubtedly complex and are not the object of the present study. Regardless, we can propose two variables for future investigation:

i) The rules for retirement in Brazil differ by gender, as men generally work longer. They contribute an average of five more years to social security, which can lead to a gender imbalance in academia. This perception might be supported by a study conducted by Waltman et al. (2019), analysing the length of academic life according to gender (1998–2018). Such research shows above average dropout rates for women in Brazil, a fact that might be influenced by age of retirement;

ii) Maternal roles can also be a factor in gender asymmetry, as the relative representation of women increases along the earliest age groups. This hypothesis seems particularly promising when comparing all female professors in higher education with those acting in graduate programs. Considering only professors holding a doctoral degree, women up to 35 years of age represent 49,96% of the entire higher education system, but only to 38,8% of graduate education professors. For the next age group, 36–40, women represent 48% of the higher education system but only reach 41% in graduate education (CAPES, 2021e; INEP, 2020). How much of this difference comes from the choice to keep away from research while still holding a professorship may account for part of the gender imbalance.

2.5.4 Student Body

As the science system in Brazil is connected to the training of highly-qualified personnel, one of the leading indicators to determine its success comes from the number of students enroled or graduating from master's and doctoral courses. Taking into account the explosion of such programs over the past two decades (Figure 2.2), the resulting number of candidates was expected to follow. In this sense, Figure 2.8 shows the last 20 years of official data on enrolment at different levels and modalities of graduate courses (CAPES, 2021e).

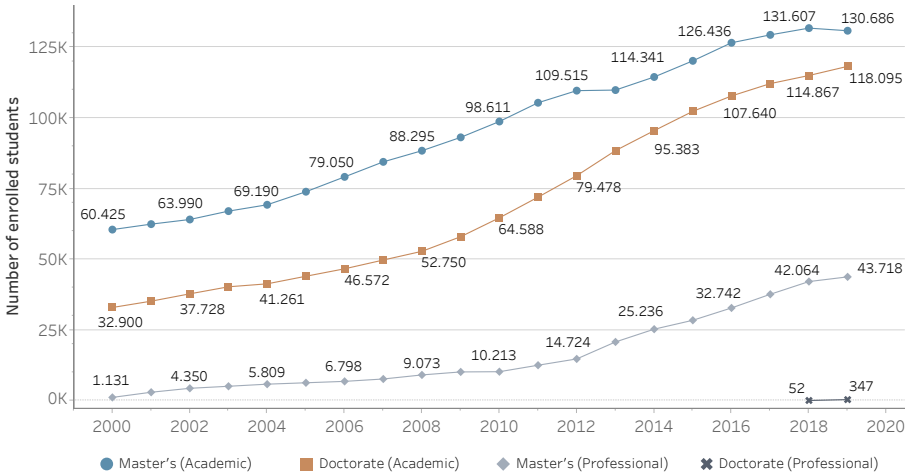

Figure 2.8.: Number of students enrolled in different levels and modalities of graduate education (2000 – 2019)

From 2000 to 2019, the growth in the number of graduate candidates enroled was of 210%. The results are remarkable and the professional courses seem of particular value. The modality was first authorised for the master's level in 1998, and the number of 1131 students in 2000 expanded to nearly 44 thousand in twenty years. One of the reasons this increase is notable is the fact that professional courses, even though tuition-free in public institutions, are not funded by scholarships. It remains to be seen whether the first recorded number of professional doctorate candidates, 52 in 2018 and 347 in 2019, will also experience this growth.

Regarding scholarships, earlier PNPGs proposed to fund all candidates in academic courses, but the plan has never become a reality. In 2019, CAPES granted 44.238 master's and 43.327 doctoral scholarships (excluding international grants), while CNPq provided an additional 13.402 and 11.252 for the corresponding levels. According to data from the National Council of State Funding Agencies (CONFAP), the state system also contributed with 13.536 scholarships (7208 for master's and 6328 for doctoral levels). Together, these agencies covered 51,6% of doctoral and 49,6% of master's students in academic courses, and any additional contribution from other sources, although welcome, would not be representative to impact the overall figure (CAPES, 2021e; CNPq, 2020; Dellagostin, 2020).

An additional aspect to note is that more women benefited from CAPES' scholarships in 2018, since they received around 53% of the master's and doctoral grants provided by the agency (CAPES, 2021e). The impact of this funding is aligned with the results of a bibliometric study considering trends of new researchers entering the science system (Waltman et al., 2019). The investigation indicated that by 2018, approximately 53% of new Brazilian researchers were female, which is quite a significant number considering that the global baseline is around 40%.

