**Impact of Governmental Policies in Science, Technology and Innovation through Synthetic Methods**

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**Abstract**: This study aims to evaluate how the shift in government policies in science, technology, and innovation (STI) impact the scientific production. All the publications of the Web of Science from 2000 to 2021 were aggregated by country/region and the effect of different policies – one expansionist and the other retractionist – were analyzed through the Synthetic Control Method. The results confirm a positive effect of the raise in investments and a marginal reduction of the publications during the retractionist period. The study also indicates that the effect of the investments has a delayed impact of approximately two years. This paper can be useful to provide a guideline for the mechanisms of public support to research and subside the decisions of policy makers based on evidence.

**Keywords:** Science Policy, Economics of Science, Scientific Production, Econometrics, Synthetic Control Method (SCM), Synthetic Diff in Diff (SDID)

# Introduction

The promotion of science is an essential component of modern society, as it is a key factor in the development of innovative technologies and knowledge-based economies. By encouraging research activities, scientific advancement can result in tremendous economic and social benefits, such as production raise and economic growth (Corrado et al., 2009; Samimi and Alerasoul, 2009), increased employment opportunities REF, improved healthcare outcomes REF, and enhanced quality of life for citizens REF. Furthermore, the promotion of science can be instrumental in inspiring further innovation by providing an environment which encourages creative thinking and collaboration between researchers.

By introducing and executing policies, the government can influence the growth and development of science, technology, and innovation in a multitude of ways. From providing funding for research projects to incentivizing companies to invest in new technologies, governmental policies can have profound impacts on the direction that a country’s scientific and technological progress takes. Therefore, its incentive has been a major goal for policymakers and for the United Nations, being pivotal to the 2030 Agenda for Sustainable Development (Walsh et al., 2020).

However, measuring this progress can be difficult due to the intangible nature of knowledge. Being such an abstract concept, it can be hard to measure how much has been advanced by governmental policies or other factors. The most usual indicators to determine the scientific production are the quantity and quality of: publications, citations REF, patents (Kogan et al., 2017), collaborations REF among researchers REF, and human resources REF (HR) formation. Although these variables can be good proxies of scientific progress, an incalculable part of knowledge evolution is based on unobservable variables. While government initiatives may lead to advancements in science, technology and innovation over time, it can be hard to accurately quantify this growth at any given moment.

COMO A POLÍTICA FUNCIONA.. Efeitos contrários.. Expor as nuances... possibilidade de um índice...

Policies are deliberately chosen, what conducts to a bias of selection and therefore to an endogeneity problem. Endogeneity occurs when bias within a model affects its outcome and leads to inaccurate results (Angrist, 2008; Morgan and Winship, 2015). This should be controlled, which is usually accomplished with an experiment, based on a Counterfactual Impact Evaluation (CIE). In social sciences some econometric techniques have been successfully applied for this purpose in different contexts such as healthcare (Kreif et al., 2016), labor market (Peri and Yasenov, 2017), XXX, YYY. In the context of R&D, Robbiano (2022) has used the Synthetic Control Method (SCM) to estimate the causal effect of public-funded research centers on the regional innovative capacity. The present work will leverage on a similar method, the Synthetic Difference-in-Differences, which uses a pool of control units to create a synthetic replica of the treated unit and then compare the effect of treatment based on the counterfactual intuition.

JUNTO COM OS OUTROS.. Another challenge to access the impact of policies is their heterogeneous time effects. Innovation is a special investment in long-term intangible assets that will generate profits in the future (Bhattacharya et al., 2017). This macro dimensional strategies take time to materialize in utility for individuals and frequently the efforts result in a dead end. XXX, studied the effect of yyy. AAA, of bbb. So, question that motivates this work is understand how different STI policies affect the scientific production along the time.

Policies generally evolve gradually and in a fuzzy way, with new projects progressively substituting older ones. This unclear edge confuses the analysis and can conduct to spurious findings. This study, however, considers the unusual case of Brazil, where the National Strategy on STI was radically changed. After a period of substantial expansion of public investments, the leftist president Dilma Rouseff was impeached from her post. The vice-president Michel Temer assumed in the end of 2016, aligned to the right-side parties and with a strategy of reducing public investments in R&D and emphasizing the participation of private equity. To contextualize the drastic contrast of the policies in these different periods a documental analysis was conducted in Section 4.

POLÍTICA ou PLANO NACIONAL DE STI.. acertar terminologia..

Política tem diferentes níveis.. estratégico.. operacional... ações... “Este trabalho adotará a tipologia de política de XXX”… Tese do Henrique Teixeira...

