

**INVESTMENT IN RESEARCH: A STUDY ON THE PRODUCTION OF PATENTS
BY FEDERAL UNIVERSITIES**

***O INVESTIMENTO NA PESQUISA: UM ESTUDO SOBRE A PRODUÇÃO DE
PATENTES DAS UNIVERSIDADES FEDERAIS***

***INVERSIÓN EN INVESTIGACIÓN: UN ESTUDIO SOBRE LA PRODUCCIÓN DE
PATENTES POR UNIVERSIDADES FEDERALES***

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ABSTRACT: Patents are considered a way of measuring innovation. Based on this information, the article proposed a study on the amount of patents granted to federal universities in Brazil compared to the amount of resources invested in their schools. For this comparison, data were collected from the Information System on Public Budgets in Education - SIOPE, from the National Institute of Industrial Property - INPI and from the World Intellectual Property Organization - WIPO, which were tabulated and analyzed individually. From this analysis, a correlation was made in order to identify whether there is a link between the invested resource and the granting of the patent. We identified that more than 80% of patents are for inventions and that the Federal University of Minas Gerais - UFMG, Federal University of Rio Grande do Sul - UFRGS and the Federal University of Rio de Janeiro- UFRJ are in the lead in the industrial property category.

KEYWORDS: Patents. Federal universities. Investment. Academic patents.

RESUMO: As patentes são consideradas uma maneira de mensurar a inovação. A partir dessa informação, o artigo propôs um estudo sobre a quantidade de patentes concedidas para as universidades federais do Brasil, comparando-a com o montante de recursos investidos nas suas escolas. Para essa comparação foram coletados dados do Sistema de Informações sobre Orçamentos Públicos em Educação – SIOPE, do Instituto Nacional de Propriedade Industrial – INPI, e da World Intellectual Property Organization - WIPO, que foram tabulados e analisados individualmente. A partir dessa análise, uma correlação foi feita para poder

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identificar se existe ligação do recurso investido com a concessão da patente. Evidenciou-se que mais de 80% das patentes são de invenção e que a Universidade Federal de Minas Gerais - UFMG, Universidade Federal do Rio Grande do Sul - UFRGS e a Universidade Federal do Rio de Janeiro - UFRJ estão na liderança no quesito propriedade industrial.

PALAVRAS-CHAVE: *Patentes. Universidades federais. Investimento. Patentes acadêmicas.*

RESUMEN: *Las patentes se consideran una forma de medir la innovación. Con base en esta información, el artículo propuso un estudio sobre la cantidad de patentes concedidas a universidades federales en Brasil en comparación con la cantidad de recursos invertidos en sus escuelas. Para esta comparación, se recolectaron datos del Sistema de Información de Presupuestos Públicos en Educación - SIOPE, del Instituto Nacional de la Propiedad Industrial - INPI y de la World Intellectual Property Organization - WIPO, los cuales fueron tabulados y analizados individualmente. A partir de este análisis se realizó una correlación con el fin de identificar si existe un vínculo entre el recurso invertido y el otorgamiento de la patente. Identificamos que más del 80% de las patentes son de invención y que la Universidad Federal de Minas Gerais - UFMG, la Universidad Federal de Rio Grande do Sul - UFRGS y la Universidad Federal de Rio de Janeiro - UFRJ están a la cabeza en propiedad industrial categoría. Se pudo analizar que la producción de patentes no depende de la cantidad de recursos invertidos, ya que las universidades con menos recursos obtienen mayor número de publicaciones.*

PALABRAS CLAVE: *Patentes. Universidades federales. Inversión. Patentes académicas.*

Introduction

The current economic scenario brings a competition between national and international companies that stems from the globalization process and has transformed the business environment into an analog of Darwinian natural selection (GHISELIN, 1995; GOWDY, 2013). Organizations have turned to a constant management of their activities and the visibility of the products offered by them to the market. In this context, innovation has become a fundamental factor for the maintenance of activities and the development of countries.

Innovation is the implementation of a new or significantly improved good or service, or a process, or a marketing method, or a new organizational method (OECD, 1997). The innovative process needs various types of technology and distinct knowledge from different sources, like blocks in the construction of a house, and these come from different sources, such as industries, companies, laboratories, universities, consumers (BARBIERI; ALVARES; CAJAZERA, 2008; HSU, 2005).

Government strategies connected to a country's science and technology policy goes through the maturation of university performance and its economic development activities

(ROCZANSKI, 2016). The evidence of this evolution is in the creation of internal structures with the objective of transposing scientific knowledge to companies and people, through joint research between the business and academic market, generating companies willing to explore the product of research, the so-called academic spin-offs (TORKOMIAN, 1997). This interaction between the business environment and universities builds partnerships that are economically sustainable and patentable technology products and processes, and such patents have gained the innovation environment guided by public policies of fomentation, the R&D (HAASE; ARAÚJO; DIAS, 2005).