Despite the limitations in financial support for all students, the number of graduates each year has also been growing, as Figure 2.9 shows.

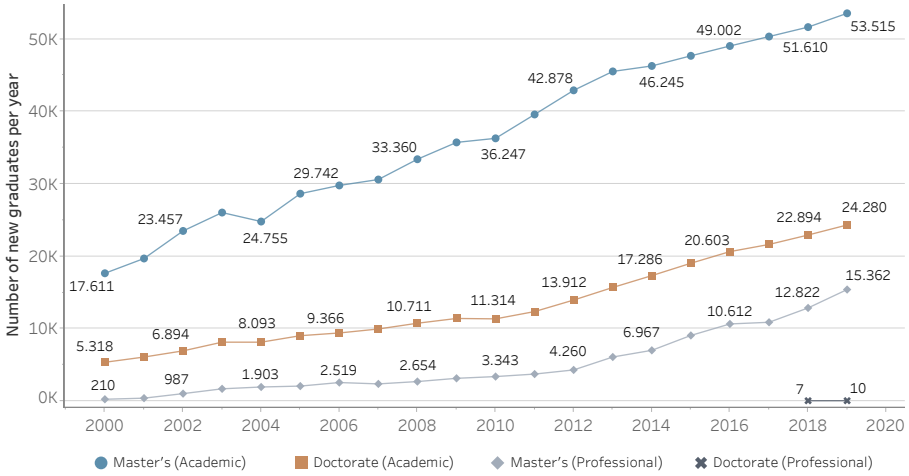

Figure 2.9.: Number of students graduating at different levels and modalities of graduate education (2000 – 2019)

As defined by the National Education Plan (BRASIL, 2014), Brazil established a goal to be reached by 2024: to graduate a minimum of 60.000 masters and 25.000 doctors per year. As Figure 2.9 shows, the desired number for the master's level had already been surpassed by 2019, with 68.877 graduates. For the doctoral level, the number was slightly below the mark, with 24.290 graduates. Although the COVID-19 pandemic might have an impact on the number of degrees awarded in 2020, considering the recorded number of PhD candidates and the four-year duration of the courses, the goal might still be reached before 2022.

2.6 A brief overview of the SNPG's impact

In recent years, several studies have discussed the evolution of one of the most evident results of the Brazilian National System of Graduate Education: its scientific production. The topic has been explored by this century's National Plans for Graduate Education (CAPES, 2004; CAPES, 2010), as well as by authors such as Balbachevsky and Schwartzman (2010) and de Almeida and Guimarães (2013) and others. These studies show a significant growth in Brazilian production, which eventually led the country to be among the top 15 in the world in the number of scientific publications.

A recent report from Clarivate Analytics (2019) analysed Web of Science data (2013–2018), ranking Brazil as 13th in the world in the output of research papers, ahead of countries such as the Netherlands (14th) and Russia (15th). Data from the report corroborate the narrative and findings presented in this research, for example, by showing that around 60% of the country's scientific production comes from only 15 institutions, all of them public universities. The report also shows a growth of 30% in the number of papers published by Brazil in the analysis period (twice the average growth in the world). This is consistent, for instance, with the observed increase in graduate education enrolment and the number of graduates in the same period.

The growth of Brazilian science above the world average is a positive result for the SNPG, but absolute numbers should be interpreted with caution. For example, while Brazil has a slightly larger scientific production than the Netherlands, the country immediately behind it in the Clarivate ranking (2019), Brazilian population surpasses 210 million people, more than 12 times more than the European nation. From this point of view, in the 2013–2018 period, Brazil produced around 130 papers per 100.000 population, while the Netherlands published more than 1.500. This relative perspective shows that Brazilian science is further from the top than we would expect from looking at such a simple measure as the number of papers published.

Another insight from the comparison of the scientific production from Brazil and the Netherlands relates to publication impact. An analysis of WoS data for the two countries shows that they perform quite differently in terms of the PP(top 10%) indicator: a common proxy of research excellence based on the percentage of publications in the world's top ten percent of highly cited papers.

From 2013 to 2018, Brazil performed under the expected value of 10% (6,9%), while the Netherlands exceeded it (15,3%).