Therefore, this study aims to evaluate the impact of these different Brazilian policies in science, technology, and innovation towards scientific production. It leverages on the Synthetic Difference-in-Differences (SDID) method introduced by Arkhangelsky et al. (2019). As robustness tests its predecessor methods – the canonical Difference-in-Differences (Card et al., 2022) and the Synthetic Control Method (Abadie, 2021; Abadie et al., 2010) – will be applied and also an placebo test using the Leave-One-Out (LOO) cross-validation.

The analysis intends to instrumentalize policymakers to better understand the conversion of policies into scientific production and therefore improve the effectiveness their designs. From the practical perspective, this study may also be useful to researchers or project managers interested in understanding the same phenomena and its heterogenous effect along the time. This work may also represent a contribution to the theory of STI studies as it formalizes some of the causal effects that stimulates and/or inhibits scientific production in Brazil, serving as reference for future generalizations in other regions. A IDEIA DE QUE POLÍTICA É DIFÍCIL DE ACESSAR.

The rest of the study is structured as follows. Section 2 describes theoretical background and the hypothesis development; while Section 3 details the methodology; Section 4 features the Brazilian case, differentiating the policies and summarizing statistics; Section 5 presents the results and discussion; and Section 6 concludes.

# Theoretical background and hypotheses development

Effective public policies design require a good understanding of the context and the characters interactions in a complex environment (Howlett, 2018). Governments have different forms of affecting science production, generally interacting with academia and industry, in format of what is called a Triple Helix Model (Leydesdorff and Etzkowitz, 1998). Their participation may be subsidiary (only as sponsor) or central (executing the R&D). The following section will present the main actors in this schema and synthesize how they contribute to the production and progress of science.

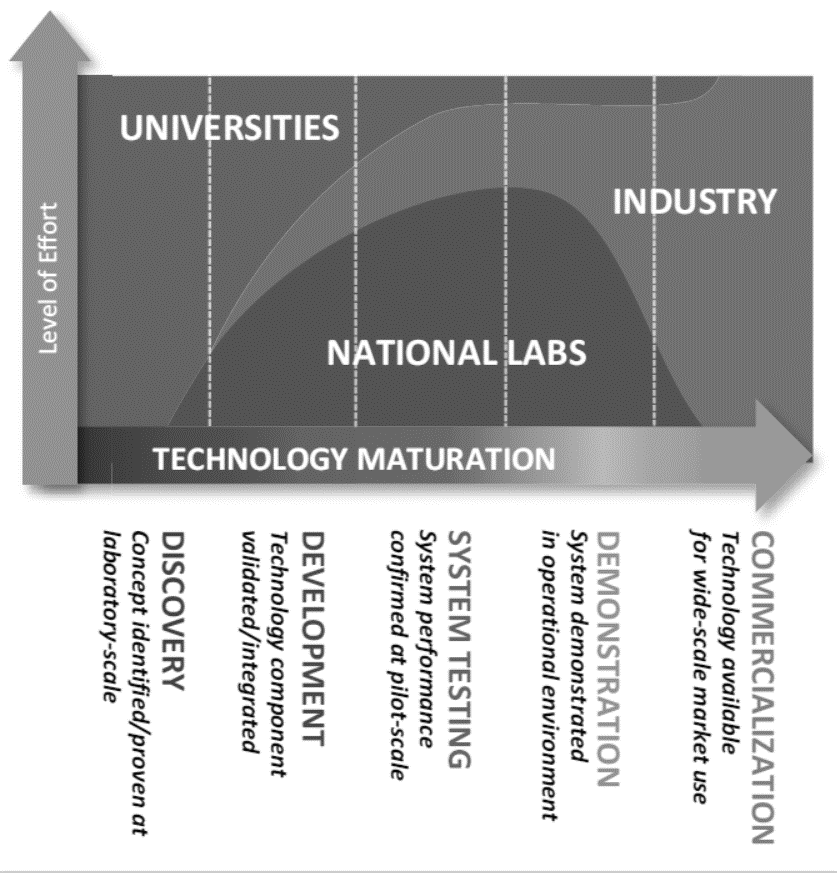
A major impact of policies is made through the definition of the public budget. Considering the scarcity of resources and the abundance of demands, the prioritization of necessities is a central issue to scientific production. The rules of the financial support may benefit specific matters of national interest and therefore have a directive effect on the research.

STI investments frequently involve large amounts of capital and long-term (often unpredictable) durations. This characteristic highlights the importance of sustainability of the support. For instance, if the support is destined to buy equipment, then its maintenance should be predicted. This upkeep can be provided either by the funder and/or by the researcher.