Thus, the patent is a property title over the invention or a utility model (INPI, 2007). This administrative title is an award for years of research and merit of the inventor in working on something not yet known. Its registration gives the inventor security in negotiations between parties interested in receiving the technology and disseminating it widely to the market in which it is inserted. In the patent registration there is an obligation for the inventor to disclose the details of the technical content of his invention, making it possible for a technician to reproduce it even without seeing it. A study by the World Intellectual Property Organization - WIPO (2007) estimated that 70% of all content reproduced in the format of patents was not available anywhere else, and that the intellectual property generated through patents stimulates the technological and economic development of the country, generating wealth, provided that the patent laws are well applied (MACEDO, 2000; MAZOCO; ANDRADE, 2014; SABINO, 2007).

In this research and patent production environment, universities have been known for basic research and not for applied research, bringing the initial and often theoretical knowledge on such subjects (OECD, 2001; SOUZA et al., 2020). However, some universities have turned to the construction of research that generate licensable patents to the market, bringing different funding resources from those used (OLIVEIRA; VELHO, 2009).

From this brief contextualization, this study presents a look at the efficiency of the investment of federal resources in its universities in the generation of patents granted at the National Institute of Industrial Property - INPI. The main characteristics of the proposal are:

- To present the amount transferred to federal universities in Brazil, presenting their application subgroups in the years 2000 through 2021;
- To present the number of patents granted in the years 2000 until 2021 of these universities;
- To present the number of permanent doctors in the institutions and the number of patents per researcher during the period 2000 until 2021;

- To present the correlation between investment and patents granted in federal universities in Brazil between 2000 and 2021.

Thus, this article, including the introduction, consists of the following sections, which discuss the quality of the academic product: methodology; patent as a revenue generator; university as a producer of applied knowledge; results and discussion; final considerations, followed by the references.

The quality of the academic product

Much has been discussed about the quality of scientific production. Many publications produced by researchers without the necessary methodological knowledge end up just reproducing the obvious, rather than contributing to local scientific development (KHATTER *et al.*, 2021). Regarding researchers, the ones that draw the most attention are the PhDs. These researchers have gone through a doctoral process, which is much more than a degree, it is a way to certify a candidate's ability to develop scientific research, and he or she must be creative, independent, and differentiated in his or her area of expertise (SOARES, 2018).

Data from 2009 (INEP, 2009) show that approximately 24% of teachers in public and private higher education institutions are PhDs, evidencing a shortage in the sector. In addition to contributing to the transmission of knowledge, the construction of research with the goal of generating products and applying theories are the roles of doctors within universities (MARANGON, 2009).

As a proposal for improvement in the doctorate frameworks in Brazil, the National Post-Graduation Plan, described in the Post-Graduation Journal - RBPGR (2020), presents all the efforts and goals placed for the expansion of post-graduation programs. It was also identified that Brazil remains well below the average of developed countries in the percentage of PhDs per inhabitant in the population aged 25-64 years (0.2%, while the average of the member countries of the Organization for Economic Cooperation and Development - OECD is 0.8%). The national strategy is to titrate 60,000 (sixty thousand) masters and 25,000 (twenty-five thousand) doctors every year, through the expansion of universities that promote programs and act to increase the base of doctors and masters in the country, which only between the years 2011 and 2018 quadrupled for master's degrees and had a 52% increase for doctoral degrees.

When analyzing the distribution of graduate programs by region, it can be seen that the Southeast region has the largest offer of courses in absolute numbers, but the Northeast region has the largest increase in the number of programs, as can be seen in Chart 1.

Chart 1 - Number of graduate programs offered and the increase in the number of graduates

Region	Number of graduate programs (2006 - 2017)	Percentage of graduates (2006-2017)
North	93 - 236	111%
Northeast	386 - 868	193%
Midwest	156 - 351	144%
Southeast	1181 - 1916	63%
South	449 - 925	122%

Source: Revista Brasileira de Pós-Graduação (2020)

The encouragement for the addition of more doctors has a clear objective, as described in item 14.15 of the National Postgraduation Plan; this aims to "stimulate applied research, within the HEIs and ICTs, in order to increase innovation and the production and registration of patents" (RBPGR, 2020).

University patents have been used in the literature to designate the production of knowledge within universities with participation of doctors and employment of resources from private and public initiative. However, it is a topic that instigates at least two major discussions: the first concerns the role of the university and its scientists in terms of their orientation and the production of usable knowledge (not only theoretical), that is, research products that can be applied to solve social problems. The second involves ethics, their efforts in academic visibility and for the gains already coming from public funding sources that should not be patentable, since they were financed with resources from the population.

