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Building a national system of research and graduate education: how did the university become the house of science in Brazil?

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Abstract: The Brazilian science system is a direct result of decades of consistent public policy connecting research and education in ways that are unprecedented in the world. As a unique outcome, most of the science conducted in Brazil takes place within a National System of Graduate Education (SNPG), mainly installed in the country's universities. The present study seeks to provide a comprehensive understanding of the system's conception, investigating conjunctures and policy decisions shaping its evolution. Furthermore, the paper will also provide a panorama of the SNPG today: how large is the system; how is it organised and distributed across the country; what are the characteristics of the faculty and student body, and more. The results of this study are essential for Brazilian academics and policymakers, but the unique approach to science and high-level education in Brazil can serve as an inspiration for the international community, both from its successes and failures.

Keywords: Science policy; Public policy; Graduate education.

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Construindo um sistema nacional de pesquisa e pós-graduação: como a universidade se tornou a casa da ciência no Brasil?

Resumo: A ciência brasileira é resultado direto de décadas de políticas públicas consistentes que conectam pesquisa e educação de forma sem precedentes no mundo. Como resultado, a maior parte da estrutura científica do Brasil integra um Sistema Nacional de Pós-Graduação (SNPG) instalado, em grande parte, nas universidades do país. O presente estudo busca fornecer uma compreensão abrangente sobre a concepção desse, investigando conjunturas e decisões políticas que moldaram sua evolução. Além disso, o artigo também fornece um panorama do SNPG nos dias de hoje: quão grande é o sistema; como ele é organizado e distribuído em todo o país; quais são as características do corpo docente e discente e muito mais. Os resultados deste estudo são importantes para acadêmicos e gestores de políticas públicas brasileiros, mas os sucessos e fracassos da pós-graduação no Brasil também podem servir de inspiração para a comunidade internacional envolvida em estudos de Ciência e Tecnologia.

Palavras-chave: Política científica; Políticas públicas; Pós-Graduação.

Construcción de un sistema nacional de investigación y posgrado: ¿cómo la universidad se convirtió en la casa de la ciencia en Brasil?

Resumen: La ciencia brasileña es el resultado de décadas de políticas públicas consistentes que conectan la investigación y la educación de maneras sin precedentes en el mundo. Como resultado, la mayor parte de la estructura científica de Brasil integra un Sistema Nacional de Posgrado (SNPG) instalado, en gran parte, en las universidades del país. El presente estudio busca ofrecer una comprensión integral de la concepción de este, investigando coyunturas y decisiones políticas que moldearon su evolución. Además, el artículo también proporciona una descripción general del SNPG actual: qué tan grande es el sistema; cómo está organizado y distribuido; cuáles son las características del cuerpo docente y de estudiantes, y más. Los resultados de este estudio son importantes para académicos y gestores de políticas públicas en Brasil, pero los éxitos y fracasos del posgrado brasileño también pueden servir de inspiración para la comunidad internacional involucrada en estudios de ciencia y tecnología.

Palabras clave: Política científica; Política pública; Posgrado.

Introduction

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 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, fell behind in the digital race. Both companies filed for bankruptcy in the last decade mostly 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 shown this need for continuous change to be true. Even though the call for a fast response to fight the pandemic has reaffirmed the importance of science and technology across the planet, scientists had to redefine concepts of collaboration, scientific publishing, influence over policy, and so on (Serafim; Dias, 2020). As a consequence, notions of change that are well-established in business are increasingly present in the scientific environment (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 those, there is an emerging interdisciplinary field which 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 the institutional structures promoting or impeding scientific progress. Among its core concepts is the idea that science is not divorced from politics, as political system demands have been, for decades, the major drivers for science investment and advancement (Fealing et al., 2011; Marburger III, 2011).

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

Brazil is such a country. As this paper will show, the nation counts with 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 came to be determined even by the country's federal constitution (Brasil, 1988; Castro, 2015). The successful result is knowledgeably 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 paper 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 the Brazilian National System of Graduate Education (SNPG) is and how representative it is in the face of the science conducted in the country; ii) how this system has evolved as a result of policy decisions over several decades; iii) why such decisions were 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 paper will also provide a panorama of what it has become: how large the system is; how it is organised and distributed across the country; what the demography of the faculty and student body is, and so on. Hopefully, the understanding of the SNPG today, as well as of the complexities behind its development, may assist policymakers on their continuous efforts to advance the science system in Brazil.

Despite the main goal to bring scientific evidence to the policymaking environment, this paper also aspires to deliver a comprehensive understanding of the Brazilian science system to the international academic community. Few studies about the SNPG have been published in English, and none of them as complete as this one proposes to be. As it 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.

The late start of higher education in Brazil

Higher education was a late phenomenon in Brazil, even when compared to other Latin American countries. There were many reasons for that, but two of them were of particular importance: first, the colonisation policy from Portugal presented absolute resistance to this kind of initiative; second, the Brazilian elites would rather pursue their education abroad, primarily at European institutions. Sadly, such determinants led not only to inaction but 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 establish the first higher education institution (HEI) in the country (Fávero, 2006; Martins, 2018; Moacyr, 1937).

Over the next centuries, other attempts were made without success. One interesting example comes from a famous separatist movement at the end of the 1700s – the Minas Conspiracy – 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 shortly 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 mostly 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, which took place in 1822, the new Brazilian Empire started to give room for a more academic mentality, and by 1828 two legal courses were installed in Brazil: one at the Saint Francis Convent in the city of São Paulo and the other in the Saint Benedict Monastery in Olinda. Even though these courses had a significant influence on the development of the political mentality in the country, the promise of advancing 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 Republic, even though the number of higher education institutions expanded to 24, they were mostly professionalising schools, devoid of scientific research. The dream of a university continued to slip away (Fávero, 2006; Martins, 2018).

The first universities

Legislation from the newly proclaimed Brazilian Republic would start to pave the way for the advent of 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, established it was no longer exclusive (Brasil, 1891). Additionally, 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 no longer had exclusive power to act on the matters of science and higher education, the first research institutes started being founded (Martins, 2018). At that time, there was a great need for better understanding of Brazilian biodiversity, tropical diseases, and other subjects 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 building the country's scientific community (Martins, 2018).

In parallel to the creation of research centres, several higher education institutions were founded, including the country's first universities: one in Manaus (1909), another in São Paulo (1911) and the third in Paraná (1912) (Cunha, 2007). As a direct reaction to this movement, secondary and higher education systems were reorganised by Decree 11.530/1915, that 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.