The analysis also shows that internationalisation is an important component in increasing the impact of Brazilian publications. Taking into account papers published in collaboration with international partners, Brazilian PP(top 10%) increased to 12,2%. When cooperating with select countries such as the Netherlands, Australia, and Japan, the results were even better, surpassing 20%. That may suggest that finding strategic international partners can increase the impact of Brazilian research, at least from a scientometric point of view.

Nevertheless, this chapter indicates the SNPG may not be a typical representation of a standard science system. Thus, its impact must be measured from a broader perspective, for instance, by considering graduate education degrees granted annually. Research by the Centre for Strategic Studies and Management (CGEE, 2016) compared the number of doctoral graduates in Brazil with 27 OECD countries. In 2013, the year of data collection, Brazil issued 7,6 doctoral degrees per 100,000 people. This performance was ahead of Mexico (4,2) and Chile (3,4) only, and it was quite far from the group's median of 25,4 graduates per year. By 2019, Brazil had graduated 11,6 new PhDs per 100,000 population, much closer to what Japan (12,9), Turkey (11,5), and Hungary (10,8) were doing in 2013. If considered that CAPES' official Portuguese name translates as "Coordination for the Improvement of Higher Education Personnel", the results are not only positive, they are a reflection of the primary goals that contributed to the birth of the SNPG.

Another core concern discussed as a motivation for the design of the SNPG was Brazilian development. By 1995, CAPES analysed the evolution of graduate education and considered that there was a need to improve the participation of scientific research in the country's economic and social development (CAPES, 1995b). The envisioned solution became a professional modality of graduate program (CAPES, 1998). Whether due to the effect of this new modality or the mentality that led to its creation, Clarivate's report (2019) shows how, after decades of slow expansion, industry collaboration in academia started to grow exponentially at the turn of the century. Looking at the ten higher education institutions that collaborate the most with authors from the industrial sector, joint publications went from around 160 per year, by 2000, to nearly 1600 in 2017. The numbers are still modest, but the observed growth offers promise.

From an industry perspective, Petrobras was responsible for 14% of the collaborative output (2015–2017), due to a strong integration program with universities. However, dozens of other national and multinational companies have been collaborating with Brazilian academia in the pharmaceutical, agricultural, and many other sectors (Clarivate Analytics, 2019). More than that, there are many success stories of strong bonds formed between industry and the SNPG, and among them is the strategic partnership between the Aeronautics Institute of Technology (ITA) and the Brazilian Aviation Company (Embraer).

With the commercial success of its first regional jets, Embraer started the 21st century investing in a specialisation program for the development of its aeronautical engineers. Due in part to the elevated costs of the program, a better solution was in order, and it came from a collaboration with ITA, a study centre founded in the 1950s inspired by the model adopted at the Massachusetts Institute of Technology (MIT). ITA became a national benchmark in developing aeronautical technologies, and its joint professional master's degree with Embraer was accredited in 2003. The course has been so successful that Boeing wanted a guarantee of its maintenance in recent negotiations for the purchase of the Brazilian company (Barata, 2020; de Andrade et al., 2005).

Although the growing industry collaboration with academia may be a recent development, its impact is becoming more evident every year. From a multidimensional perspective, its combination with the social, economic, scientific, publishing impacts may add to a better perception of a more precise picture of the contribution of SNPG to Brazil and the world.

2.7 Conclusion and perspectives for the future

The Sucupira Report (1965), while building the core definitions of the future SNPG, stated that Brazil was yet to create a tradition in graduate education. The present study aimed to achieve a better understanding of the long-term historical process crafting such tradition. As comprehensive as it was intended to be, it is far from complete, as the subject could easily justify a lifelong investigation. What was possible within this chapter was to recount critical moments in history that shaped how science is done in Brazil, especially in its relation to graduate education. From this research, we can understand some of the

reasons behind the design of the system, as well as its most peculiar aspects. The following paragraphs summarise part of these findings.

First, **the Brazilian science system was not a spontaneous creation**. It was built as a result of mostly consistent public policy, developed over multiple regimes and governments for several decades. The resulting system is a unique product of social, political, and economic conjunctures, and the path behind it can never be ignored moving forward.

Secondly, **the SNPG is the science system in Brazil**. For more than a century, the core idea of having the university as the house of science has guided policy in the country, to the point that the indivisibility of research and education became a constitutional matter. As a direct consequence, the entire science system was structured around graduate education, and the master's and doctoral courses are responsible for the absolute majority of the national S&T research.