Stokes (2005) explains that throughout the twentieth century the idea that basic and applied science would always be antagonistic remained strong, and that the direction of researchers is exclusively to advance the understanding of nature and society without concern for the practical use of this knowledge. Despite this controversial statement, currently, authors have defended the position of the practical use of this knowledge, also making use of patenting as a tool for the economic and scientific development of the country. The problem for universities becomes "how" to patent their discoveries, and whether they should not do it. For Federman (2009) and Schoellman and Smirnyagin (2021) the option of patenting the knowledge generated by universities is essential, taking a look at the importance of filing the patent before the academic publication, once the knowledge is disseminated before the protection request, it becomes public knowledge and cannot be protected.

Researchers were guided in their origin (SILVA; FERREIRA, 2020) to discover the truth and then advance in the understanding about things, being their prize for science the publication referenced by their peers. The research that has the objective of patenting demands a behavior distinct from the usual. This is because the discovery will not be taken to peers, but to a body that will look strictly at the characteristics of novelty, inventive step and industrial application, and this will be treated as a product of applied science, being delivered to the market, capable of generating financial resources to its inventor.

Methodology

This research was built based on the quantitative and exploratory model as from the survey of information on the patents granted coming from the INPI and the amounts destined for the federal universities among the years studied. The data of patents granted between the years 2000 and 2021 were analyzed. The choice of federal universities was based on their importance for the dissemination of scientific and technological knowledge to society (MOURA, 2019).

The universities analyzed here have already been subjects of previous studies, but they have advanced significantly on the issue of intellectual property (GARNICA, 2007). For comparison, the quantity of permanent PhDs was collected from the Coordination for the Improvement of Higher Level Personnel - CAPES system, to complement the information on investment and efficiency of the use of the resource effectively invested. We brought data from 2009 and also the proposed expansion plan for the National Post-Graduation Program from 2020.

To obtain the amount invested in Education and in Higher Education we used data from the Information System on Public Budgets in Education - SIOPE (2021), using the filters "Higher Education" and "Federal University" and "Federal University Foundation" to filter the data of the institutions selected in the study. The data were tabulated and analyzed descriptively based on Pearson's correlation, and a regression study was conducted to identify the synergy between the data collected from the federal agencies.

Patent as a revenue generator

The intellectual production generates gains for the economic development when introduced in the society so as to reach the general public with innovative products and processes that bring significant gains to the society as a whole (FERREIRA; GUIMARÃES;

CONTADOR, 2009). In this dynamic, the licensing of patents so that companies can take advantage of the research already carried out within the university speeds up innovation and generates foreign exchange for the country. Usually, health research is funded by the government and brought to public attention by companies and research centers that have employed public resources to obtain innovations (MAZZUCATO, 2014). This accounting of the "entrepreneurial state" should be done by the university through specific regulations when funded by public resource (RAI; SAMPAT, 2012).

The generation of values for new research is in the gain with royalties from applied research developed by universities and their PhDs. Licensing and transfer tech are also tools for gains with the production of university patents.

University as a producer of applied knowledge

Theoretical studies have been modeled to explain the role of universities and their connections with business and government. Currently, three major theories are accepted to relate and understand the connections. The first is the triangular model of Sabato (1968), where the state is the privileged actor of the relationship; the second, known as the theory of national innovation systems, which, according to Lundvall (1992) and Nelson (1993), consider in their studies the company as the driving force of the national innovative process; and the third, of the triple helix structure (ETZKOWITZ; ZHOU, 2017), which advocates a more relevant role for universities for their ability to absorb and disseminate knowledge. Looking at the three theories, what we have in common is the relationship between the entities: university, company, and government, with distinct roles for each one in the process of building economic development.

This view of economic development shows us that governments are increasingly investing in universities as producers of innovation. Looking at the governmental incentive for innovation, the United States approved in 1980 the Bayh-Dole Act (CORNELL, 2021), which aims to encourage the commercialization of academic discoveries, facilitating the obtaining of patents in research financed by federal funds and commercialized by universities (PÓVOA, 2008). In Brazil, the beginning of the process of encouraging innovation and commercialization of academic patents occurred with Law 10.973, 2004 (BRASIL, 2004), which resulted in the creation of a Forum of Innovation and Technology Transfer Managers (FORTEC), adding up to 2012 more than 156 Centers of Technological Innovations - NITs.

Torkomian (2011) cites that the creation of business incubators and technology parks are initiatives of universities that would contribute to the generation of patents and their spin-

offs. This management of intellectual property within universities has been in focus since the creation of the aforementioned law, which was regulated by decree one year later (TORKOMIAN, 1997).

For many years, universities were seen as timeless places in front of social and economic events, however, all changes happen because of universities, which, slowly through research, foster regional and national evolution. These changes, according to Etzkowitz and Zhou (2017), were possible due to a first academic revolution that occurred at the end of the 19th century, where universities added research activities to their functions. A second revolution allowed universities to direct their activities beyond research, also contributing to economic development.