Early concepts for a graduation system

While Brazil was mobilising to build its first universities, prominent organisations were emerging in the country. Among them was the Brazilian Academy of Sciences (originally founded in 1916 as the Brazilian Society of Science); and the Brazilian Education Association (ABE) in 1924 (Fávero, 2006). Such institutions would play a fundamental role in the design of the country's universities and how they would further integrate teaching and research activities (Martins, 2018). For instance, on the document "The problem of the Brazilian university", ABE (1929) stated the university would only be worthy of that name if it became a focus of culture, disseminating acquired science and creating new science.

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

Even though there had been records of institutions already providing doctoral 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; 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, s./p.). 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).

The first steps of the SNPG

In the years that followed 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 came 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 from private and foreign investment in Brazil (Cano, 2015).

What came next contributed to shaping the primary *modus operandi* of the Brazilian Government in terms of State matters. Since it was not possible to count with the market to act, the State stepped up to keep developing, and that meant founding its own industries, such as the National Steel Company (1941) and Rio Doce Valley Company (1942, known today as Vale) (Cano, 2015; Gouvêa, 2012).

While all this happened, few actions 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. Additionally, 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 moving to Brazil in order to escape the threat of war (Fonseca, 2015).

Still, World War II (WWII) 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 John Desmond Bernal and his book “The social function of science” (1939). In the inevitability of war, those ideas had to be put into practice as scientists played critical roles in cracking the German secret code, improving the radar, and so many other relevant activities, including the development of the atomic bomb (Schwartzman, 1989).

As WWII 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 great 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). This 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 to “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, s./p.). For that, a mixed group of policymakers, academics, and even financial sector representatives received unprecedented autonomy to implement pioneering programs for graduate education in Brazil (CAPES, 2010).

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

ii) To 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) To promote the expansion of graduate education and research centres in Brazil.

The study by Gouvêa (2012) described how CAPES was organised in order to undertake 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 their deficiencies regarding scientific personnel. To act on that, 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 the academic institutions and provide them with direct support in research infrastructure and staff (Balbachevsky; 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). Even though statistical data from that period seems not to be completely reliable, 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 take part in the design of the new master's and doctoral courses so needed in the country (Balbachevsky; Schwartzman, 2010; Gouvêa, 2012; Martins, 2018).

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 push science forward in the country (Gouvêa, 2012). Now, the international experience from the researchers who graduated abroad would challenge the established design of the national institutions to reach the once planned result: the university as both an educational and research environment (Sucupira, 1980). According to Fávero (2006), such 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 80km 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" (Ribeiro, 1961, s./p.).

The plans that led to the structure of UnB included a series of innovations that would soon be reflected in broader legislation: Law 4.024 (LDB), which set the guidelines and bases of 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; Ribeiro, 1961; Sucupira, 1980).

Despite the conceptual advances of UnB and the LDB regarding graduate education, the lack of accumulated tradition in research at Brazilian universities hindered the expected growth of the system (Balbachevsky, 2004). The year of 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 still reigning about their nature and purposes (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) Even though 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 *lato sensu*. They are not included in the scientific policy initiative at hand;

ii) *Stricto sensu* graduate education 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 desired duration would soon be established as two and four years, respectively).

As it may be evident to those familiar with the American graduate system at that time, the proposed model was strongly influenced by it. The Sucupira Report (CFE, 1965) recognised the inspiration, citing

the Robbins Report (1963) to support the decision. Such 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. Additionally, 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; Martins, 2018). Such 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 for implementing 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. Even though the Sucupira Report (CFE, 1965) recounts objections among its authors on the adoption of the master's level in Brazil, such 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.

The research system as a public policy

The Sucupira Report (CFE, 1965) was able to advance previous efforts to develop Brazilian graduate education. Further initiatives recognised the value of such policy, by either confirming its main concepts or by strengthening them (Sucupira, 1980). The university reform of 1968–69, 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 universities should institute programs for the improvement of current teaching staff, creating a demand that would further stimulate the growth of the graduate system (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 from 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.

The National Plans for Graduate Education

According to 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 by conjunctural reasons. That differed from the intended coordinated form, even though CAPES

had been making efforts, from its very foundation, to understand and act on the country's needs. 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 (Capes, 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 I 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, with a choice between continuing their studies and the job market. Therefore, the path to master's and doctoral degrees must be attractive. The majority of students should work full-time on a scholarship robust enough to supply for their needs. CAPES, CNPq and other agencies should devise a harmonious policy of scholarships to meet these demands as well as 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 guided by 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 render larger results. Finally, the PNPG considered the costs of graduate education too high to be maintained with resources from school fees, while keeping 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 (CFE, 1965), which believed that 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 such process, but it was conducted *a posteriori*, lacking appropriate mechanisms and procedures to be successful (Balbachevsky, 2004). The plan identified this limitation and called for an analysis of alternatives for the future, leading to a transfer of the responsibility to CAPES.

In the complexity and level of detail of a PNPG, some goals and consequent actions were significant for the design of a national science policy. For instance, the section about the current state of the 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 small group of 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 a fraction of master's and doctoral candidates has ever counted with a scholarship, reaching a coverage of only around 50% today.

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 an 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 the 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).

Aiming to improve the quality assessment previously conducted by the Federal Education Council, CAPES performed the first general evaluation of graduate courses in 1976. At that time, the agency had to decide on the allocation of student's scholarships and, instead of focusing 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 enhances the chances for substantial support in student scholarships, research infrastructure and funds (Balbachevsky; Schwartzman, 2010).

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

The complexity of such evaluation cannot be briefly captured, and a whole study will be conducted to investigate its evolution and current perspectives, in a similar way to what has been done for this paper. 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).

On top of the recently acquired evaluative role, by 1981 CAPES experienced yet another progression in its strategic importance within the science policy scenario (Hostins, 2006). At that 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 covering the 1982-1985 period. The document expanded and updated the goals presented in the first plan, but now emphasising the need to further assess the quality of graduate education. The evaluation system under development would then become more expressive with increased engagement of the scientific community. In addition, 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 period covered by the II PNPG, 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 mostly on a base of updated and incremental goals.

The III PNPG hardened criteria for the accreditation of new courses, while proposing inductive action in strategic areas. It recognised the shortcomings of the original scholarship policy, both in coverage and the loss of purchasing power over the years. The plan also increased the relevance of the evaluation system to fight high student dropout rates, long graduation times, low overall performance, and so on. On top of that, evaluation should also guide an increase of investments in the best courses, aiming to improve 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 higher education institutions. According to the PNPG, that problem created instability for research groups, frequently leading to temporary or permanent interruption of their work. Besides that, institutions and researchers had been dedicating too much time to the continuous elaboration 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 either a master's course or a doctorate, 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 the majority of these programs in Brazil are within public universities, the most common path to become a professor is by public tenders.