Due to the long-term and risky nature of research most of the national investing matrixes are based on public subsides. Huang & Huang (2018) analyzed the funding of 5,856,744 articles of G9 countries[[1]](#footnote-1) published between 2009 and 2014. They discovered that governmental agencies were the major sponsors in these countries and the top three funding agencies in each G9 country were primarily domestic agencies. McManus & Neves (2021) studied 660,308 funded publications in Brazil and found that 70% of these documents were received support of federal or statal agencies.

In a smaller scale, the private funding also contributes to research, mainly in later stages of maturity (REF). Figure 1 shows how the industry progressively join in the R&D, from a modest participation during the development stage, to the main contribution in commercialization.

**Figure 1** – Level of effort of universities, national laboratories and indutry,   
according to technology maturation



Source: U.S. Department of Energy

The private investing in R&D can be divided in three major types. First there is budget of large-cap companies to develop research and development for their established products and processes or for the broaden of their portfolio. Second, there is the investment of small-cap companies - such as venture capital, seed funding, and angel investing – generally combining the capital injection with some kind of know-how support of the investor [REF]. And third, there is the non-profit organizations funding, associated to social and health matters and often related philanthropic foundations.

Since it is very common that governments and companies invest abroad, another important differentiation is among national and foreign players. Park et al. (2022) have conducted a study that highlights the importance of stimuli to local R&D to attract foreign R&D, also pointed the different factors that drive multinational corporation spendings abroad. usually there is a concern about technological competition, while in developing countries the focus is to just modify the products according to the local or export markets. They recommend first that local R&D is important to attract foreign investments, and also that in developed economies policies should focus on attracting private R&D aiming for technological competition, while in developing countries there is a necessity for a minimum level of infrastructure which can public R&D to then be able to attract private foreign capital.

Drivas et al (2015) compared the impact of the type of research funding in the outcomes of laboratories of the Agricultural University of Athens. They have found that private and public fundings have similar effect on publications and citations. Considering that we propose the following hypothesis:

**H1.** *: Public and private STI funding have a substitutive relation to each other.*

The high education institutions play a central role in the execution of research. Valero & Reenen (2019) details the mechanisms how universities impact in Gross Domestic Production (GDP) estimate that a 10% raise in the number of universities per capita of a region increases 0.4% increase the economic indicator. They also demonstrate the positive spillover effects from universities to geographically close neighboring regions. This finding contrasts with previous studies (Bonander et al., 2016) that cast doubt on the effectiveness of research universities in fostering regional growth and development.

A most recent study, by Robbiano (2022) highlights that Public Research Institutes (PRIs), such as new universities, research infrastructures and organizations traditionally involved in the process of generation, accumulation and transmission of the latter through a causal chain of effects between research investments, increases in the knowledge production infrastructure, creation of a (local) knowledge base, knowledge spillovers, and economic agglomeration. This results in long-term growth in production, and wealth”. Since the number of universities and PRIs can be considered a metric of advancement in STI policies we consider the following hypotheses:

**H2a.** *: The public policies in STI directly impacts the quantity of high education institutions.*

**H2b.** *: The public policies in STI directly impacts the quality of high education institutions.*

Reichert (2016) emphasizes in the role that universities, the government and the companies operate in regional innovation ecosystems. She also underlines the importance of networking and channels of interaction of among all the sides of this Triple Helix. This framework is used for understanding the interdependence of university, industry, and government in facilitating economic development. The concept emphasizes the importance of collaboration among these three key stakeholders to achieve sustainable growth and dynamism. It is argued that a mutually beneficial triadic relationship can be developed to stimulate innovation through knowledge transfer REF, resources sharing REF, and complementary expertise REF. Considering the benefits of the collaborations to the scientific production we propose the following hypotheses:

**H3a.** *: The public policies in STI directly impacts the number of domestic collaborations.*

**H3b.** *: The public policies in STI directly impacts the number of international collaborations.*

**H3c.** *: The public policies in STI directly impacts the number of industry collaborations.*

The direct impact of STI funding upon the number of publications has been demonstrated through various quantitative models, such as REF. This is due to the increased accessibility of resources, such as research funding, technological advancements and higher quality training programs, access more advanced tools and equipment, that are made available through public investment in STI.