Chart 2 – Academic Revolutions

Teaching	Research	Entrepreneurial University
Preservation and dissemination of knowledge	First Revolution	Second Academic Revolution
Missions	Teaching and research	Teaching, research, economic development

Source: Etzkowitz (2017)

Chart 2 presents the proposal of universities within each moment in history and in the revolutions presented by Etzkowitz (2017). The university revolutions have left their mark on the innovations of many countries, now known as developed. One example of this evolution is the support provided to basic research in American universities after the end of World War II. One of the strategies of the American government to work on the recovery of economic development and resume the top as a world power was to employ resources from research funds to fine-tune the relationships of universities with industry (CALDARELLI; CAMARA; PERDIGÃO, 2015; CHIARELLO, 2015; MOWERY; SAMPAT, 2005).

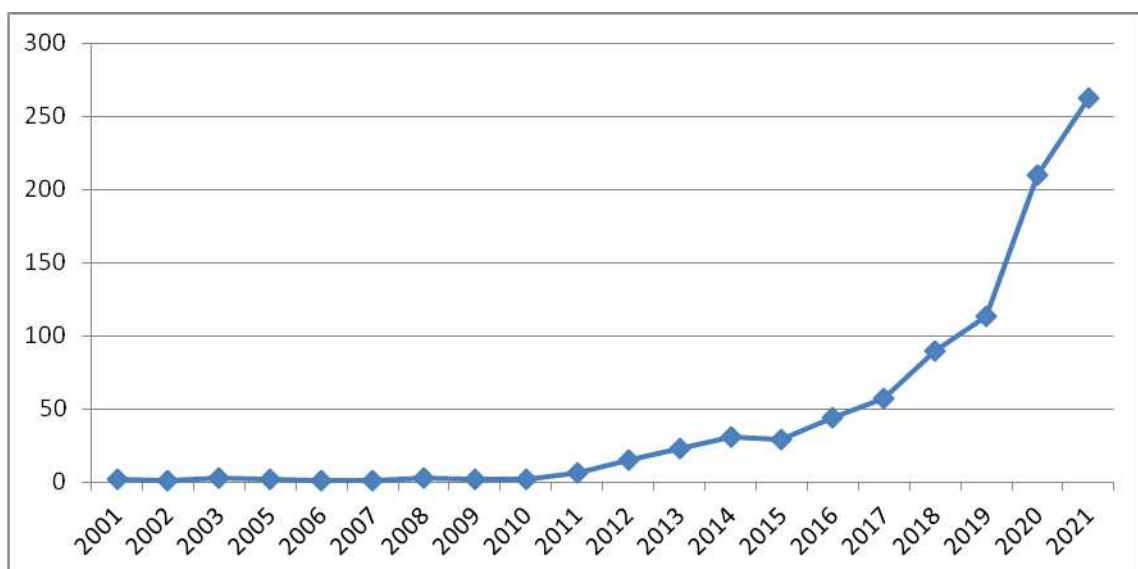
In Brazil, the university-company relationship has gained prominence. Programs such as "*Novos Caminhos*" (IFES, 2020), from the Ministry of Economy and made possible by the Federal Institute of Espírito Santo - IFES, have contributed to the development of entrepreneurship among high school and college students, also fostering the production of intellectual property, such as patents and publications of results. These policies and guidelines have the purpose of bringing to light the university proposal to induce regional development, an optic of delivering applied research, and no longer basic, as it used to be.

Results and discussion

Figure 1, below, shows the growth of patents granted to federal universities between the years 2000 and 2021, a period in which there were 897 concessions of patent applications filed. The figure shows the importance that has been given to applied intellectual production in recent years, peaking in the year 2021. The most significant growth occurred between the years 2019 and 2020, because that is when the grants jumped from 113 to 210 in just one year, possibly due to the analysis of dammed demands at the BPTO.

It should be taken into account that for many years the average time for analyzing a patent was approximately 10 years in Brazil, i.e., applications granted in 2021 were filed in the years 2011 (WIPO, Wipo Statistics Data Center, 2021).

Figure 1 – Patents granted to federal universities (2000-2021)