The idea that every citizen could have the possibility to work for the government based solely on "talents and virtues" was first introduced by the Imperial Constitution of 1824. This concept would be perfected 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. On top of that, 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 (Brasil, 1988, 123-124) also included three important concepts already in place. 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”.

The latest chapters in designing the SNPG

The 1980s were very prolific for the continuous evolution of the science system in Brazil. The military government held a nationalist ideal of turning the country into a world power, and that had motivated the push for a Science and Technology agenda (Rothen, 2019). Such plan continued to advance in the first years of the democratic regime, but Latin America had been experiencing what came to be 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; Moreira, 2002).

A significant sign of that came with the 1990 restructuring of the federal government, in which CAPES was extinguished (Brasil, 1990b). Due to the negative repercussion within universities and the decisive action of the academic community, the agency was re-established in under a month (Brasil, 1990a) and later gained public foundation status (Brasil, 1992). Despite this renewal that even enhanced CAPES’ standing in the federal structure, in the early 1990s Brazil was facing hyperinflation reaching, at one point, the mark of 80% a month. 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 instance, 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 lack of articulation among funding agencies at the time would lead the final plan to be abandoned (CAPES, 2004).

Even though 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

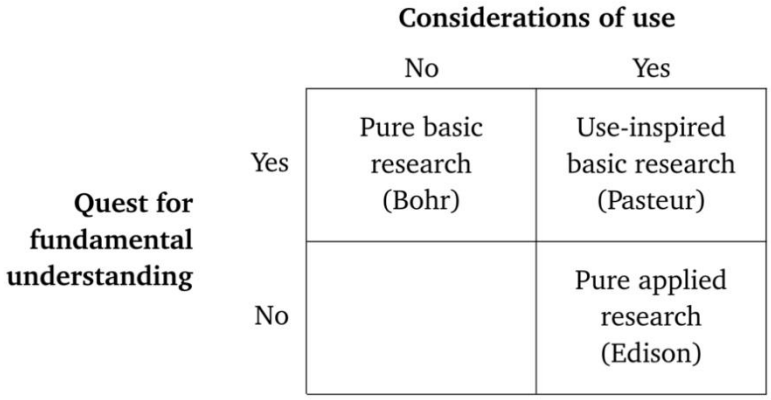
graduate education model would lead to one more significant addition to the PNPG before the turn of the century: the professional master's courses (CAPES, 2004).

The professional modality of graduate courses

The Sucupira Report (CFE, 1965) determined master's courses could be seen as a terminal degree, contributing to advancing 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 were not fulfilling their whole intended purpose (CAPES, 1995).

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 the professionals interested in problem-solving through the advancement of existing knowledge (CAPES, 1998). To understand the different perspectives of the academic and professional modalities, we can use the quadrant model outlined by Stokes (1997) from his investigation about the relations between basic science and technological innovation, as seen on figure 1.

Figure 1: Quadrant modelo f scientific research, as proposed by Stokes



Source: Stokes (1997, p. 73).

According to Stokes (1997), research can be categorised based on its quest for fundamental understanding and also by considerations of use. From this perspective, academic graduate courses in Brazil can be classified in the 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 continue with the pursuit of knowledge but having some sort of use as the immediate goal, thus existing within the Pasteur's Quadrant. The final Quadrant, Edison's, might be appropriate to describe *latu sensu* courses, as they focus on the training of professionals based on already established knowledge.

Over the years, there has been a lot of debate in academia about the validity of the professional modality, with advocates on both sides of the discussion (Ferreira; Moreira, 2002). Despite the opposition, these courses have become quite representative within the SNPG, even in their role to produce more

applied research outputs (Brasil, 2018). As a consequence of such results, in 2017, the Ministry of Education authorised the professional modality to the doctoral level as well (MEC, 2017). By August 2020, CAPES had already accredited 53 of these courses, complementing the 873 professional master's in the system (CAPES, 2020a).

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 Brazilian 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 those libraries linked to graduate education. CAPES was in charge of dealing with editors and subscribing to the journals which would be sent directly to each participating institution (CAPES, 2020d; Almeida; Guimarães; Alves, 2010).

Despite delays in the journal acquisitions, mostly because requests by HEI would customarily take longer than desired, the model seemed to work 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 seemed to be a possible solution, as most scientific publishers were already digitising their collections (Almeida; Guimarães; Alves, 2010).

From the restructuring of the acquisition program, the Brazilian Portal of Journals was launched in November 2000. With it, 72 institutions offering graduate education at that 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. Besides that, it also helped reduce asymmetries, as institutions would have access to the same collections, regardless of their size, budget or location (CAPES, 2020d).

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 much more (CAPES, 2020d). Data from Geocapes (CAPES, 2020b) 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 approximately 100 million US dollars (CAPES, 2020c). 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 (Almeida; Guimarães; Alves, 2010). Without the centralised, top-down structure of the Brazilian science system, the Portal would probably never exist.

We can conclude that direct action from the government and its top agencies has been able to shape and develop the SNPG. Nonetheless, experience shows such power comes with risks. For instance,

high managers at CAPES have consistently re-ported how changes at various levels of government have led to questions regarding the very existence of the Portal of Journals (SBPC; ABC, 2020a).

One example of such threats came in 2015, with the announcement of budget cuts to the Portal in the following year. At that 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 activities of its education, science, technology and innovation system (Nader et al., 2015). Fortunately, such initiatives helped contain threats not only to the Portal of Journals, but to several core components of the SNPG. Nonetheless, there is always the apprehension that misguided actions from top government levels could change all that.

The SNPG today

As the historical panorama has shown, the evolution of the Brazilian National System of Graduate Education has been the result of decades of coordinated work from CAPES, CNPq, MEC, higher education institutions and a series of other actors. Even though they have continued to be very active in the past twenty years, the core design of the graduate system was already in place, and most actions not covered in this study had only incremental effects in the system's evolution.

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

Even though the most recent PNPGs did not perform the same role in shaping the SNPG as its predecessors, they have been essential to guide the impressive growth of the system that will be displayed in this section. Here, we are going to examine information obtained from distinct national databases to see what the system has become. In particular, we will work with CAPES' integrated system of graduate education data – Sucupira Platform (CAPES, 2020a); and the agency's Georeferenced Information System – Geocapes (CAPES, 2020b).