In the third place, **the SNPG has, until recently, been too academic**. Although the pursuit of development has motivated much of the significant science policy in Brazil, the idea of the type of research that is applied to solve social and economic problems began to expand only in the past two decades. This is probably the result of funding models, faculty hiring methods, limits of the evaluation model, and pure tradition. A professional modality of the graduate course was implemented in 1998, with the aim of promoting balance. The results have been promising at the master's level. Despite lingering opposition, the first professional doctorates have joined the system in 2017.

Fourth, **the SNPG numbers are significant**. There are 432 higher education institutions offering graduate education in Brazil. They are spread over 307 cities across all Brazilian states and hold 7.146 master's and doctoral courses organised into 4.690 graduate programs; 18,7% of which are in the professional modality. Furthermore, almost 80% of the programs are concentrated in only 20% of the HEI, most of them public. In terms of people involved, over 80 thousand professors are active in graduate education, supervising more than 290 thousand master's and doctoral candidates, which leads to over 93 thousand graduates every year (nearly 25 thousand of those at the PhD level).

In the fifth place, **the master's has always been essential in Brazil**. Despite the influence of the United States graduate system in the design of the SNPG, the Brazilian master's did not follow the American path that allowed such

courses to represent professional competence in fields such as Engineering or Business Administration. In Brazil, master's degrees were mostly implemented as minidoctorates, and they have performed a significant role in the development of science in the country. Even though the advent of the professional modality has addressed the need for applied approach in these courses, the geographical asymmetry of doctorates in Brazil makes the academic master's still quite relevant as a scientific degree across the country. While top institutions such as the University of São Paulo can justifiably decrease the role of the master's when used as a stepping stone towards the PhD, such experiences cannot be adopted as a policy for the whole country.

Finally, **the SNPG has both weakness and strength in the concept of change**. Throughout this study, we demonstrated how the Brazilian science system is organised under a top-down structure of influential government agencies promoting change through regulation, evaluation, and funding. Such centralised structures have the potential to promptly produce change as decisions can be easily disseminated, often even imposed, throughout the whole system.

From a weakness perspective, the SNPG faces a lingering concern of disruption from political motivations. For instance, the government elected to run the country from 2019 to 2022 has consistently criticised the value of basic science, in particular the Social Sciences and Humanities. As a result, priority plans for CAPES, MEC, CNPq and others have impacted whole disciplines ranging from Mathematics and Physics to Sociology and Philosophy. Several funding cuts led to the mobilisation of scientific entities who were hoping to have a voice capable of minimising long-term damage to the SNPG (Saldaña, 2020).

Despite the current apprehension around the system's susceptibility to change, the same property has benefited SNPG in the past. According to testimony from four CAPES' ex-presidents, with over 20 years of combined experience leading the agency, positive change comes from respecting critical ingredients (SBPC and ABC, 2020a). The first of them is treating science as a state policy, not as a government agenda. Continuity is key, as a research system cannot really develop when restricted to four-year terms. In addition to that, evolution must be incremental rather than disruptive and decision making should be based on a thorough understanding of the system. Finally, leading the SNPG must be a democratic effort, where policymakers and all levels of academia work together to implement plans for a better future.

Although the SNPG is still far from perfect, looking at the accomplishments and obstacles of its past, we can better shape the improvements for the future. Hopefully, the policymakers in charge of evolving the system will value such lessons, enabling Brazilian science to move forward.

References

ABE. (1929). *O problema universitário brasileiro: Inquérito promovido pela Secção de Ensino Technico e Superior da Associação Brasileira de Educação*. Rio de Janeiro: Encadernadora.

Balbachevsky, E. (2004). Graduate education: emerging challenges to a successful policy. In C. Brock & S. Schwartzman (Eds.), *The challenges of education in Brazil* (pp. 209–228). Oxford, UK: Triangle Journals.

Balbachevsky, E., & Schwartzman, S. (2010). The graduate foundations of research in Brazil. *Higher Education Forum*, *7*(1), 85–101.

Barata, R. B. (2020). Programas de pós-graduação profissionais: Por que precisamos deles? *International Journal of Business & Marketing*, *5*(2), 30–34.