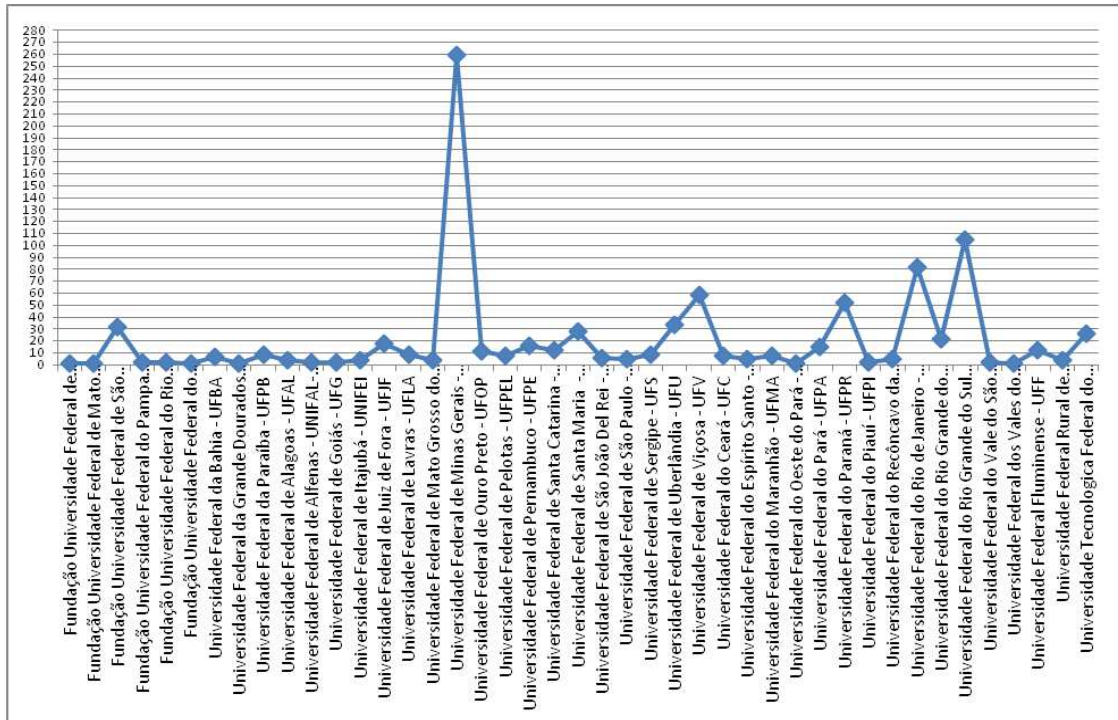


Source: INPI (2020)

Figure 2 reflects the participation of each university in the 897 concessions in the period presented. The Federal University of Minas Gerais (UFMG) presents a significant share in the concessions, with 29% of the total concessions in the period, and, of these applications, 88% are patent applications for innovation and 12% for utility models. This movement is largely due to the Federal University of Minas Gerais (UFMG) having a specific coordination for research, called Coordination of Technology Transfer and Innovation (CTIT, UFMG, 2016), for the interaction between the university and society in general, called "technological showcase". It is followed by the Federal University of Rio Grande do Sul (UFRGS), with 12%, and the Federal

University of Rio de Janeiro (UFRJ), with 9%. Of the total analyzed, 798 (88.96%) concessions are innovation patents and 99 (11.03%) are utility models.

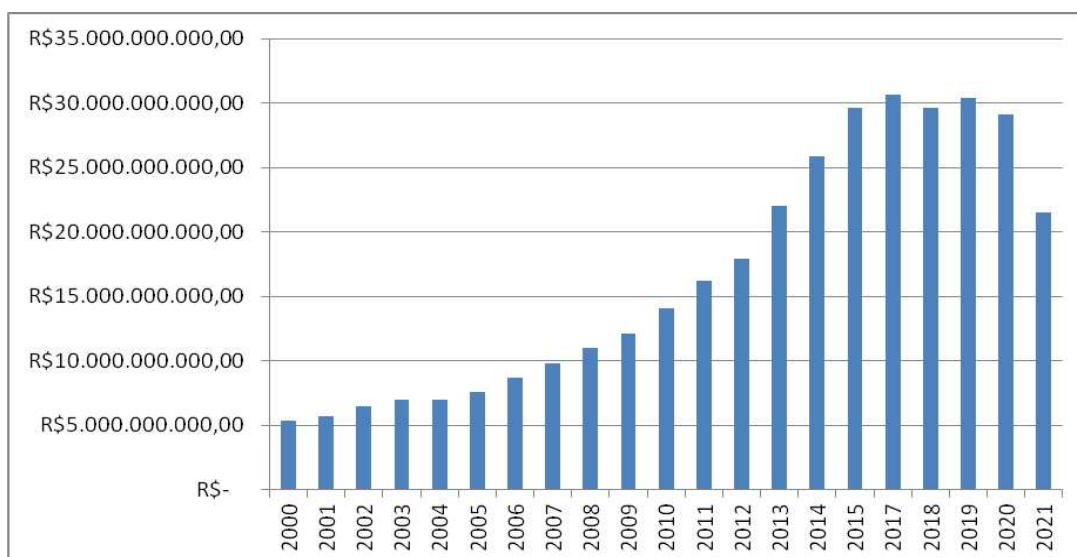
Figure 2 – Applications granted by university (2000-2021)



Source: INPI (2021)

An important fact is that the production of intellectual and industrial property does not come out of nowhere. It is the result of an investment of resources allocated in the correct place for the generation of this IP. This study took into consideration the amount of resources invested by the federal government in the institutions analyzed, segmented into funding and investment resources, between the years 2000 and 2021. The costing is the resource needed to maintain the basic activities of the institution, such as payment of salaries and consumption materials. Investment resources, on the other hand, are those that the university has available for basic and applied research. Figure 3 shows the amount of resources invested in higher education by the federal government.