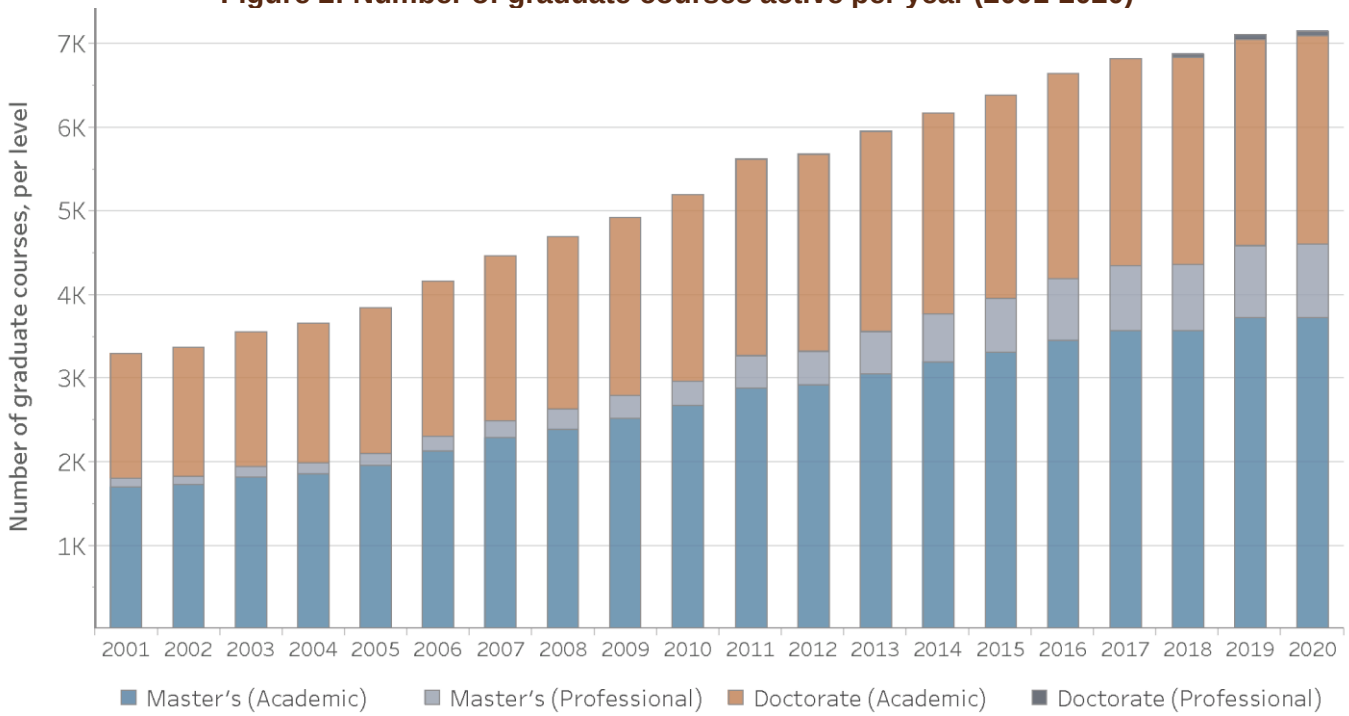
Graduate courses and programs

All of the basic research conducted in Brazil takes place within graduate education, and the same is true for around 95% of all S&T research in the country (SBPC; ABC, 2020b). As we have discussed, such 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 shows, this century 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: Number of graduate courses active per year (2001-2020)



Source: Elaborated by the author with data from CAPES (2020a).

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 1.

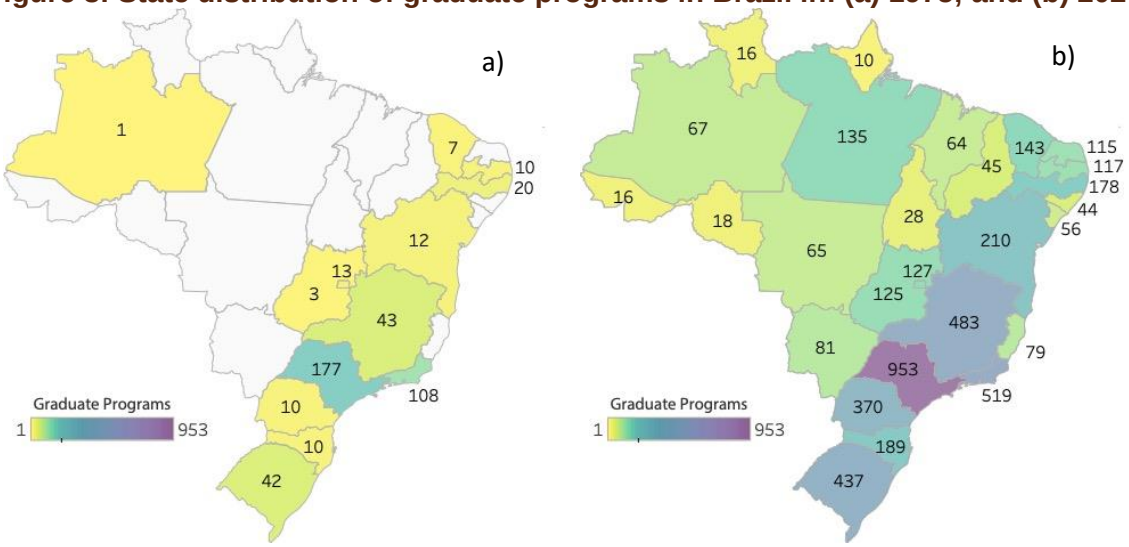
Table 1: Organisation of active courses into graduate programs (2020)

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

Source: Elaborated by the author with data from CAPES (2020a).

Even though the Sucupira Report (CFE, 1965) established isolated doctoral courses to be acceptable, even desirable for specific fields, table 1 shows there are only 89 programs in this situation. On the other hand, the number of PPG with just 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. Considering the graduate program perspective, figure 3 shows how the system has grown from a geographical point of view, as it contrasts the current distribution of PPG with that of 1975, the first year of coverage of the original PNPG.