BRASIL. (1891). *Constituição da República Federativa do Brasil*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1893). *Lei nº 173, de 10 de setembro de 1893. Regulamenta a organização de associações que se fundarem para fins religiosos, Moraes, scientíficos, artísticos, políticos ou de simples recreio, nos termos do art. 72 da Constituição*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1915). *Decreto nº 11.530, de 18 de Março de 1915. Reorganiza o ensino secundario e o superior na Republica*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1920). *Decreto nº 14.343, de 07 de setembro de 1920. Institue a Universidade do Rio de Janeiro*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1931a). *Decreto nº 19.850, de 11 de Abril de 1931. Exposição de motivos*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1931b). *Decreto nº 19.851, de 11 de Abril de 1931. Dispõe que o ensino superior no Brasil obedecerá o sistema universitário*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1931c). *Decreto nº 19.852, de 11 de Abril de 1931. Dispõe sobre a organização da Universidade do Rio de Janeiro*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1951). *Decreto nº 29.741, de 11 de julho de 1951. Institui uma comissão para promover a Campanha Nacional de Aperfeiçoamento de Pessoal de Nível Superior*. Diário Oficial da União. Rio de Janeiro, RJ.

BRASIL. (1961). *Lei nº 4024, de 20 de dezembro de 1961. Fixa as diretrizes e bases da educação nacional*. Diário Oficial da União. Brasília, DF.

BRASIL. (1974a). *Decreto nº 73.411, de 4 de janeiro de 1974. Institui o Conselho Nacional de Pós-Graduação e dá outras providências*. Diário Oficial da União. Brasília, DF.

BRASIL. (1974b). *Decreto nº 74.299, de 18 de julho de 1974. Dispõe sobre a Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) e dá outras providências*. Diário Oficial da União. Brasília, DF.

BRASIL. (1981). *Decreto nº 86.791, de 28 de dezembro de 1981. Extingue o Conselho Nacional de Pós-Graduação e dá outras providências*. Diário Oficial da União. Brasília, DF.

BRASIL. (1988). *Constituição da República Federativa do Brasil*. Senado Federal do Brasil. Brasília, DF.

BRASIL. (1990a). *Lei nº 8028, de 12 de abril de 1990. Dispõe sobre a organização da Presidência da República e dos Ministérios, e dá outras providências*. Diário Oficial da União. Brasília, DF.

BRASIL. (1990b). *Medida Provisória nº 150, de 15 de março de 1990. Dispõe sobre a organização da Presidência da República e dos Ministérios e dá outras providências*. Diário Oficial da União. Brasília, DF.

BRASIL. (1992). *Lei nº 8405, de 9 de janeiro de 1992. Autoriza o Poder Executivo a instituir como fundação pública a Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes) e dá outras providências*. Diário Oficial da União. Brasília, DF.

BRASIL. (2014). *Lei nº 13.005, de 25 de junho de 2014. Aprova o Plano Nacional de Educação*. Diário Oficial da União. Brasília, DF.

Brasil, A. (2018). Exploring differences in scientific production originated from professional and academic graduate courses in Brazil. In *Proceedings of the 23rd international conference on science and technology indicators* (pp. 27–40). https://doi.org/10.6084/m9.figshare.9443693.v1

BRASIL. Ministério da Educação. (2017). *Portaria nº 389, de 23 de março de 2017. Dispõe sobre o mestrado e doutorado profissional no âmbito da pós-graduação stricto sensu*. Diário Oficial da União. Brasília, DF.

Cano, W. (2015). Crise e industrialização no Brasil entre 1929 e 1954: A reconstrução do Estado Nacional e a Política Nacional de Desenvolvimento. *Brazilian Journal of Political Economy*, *35*(3), 444–460. https://doi.org/10.1590/0101-31572015v35n03a04

CAPES. (1981). *Plano Nacional de Pós-Graduação - PNPG 1982-1985*. Brasília, DF: CAPES.

CAPES. (1985). *Plano Nacional de Pós-Graduação - PNPG 1986-1989*. Brasília, DF: CAPES.

CAPES. (1995b). *Programa de flexibilização do modelo de pós-graduação senso estrito em nível de mestrado*. Brasília, DF. Retrieved from https://bit.ly/3sp5Aic

CAPES. (1998). *Portaria nº 80, de 16 de dezembro de 1998. Dispõe sobre o reconhecimento dos mestrados profissionais e dá outras providências*. Diário Oficial da União. Brasília, DF.

CAPES. (2004). *Plano Nacional de Pós-Graduação - PNPG 2005-2010*. Brasília, DF: CAPES.