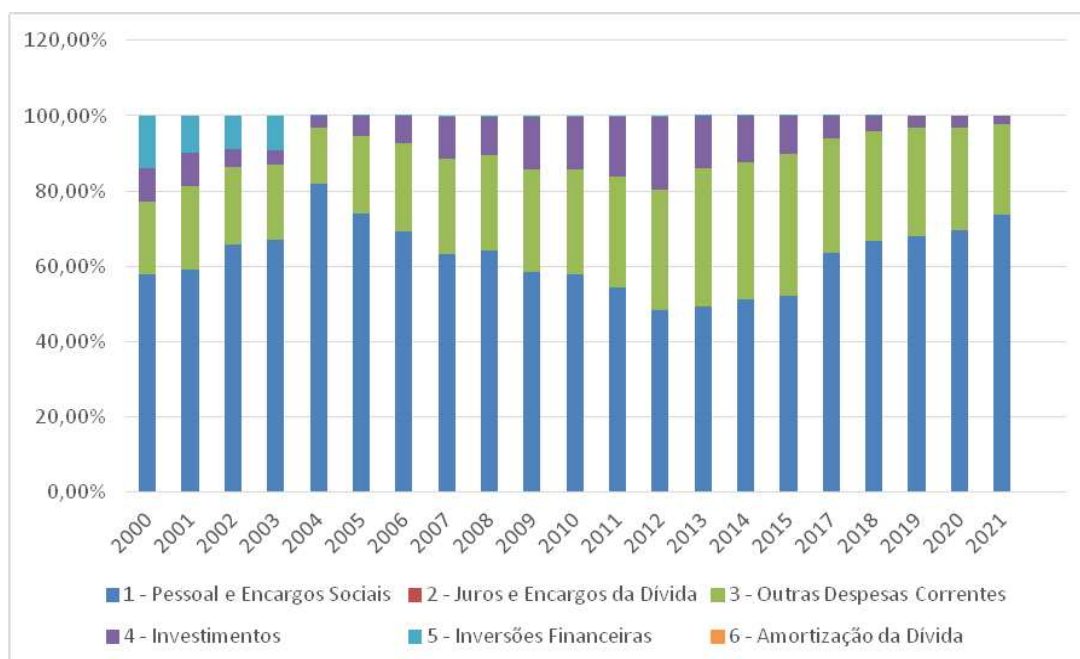
Figure 3 – Amount invested in Higher Education between the years 2000 and 2021.



Source: SIOPE (2021).

Between the years 2012 and 2019 a high volume of investment can be seen, linked to the good performance of the universities and their patent grants during the period. Figure 4 shows where the resources are applied, whether they are used for funding or for investment. The average resource used for investment is 8% during the years analyzed, peaking in 2012, with 19.42% of investment in research.

Figure 4 - Type of resource application for Higher Education

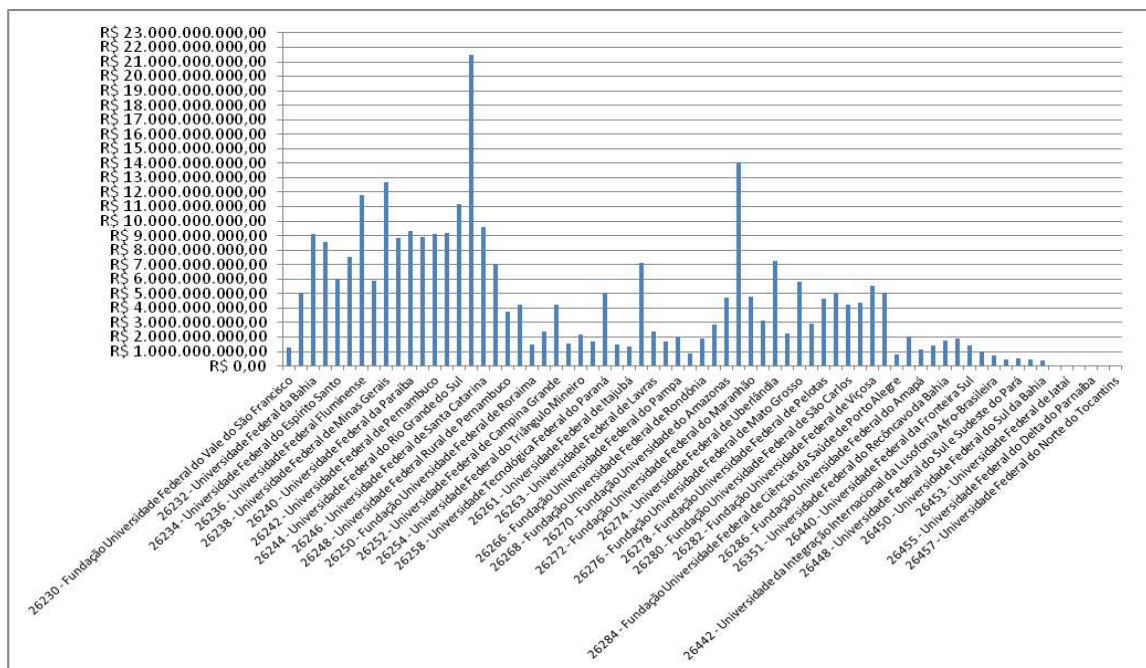


Source: SIOPE (2021)