Figure 3: State distribution of graduate programs in Brazil in: (a) 1975; and (b) 2020

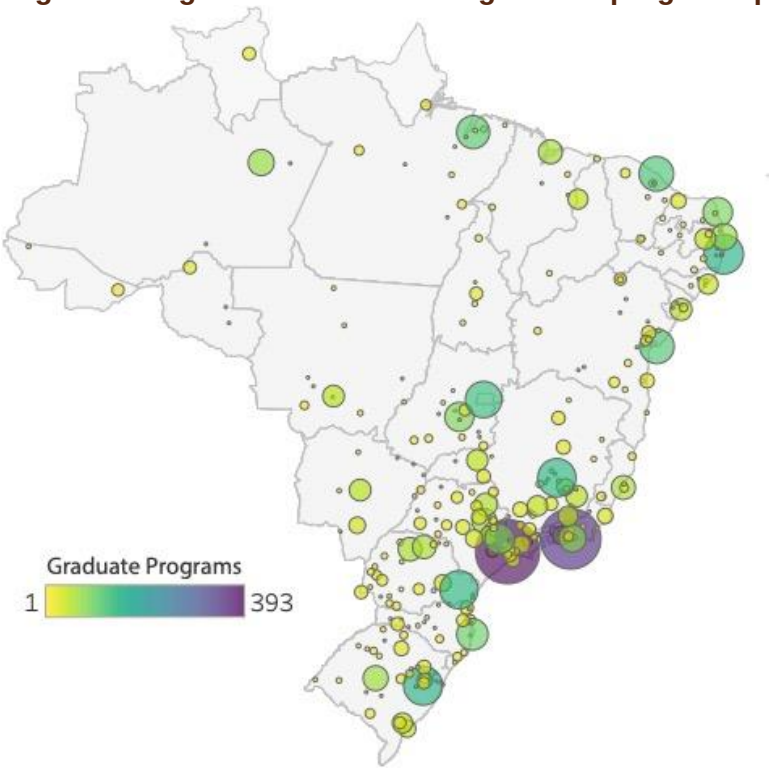


Source: Elaborated by the author with data from CAPES (2020a) and IBGE (2020).

The contrasting maps included in figure 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 population dispersion is considered, the current distribution is even more balanced, and we can use the state with the most PPG as an example: São Paulo counts with 953 programs (20,3% of the total), while holding 21,9% of the country's 210 million inhabitants, according to recent estimates from the Brazilian Institute of Geography and Statistics (IBGE, 2020). On the other extreme, at the north of the second map, we see the state of Amapá, with only 10 programs. Even though a 0,2% representation is far from adequate, the discrepancy seems less extreme if we consider the state accounts for only 0,4% of the country's population.

Despite the scenario presented by a state-based analysis of graduate program distribution, if we change the unit of inquiry to cities, an unbalanced configuration becomes apparent. In Brazil, out of 5.570 municipalities, only 307 count with graduate education, as it can be seen on figure 4.

Figure 4: Regional distribution of graduate programs per city



Source: Elaborated by the author with data from CAPES (2020a) and IBGE (2020).

The distribution of courses on Figure 4 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, one can say figure 3 can nicely reflect how far asymmetry reduction policies have come, but figure 4 shows how far they still need to go.

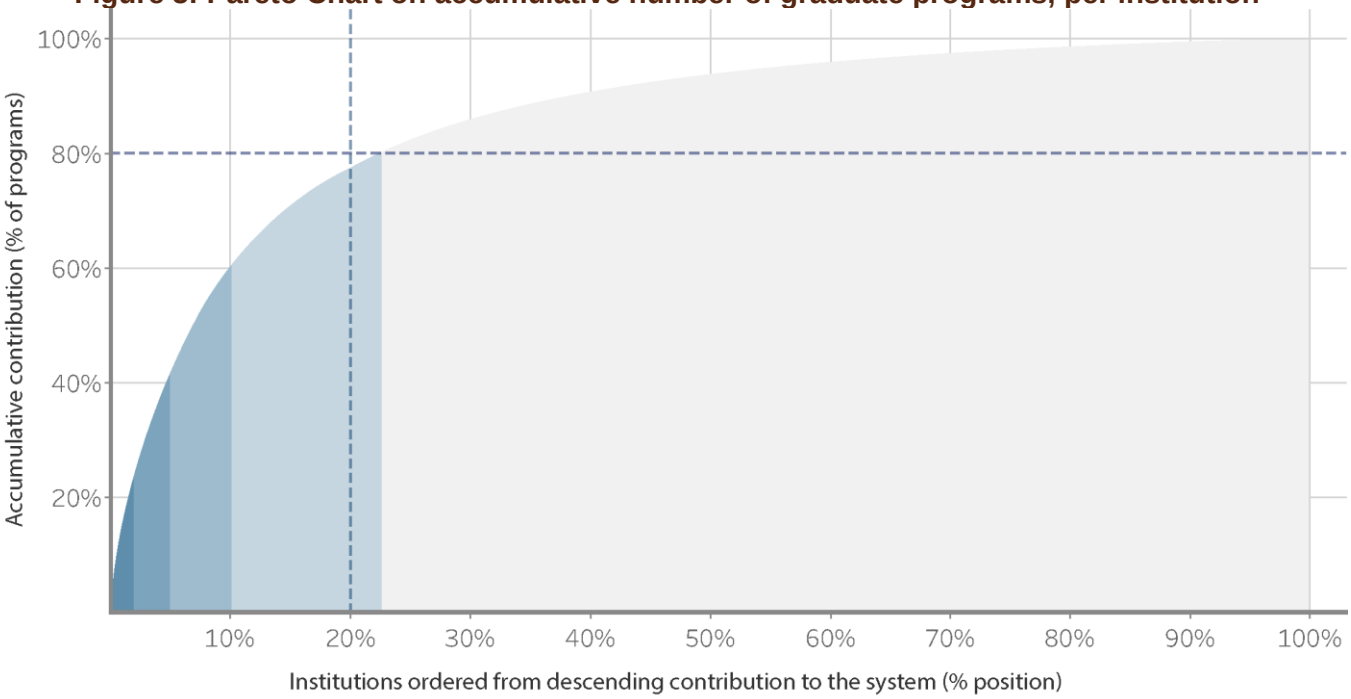
Higher Education Institutions

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

Nevertheless, the access policies leading to institutional expansion focused mainly on the undergraduate training of professionals, while the graduate system continued to be very meritocratic and restricted to a limited set of HEI. As a result, only 432 of the 2.537 institutions currently offer graduate education. More than that, as a direct result of the policies prioritising investments to develop research within universities and large institutions, there is significant concentration of graduate programs in a small group of these already select HEI.

The Pareto chart in figure 5 confirms such perception, by 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 courses.