CAPES. (2010). *Plano Nacional de Pós-Graduação - PNPG 2011-2020*. Brasília, DF: CAPES.

CAPES. (2020b). Orçamento da CAPES: Evolução em Reais. Brasília, DF: CAPES. Retrieved from https://bit.ly/37NYz0P

CAPES. (2020c). Portal de Periódicos. Retrieved August 17, 2021, from https://periodicos.capes.gov.br/

CAPES. (2021c). Coleta de dados dos programas de pós-graduação. Plataforma Sucupira. Brasília, DF. Retrieved from http://sucupira.capes.gov.br/

CAPES. (2021e). Sistema de Informações Georreferenciadas. Geocapes. Brasília, DF. Retrieved August 20, 2021, from https://geocapes.capes.gov.br/

Castro, M. H. d. M. (2015). Higher education policies in Brazil: A case of failure in market regulation. In S. Schwartzman, R. Pinheiro, & P. Pillay (Eds.), *Higher education in the brics countries* (pp. 271–289). Dordrecht: Springer.

CGEE. (2016). *Mestres e doutores 2015: Estudos da demografia da base técnico-científica brasileira*. Brasília, DF: CGEE.

Clarivate Analytics. (2019). *Research in Brazil: Funding excellence*. Retrieved from https://bit.ly/3gdf5vY

CNPG. (1974). *Plano Nacional de Pós-Graduação - PNPG 1975-1979*. Brasília, DF: MEC.

CNPq. (2020). Portal de Dados Abertos do CNPq. Retrieved from http://dadosabertos.cnpq.br/

Conselho Federal de Educação. (1965). *Parecer CFE nº 977, de 3 de dezembro de 1965. Estabelece a definição dos cursos de pós-graduação no país*. Brasília, DF.

Cunha, L. A. (2007). *A universidade temporã: o ensino superior da colônia à era Vargas* (3rd ed.). São Paulo: Editora UNESP.

da Fonseca, M. L. M. (2015). A institucionalização da pesquisa científica brasileira: Os primeiros anos de atuação do Conselho Nacional de Pesquisas (CNPq). *Parcerias Estratégicas*, *18*(36), 253–268.

de Almeida, E. C. E., & Guimarães, J. A. (2013). Brazil's growing production of scientific articles—how are we doing with review articles and other qualitative indicators? *Scientometrics*, *97*(2), 287–315. https://doi.org/10.1007/s11192-013-0967-y

de Almeida, E. C. E., Guimarães, J. A., & Alves, I. T. G. (2010). Dez anos do Portal de Periódicos da Capes: Histórico, evolução e utilização. *Revista Brasileira de Pós-Graduação*, *7*(13), 218–246. https://doi.org/10.21713/2358-2332.2010.v7.194

de Andrade, D., Rizzi, P., & de Almeida, S. F. M. (2005). Experiência em parceria estratégica: mestrado profissional em Engenharia Aeronáutica, ITA-Embraer. *Revista Brasileira de Pós-Graduação*, *2*(4), 48–60. https://doi.org/10.21713/2358-2332.2005.v2.77

de Biasi, K. (2019). *Solving the Change Paradox by means of trust*. https://doi.org/10.1007/978-3-658-23912-1

Dellagostin, O. (2020). Semelhanças e diferenças entre os estados no financiamento à pesquisa e na pós-graduação [webinar]. presentation. Retrieved November 13, 2020, from https://youtu.be/JFBKShfJKDM

Fávero, M. d. L. d. A. (2006). A universidade no Brasil: Das origens à reforma universitária de 1968. *Educar em Revista*, *22*(28), 17–36. https://doi.org/10.1590/s0104-40602006000200003

Fealing, K. H., Lane, J., Marburger III, J. H., & Shipp, S. (Eds.). (2011). *The Science of Science Policy: A Handbook*. Stanford: Stanford University Press.

Ferreira, M. d. M., & Moreira, R. d. L. (Eds.). (2002). *CAPES, 50 anos: Depoimentos ao CPDOC/FGV*. Rio de Janeiro: Fundação Getúlio Vargas.

Gershon, R. A. (2013). Innovation failure: A case study analysis of Eastman Kodak and Blockbuster Inc. In A. B. Albarran (Ed.), *Media management and economics research in a transmedia environment* (pp. 46–68). New York: Routledge.