Figure 5 shows the amounts received from 2000 to 2021 together (in thousands of Reais). In this figure it is observed that the universities that obtained the most resources from the federal government were not necessarily those that obtained the most academic patent concessions in the period. The Federal University of Rio Grande do Sul appears leading in resources, but it is in third place in the production of academic patents.

From this point of view, it is possible to corroborate the analysis of Carracedo and Puertas (2021), which disconnects the amount of resources applied to Research and Development (R&D) from the generation of more patents.

Figura 5– Amounts received in thousands per Federal University



Source: SIOPE (2021)

Figure 6 shows the correlation between the values effectively invested (amounts paid) in research. These values are separated from the values used for funding and were extracted from the SIOPE, using the values paid and not the values committed. It can be seen that not necessarily the greater the amount invested in resources applied to research development at the university, the greater is the number of patents granted, demonstrating once again that the production and granting of patents is independent of the amounts applied.

Pearson's correlation shows an indicator of 0.4630 between the amount applied and the patents granted, demonstrating a moderate correlation between these indicators.

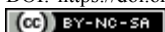
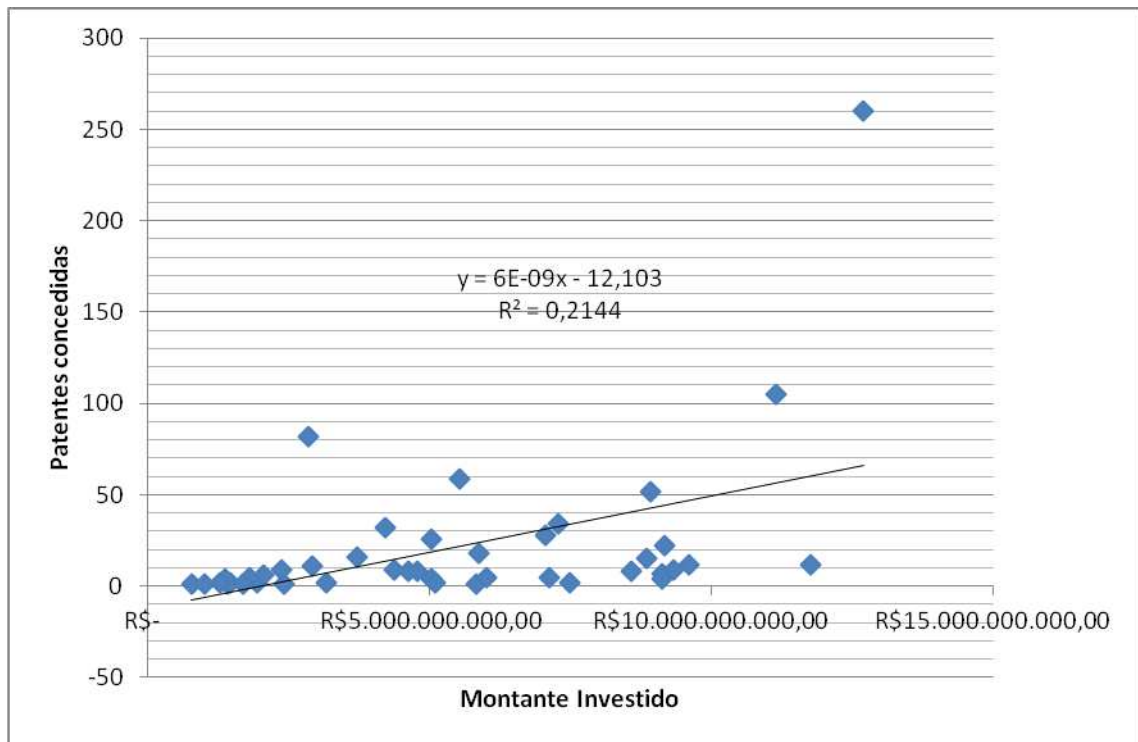