Figure 5: Pareto Chart on accumulative number of graduate programs, per institution



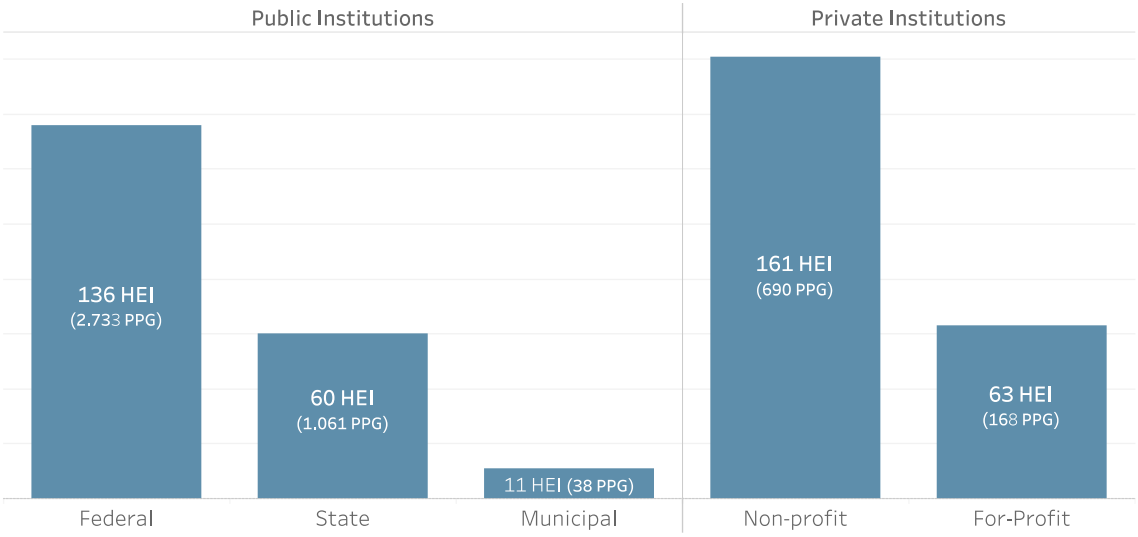
Source: Elaborated by the author with data from CAPES (2020a).

From figure 5, we can conclude that nearly 80% of all graduate courses are offered by 20% of the institutions. By looking at the first colour group, the situation is even more impressive, as 20% of the courses can be found in just seven universities: USP, UNESP, UFRJ, UnB, UFRGS, UFMG and UFPE.

Considering the policies that prioritised graduate expansion in public institutions, it was expected for the top seven HEI 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 place in the list: The Pontifical Catholic University of Rio de Janeiro (PUC-Rio), offering 34 distinct programs.

For further comprehension of the public versus private dimension of graduate education, figure 6 details the higher education institutions (HEI) according to type.

Figure 6: Higher Education Institutions (HEI) in Brazil with active graduate programs in 2020, and the total number of PPG offered



Source: Elaborated by the author with data from CAPES (2020a).

Out of the 2.537 Brazilian higher education institutions active in 2018, 2.238 (88,2%) are private (INEP, 2019). Figure 6 shows a different scenario for those involved in research, as this percentage drops to 52%. Even though the number might still seem significant when considering research policies discussed throughout this paper, 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 the private ones do the same.

The first PNPG stated that the costs to offer graduate education are too high for institutions relying on student tuition (Capes, 1974). In Brazil, these are private organisations which can be subdivided into two categories: non-profit and for-profit. The first group includes philanthropic and community HEI, as well as those with official religious affiliations. They hold 80,4% of the programs offered by private institutions: an average of 4,28 per HEI, against 2,7 in the for-profit group.

Besides the financial aspect, another element that might contribute to a minor involvement of private institutions in research and graduate education is their faculty profile, as we will discuss ahead.

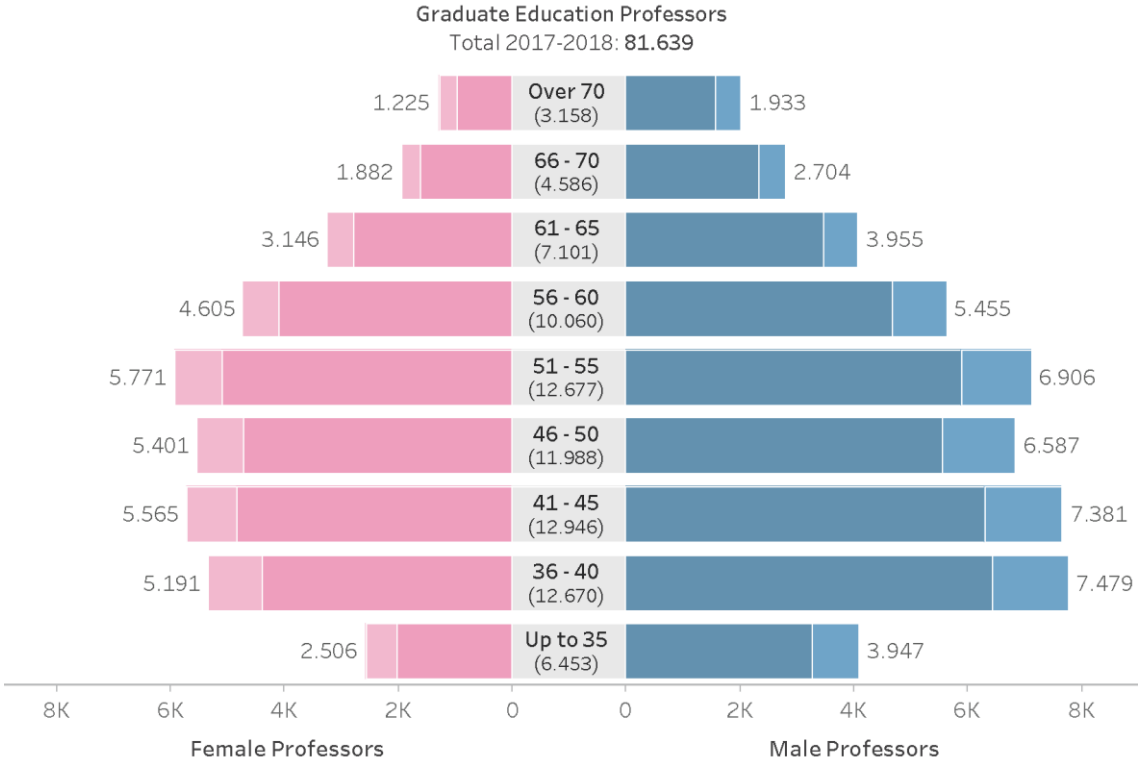
Faculty

According to the 2018 educational census (INEP, 2019), the Brazilian higher education system counts with 384.474 faculty members, 173.868 working for public and 210.606 for private institutions. From that, we can see the workforce in the private sector is relatively smaller, as there is an average of 95 faculty members per institution, while the public sector counts with 581. Another difference is that the public side favours 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 counts with a doctoral degree (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 institutions is

seemingly smaller than in the public HEI, this can be considered an obstacle for implementing new graduate programs.