Gouvêa, F. C. F. (2012). A institucionalização da pós-graduação no Brasil: O primeiro decênio da CAPES (1951-1961). *Revista Brasileira de Pós-Graduação*, *9*(17), 373–397. https://doi.org/10.21713/2358-2332.2012.v9.312

Hostins, R. C. L. (2006). Os Planos Nacionais de Pós-graduação (PNPG) e suas repercussões na pós-graduação brasileira. *Perspectiva*, *24*(1), 1–28.

IBGE. (2021). Sistema IBGE de Recuperação Automática. SIDRA. Brasília, DF. Retrieved from https://sidra.ibge.gov.br/

INEP. (2020). Censo da Educação Superior 2019. Retrieved August 17, 2021, from https://bit.ly/3ABVsFK

London, S. (1996). Understanding change: The dynamics of social transformation. Retrieved July 8, 2021, from https://bit.ly/3k0MFq7

Lord Robbins, L. C. (1963). *The Robbins Report*. Retrieved from https://bit.ly/2WrVdeS

Marburger III, J. H. (2011). Why policy implementation needs a Science of Science policy. In K. H. Fealing, J. Lane, J. H. Marburger III, & S. Shipp (Eds.), *The science of science policy: A handbook* (pp. 31–55). Stanford: Stanford University Press.

Martins, C. B. (2018). As origens da pós-graduação nacional (1960-1980). *Revista Brasileira de Sociologia*, *6*(13), 9–26. https://doi.org/10.20336/rbs.256

Moacyr, P. (1937). *A instrução e o Império: Subsídios para a história da educação no Brasil*. São Paulo: Companhia Editora Nacional.

Nader, H., Palis, J., Sampaio, F., Garcia, F. et al.. (2015). Carta ao ministro da Educação contra os possíveis cortes no Portal de Periódicos da CAPES. letter. Retrieved August 5, 2020, from http://www.sbpcnet.org.br/site/arquivos/arquivo%5C_467.pdf

Ribeiro, D. (1961). Universidade de Brasília. *Revista Brasileira de Estudos Pedagógicos*, *36*(83), 161–230.

Rothen, J. C. (2018). A universidade brasileira na Reforma Francisco Campos de 1931. *Revista Brasileira de História da Educação*, *8*(17), 141–160.

Rothen, J. C. (2019). O ensino superior e a Nova Gestão Pública: Aproximações do caso brasileiro com o francês. *Revista Eletrônica de Educação*, *13*(3), 970–995. https://doi.org/10.14244/198271993549

Saldaña, P. (2020). Em meio a pandemia, governo Bolsonaro investe contra pesquisa em ciências humanas. Retrieved August 10, 2020, from https://bit.ly/2PHEUH8

Sapolsky, H. M., & Taylor, M. Z. (2011). Politics and the Science of Science Policy. In K. H. Fealing, J. Lane, J. H. Marburger III, & S. Shipp (Eds.), *The science of science policy: A handbook* (pp. 9–22). Stanford: Stanford University Press.

SBPC, & ABC. (2020a). A história da CAPES na voz dos seus ex-presidentes [webinar]. Brasília, DF: SBPCnet. Retrieved August 17, 2021, from https://youtu.be/o1ztaCBihAk

SBPC, & ABC. (2020b). Qual o papel da CAPES na construção da ciência e da pesquisa no Brasil? [webinar]. Brasília, DF: SBPCnet. Retrieved August 17, 2021, from https://youtu.be/o1ztaCBihAk

Schwartzman, S. (1989). A ciência no período de pós-guerra. presentation. Brasília, DF.

Schwartzman, S. (1991). *A space for science: The development of the scientific community in Brazil*. University Park, Pennsylvania: Penn State Press.

Serafim, M. P., & Dias, R. d. B. (2020). A importância da ciência e das universidades públicas na resolução de problemas sociais. *Avaliação: Revista da Avaliação da Educação Superior (Campinas)*, *25*(1), 1–4. https://doi.org/10.1590/s1414-40772020000100001

Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation*. Washington, DC: Brookings Institution Press.

Sucupira, N. (1980). Antecedentes e primórdios da pós-graduação. *Forum Educacional*, *4*(4), 3–18.

Waltman, L., Boekhout, H., & van der Weijden, I. (2019). A large scale bibliometric analysis of differences between male and female researchers: Time trends and career paths. In *Proceedings...* Amsterdam, Netherlands.