Figure 6 – Correlation between Investment x Number of Concessions
5

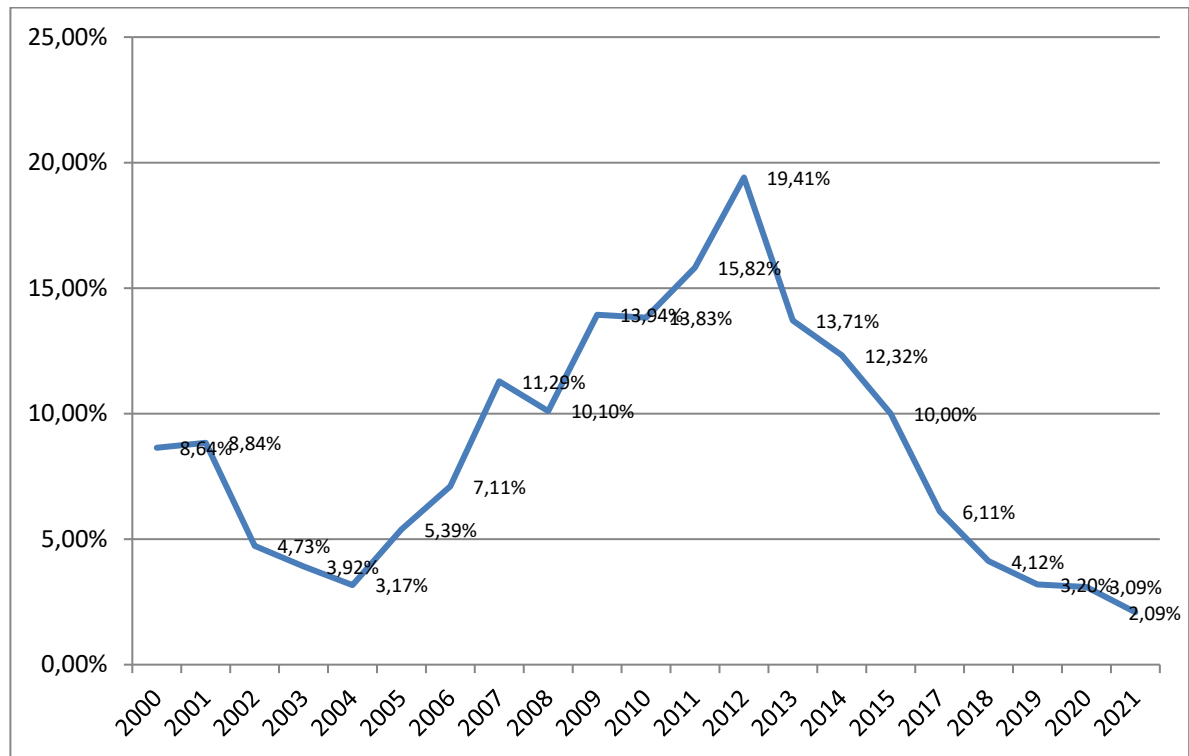


Source: Prepared by the authors

The data presented during the analyzed period brings an important reflection for resource managers and promoters of Research and Development, that not always a larger amount of resources means an increase in the production of industrial property - patents. Another important point to be highlighted is that from 2000 to 2021 the amounts invested in Higher Education increased by 619%, which can be understood as an increase in investment in public higher education, even when inflation for the period is excluded. The percentage of resources released for investment in research in federal universities had its expressive point or its apex between the years 2007 and 2015 (Figure 7), when it was always higher than 10% of the total invested in Higher Education.

⁵ Patentes concedidas = Patents granted; Montante investido = Amount invested

Figure 7 – Percentage of resources released for Investment in Research.



Source: SIOPE (2021)

From the data presented here, it is possible to affirm that the patents granted also presented a growth with a greater application of resources, but did not follow the same growth curve as the investment in research, because it is a product of innovation that takes a long time to be obtained.

Final considerations

During this study it was possible to understand the importance of innovation for national economic development. Meanwhile, universities play an important role in the dissemination of knowledge and technological diffusion.

Academic patents have taken over the progress of universities as a solid tripod in the helix structure, formatting research and impact studies not only in basic research, but also in applied research. The generation of academic patents has been one of the ways for universities to connect with the market, acting not only as disseminators of knowledge, but also bringing relevance and resources to their campuses through optimal intellectual and industrial production.

The study discusses data that show that federal universities in Brazil have acted to produce patents along with their innovation and technology centers and their support for industrial protection with regard to their publications. At this stage, it is possible or can be understood that during the period studied, the University of Minas Gerais (UFMG) has captained the production of academic patents (28% of the total produced in the period), even though it does not have the largest amount of investment applied in research.

The descriptive analysis shows that most of the resources coming from the federal government are not destined for research, but to cover the cost of the universities in relation to their professionals and consumables, having only 8% on average of the amount available for investment in R&D. Pearson's correlation shows that there is a moderate relationship (0.4630) between the amount invested and the number of patents granted, bringing to light the discussion that the amount of resources for patent production does not depend on the amount of resources, being necessary an academic body and researchers oriented to deliver to society solutions that are able to meet its expectations and, thus, bring resources from patent licensing.

It is noteworthy that this study was limited by the lack of information on which departments specifically the federal resources invested in federal universities are applied, leaving as a suggestion for future research the proposal of a detailed analysis by Brazilian state on the application of the amount invested per research effectively published or patented.

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