Considering faculty members active in graduate education, data from the Sucupira Platform (CAPES, 2020a) show there were 81.639 professors working in Brazilian PPG, during the 2017-2018 biennium. Of these, 99,1% had a doctoral degree, and their distribution by gender and age group can be seen on figure 7.

Figure 7: Age and gender distribution of graduate education professor in Brazil (2017-2018). Lighter colours highlight those working for private HEI



Source: Elaborated by the author with data from CAPES (2020a).

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 7 is a slight skew towards the male side, which accounts for 56,8% of the total number of professors. The reasons for that are undoubtedly complex, and they are not the object of the present study. Regardless, we can propose two variables for future investigation:

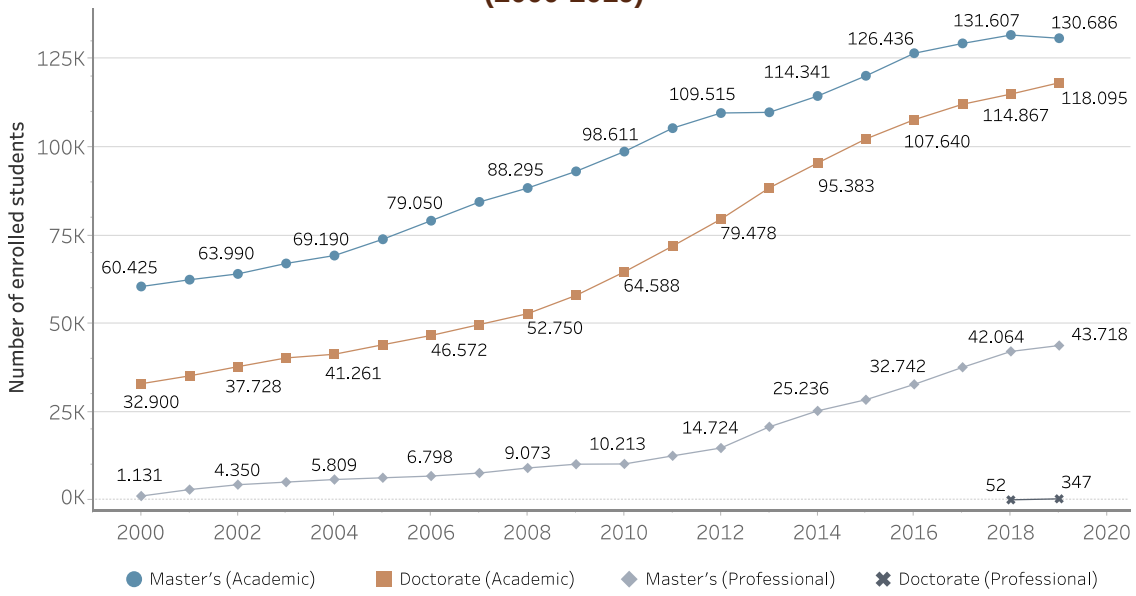
i) Rules for retirement in Brazil differ with gender, as men are usually required to contribute five years longer to social security. That may lead to a gender imbalance in academia. This perception might be supported by a study conducted by Waltman; Boekhout; Van Der Weijden (2019), analysing length 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 the gender asymmetry, as the relative representation of women seems smaller along age groups where childcare would usually take place. This hypothesis seems promising when comparing all female professors in higher education to those acting in graduate programs. Considering only professors holding a doctoral degree, women up to 35 years old account for 49,96% of the whole 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, 2020b; INEP, 2019). 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.

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 enrolled or graduating from master's and doctoral courses. Considering the explosion of such programs over the past two decades (Figure 2), the resulting number of candidates was expected to follow. In this sense, figure 8 shows the last 20 years of official information regarding enrolment in distinct levels and modalities of graduate courses (CAPES, 2020b).

Figure 8: Number of students enrolled in diferente levels and modalities of graduate education (2000-2019)



Source: Elaborated by the author with data from CAPES (2020b).

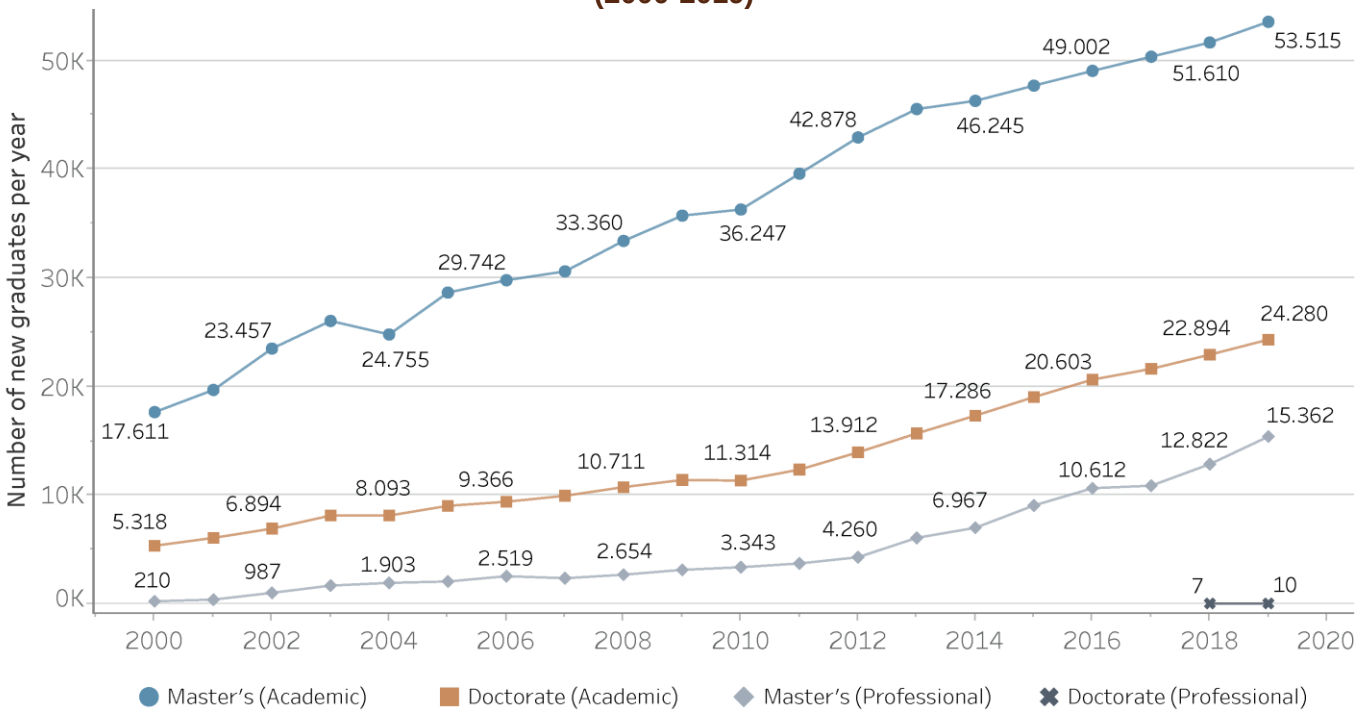
From 2000 to 2019, the observed growth in the number of enrolled graduate candidates was of 210%. The results are remarkable, and the professional courses seem of particular value. The modality was first authorised for the master's level in 1998, and the number of 1131 students in 2000 expanded to nearly 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 if the first numbers of professional doctorate candidates recorded, 52 in 2018 and 347 in 2019, will also experience such 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[1]. 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 (CNPq, 2020; CAPES, 2020b; Dellagostin, 2020).

One additional aspect to note is that more women benefited from CAPES' scholarships in 2018, as they received around 53% of the master's and doctoral grants provided by the agency (CAPES, 2020b). The impact of such funding is aligned with results from a bibliometric study considering trends of new researchers entering the science system (Waltman; Boekhout; Van Der Weijden, 2019). The investigation indicated that, by 2018, around 53% of Brazilian new researchers were female, which is a remarkable number when considering the global baseline is around 40%. Despite the limitations of financial support to all students, the number of graduates each year has also been growing, as figure 9 shows.

Figure 9: Number of students graduating at diferente levels and modalities of graduate education (2000-2019)



Source: Elaborated by the author with data from CAPES (2020b).

[1] The number of scholarships from CNPq was calculated from the nominal benefits listed in the agency's Open Data platform. The presented numbers are expected to be an overestimation, for instance because of the double counting of the transference of grants between master's or PhD candidates within the same year.

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 9 shows, the desired number for the master's level had already been surpassed by 2019, with 68.877 graduates. For the doctoral level, we see the number was slightly below the mark, with 24.290 graduates. Even though the COVID-19 pandemic might impact the number of degrees 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.

A brief overview of the SNPG's impact

Over the past years, several studies 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, 2010), as well as by authors such as Balbachevsky and Schwartzman (2010), 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 research paper output, 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 instance, 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 period of analysis (twice the average world growth). This is consistent, for instance, with the observed increase in graduate education enrolments 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 that of the Netherlands, the country immediately behind it in the Clarivate ranking (Clarivate Analytics, 2019), Brazilian population surpasses 210 million people, over 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 over 1.500. This relative perspective shows 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 they perform quite differently in terms of the PP (top 10%) indicator: a common proxy for 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% (7%), while the Netherlands was above it (17%).

The analysis also shows internationalisation to be an important component to increase the impact of Brazilian publications. Considering only papers published in collaboration with international partners, Brazilian PP (top 10%) increased to 12,5%. When cooperating with select countries such as the Netherlands, Australia, Japan and South Korea, the results were even better, surpassing 20%. That may

suggest that finding strategic international partners can elevate the impact of Brazilian research, at least from the scientometric point of view.

Nevertheless, this paper 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 thousand population. 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 graduated 11,6 new PhDs per 100 thousand 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 there was a need to improve the participation of scientific research in the economic and social development of the country (CAPES, 1995). The envisioned solution materialised as a professional modality of graduate program (CAPES, 1998). Whether because of the effect of such new modality or the mentality that led to its creation, Clarivate's report (Clarivate Analytics, 2019) shows how, after decades of very slow expansion, industry collaboration in academia started to grow exponentially by the turn of the century, as joint publications went from around 160 per year, by 2000, to nearly 1600 in 2017.

From the industry perspective, Petrobras was responsible for 14% of the collaborative output (2015-2017), due to a strong integration program with universities. Yet, dozens of other companies, both national and multinational, have been collaborating with Brazilian academia in the pharmaceutical, agricultural and several 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 the1950s 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 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 (Andrade; Rizzi; Almeida, 2005; Barata, 2020).

While 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 SNPG's contribution to Brazil and the world.

Conclusion and perspectives for the future

The Sucupira Report (CFE, 1965), while building the core definitions of the future SNPG, stated 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 intended to be, it is far from complete, as the subject could easily justify a lifelong investigation. What was possible within this paper 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 whole 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, even though the pursuit for development motivated much of the science policy in Brazil, the SNPG has been, until recently, too academic. The problem is possibly the result of funding models, faculty hiring methods, limits of the evaluation model and pure tradition. The idea of the type of research that is applied to solve social and economic problems began to broaden only in the past two decades. A professional modality of graduate course was implemented in 1998, aiming to promote balance. Results have been promising at the master's level and, despite lingering opposition, the first professional doctorates have joined the system from 2017.

Fourth, the SNPG numbers are quite significant. There are 432 higher education institutions offering graduate education in Brazil. They are spread over 307 municipalities covering all of the Brazilian states, and they hold 7.146 master's and doctoral courses organised into 4.690 graduate programs; 18,7% of which are in the professional modality. Additionally, almost 80% of the programs are concentrated in only 20% of the HEI, and most of these are 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 were mostly implemented as mini-doctorates, 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 make 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 a weakness and a 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 the weakness perspective, the SNPG faces a lingering concern of disruption based on political motivations. For instance, the national government elected to run the country from 2019 to 2022 has consistently criticised the value of basic science, in particular of 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 hoping to have a voice able to minimise any long-term damage to the SNPG (Saldaña, 2020).

Despite the current apprehension around the system's susceptibility to change, the same property has benefited the 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. 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. Besides 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 (SBPC; ABC, 2020a).

Even though the SNPG is still far from perfect, by looking at the accomplishments and obstacles in its past, we can better shape the improvements for the future. Hopefully, the policymakers in charge of evolving the system will value such lessons, being able to keep Brazilian science moving forward.

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