**H4a*.*** *: The public policies in STI directly impacts the quantity of publications*

It is expected that this improved access to resources leads to increased productivity, not only in terms of the quantity, but also of quality of scientific publications. REF studies the effect on quality. The idea of 'publish or perish' has been a mainstay amongst academics for many years. Some policies that reward the number of publications without regard to the quality of the production have conducted to an inflation of researches with insignificant contributions. Recently, incentives to better publications have increasingly been included in STI policies.

**H4b*.*** *: The public policies in STI directly impacts the quality of publications*

The role of citations on the scientific production is an important factor to consider when discussing the impact of governmental policies in science, technology, and innovation. Citations are a way for scientists and researchers to acknowledge each other’s work while advancing their own research through collaboration. With the rise of digitalization, more and more research are being published online and shared across multiple platforms which makes it easier for researchers to cite each other's work. This facilitates an increase in knowledge sharing among scholars and institutions, allowing new ideas to be generated from existing ones. Citations also act as indicators of quality by enabling researchers to compare the impact of different studies or papers. A higher citation rate signifies that a piece of writing has been found useful by many peers in the field, giving it more credibility than those with lower rates.

**H5a*.*** *: The public policies in STI directly impacts the quantity of citations.*

**H5b*.*** *: The public policies in STI directly impacts the quality of citations.*

The public investment in Science, Technology, and Innovation (STI) plays a crucial role in the quantity of patents both in the national office, as well as those belonging to national inventors. It is estimated that government policies have a direct influence on advancing technological progress and improving innovation processes REF. Recent studies have demonstrated that countries with higher levels of STI investment experience significant growth in patent production REF. Government policies can be key drivers for increases in patent activity, particularly when they focus on incentivizing research activities, providing access to resources and knowledge networks, or assisting businesses with certain costs associated with the development of novel products and services REF.

Drivas et al (2015) have found that “research laboratories that have filed for at least one patent application produce more publications and citations to their work, indicating that laboratories that are close to industry are also engaged actively in research”. Blind et al (2018) studies indicate that “researchers who are active in patenting seem to be driven by the motivation to commercialize their research, and gaining reputation has no significant effect on patenting”. Some of the main mechanisms to foster this output are introducing measures such as tax credits for research expenses, subsidies for R&D projects and programs focused on commercialization of new technologies.

**H6a*.*** *: The public policies in STI directly impacts the quantity of patents in the national office*

**H6b*.*** *: The public policies in STI directly impacts the quantity of patents of national inventors*

The implementation of public policies related to the field of Science, Technology and Innovation (STI) have a direct effect on the formation of human capital in terms of advanced qualifications, such as Masters and Doctoral degrees. Through STI-related public policies, fiscal incentives, research grants and development projects are made available to facilitate educational pathways for potential postgraduate students. This consequently facilitates access to higher education, allowing graduates to pursue more specialized courses of study in their chosen fields.

**H7*.*** *: The public policies in STI directly impacts the HR formation*

The proliferation of government policies in the areas of science, technology and innovation is an important factor in determining the economic growth trajectory of a nation. By investing in cutting-edge research initiatives, encouraging commercialization of scientific discoveries, and providing incentives for R&D activities, governments can create beneficial conditions for technological growth, consequently leading to improvements in productivity, increased efficiency, and higher profits. The quality and directionality of public policy in STI is an essential determinant for economic growth, particularly as it relates to Gross Domestic Product (GDP). Coccia (2009) discusses what would be the optimal rate of R&D investment to maximize productivity growth. His findings point that the range of gross domestic expenditure on R&D expressed as percentage of GDP (GERD) between 2.3 percent and 2.6 percent maximizes the long-run impact on Productivity growth.

**H8***. : The public policies in STI directly impacts the GDP*

The mechanisms and relationships, as well as the hypotheses presented in this section are synthetized on Figure 1.

**Figure 1** – Conceptual framework of STI Policies effects on scientific production

Diagram

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ESTRATEGIA

* SUBSÍDIOS
* SETOR PRIVADO
* TIRAR TRIPLICE HÉIX

# Methodology

The first part of this study aims to characterize the differentiation of two STI policies implemented in Brazil. The data used for this objective was collected from government departments, such as Ministry of Economy (ME) and the Brazilian Ministry of Science, Technology, Innovation and Communication (MCTIC). A quantitative analysis of the budget addressed to the main national STI initiatives was based on data of Integrated Planning and Budgeting System[[2]](#footnote-2) (*Sistema Integrado de Planejamento e Orçamento* - SIOP), from 2000 to 2022. This was reinforced by a qualitative comparison of the National STI Plans adopted during this period. This first part of the analysis is presented in Section 4.

The second part of this study consists in application of the Synthetic Difference-in-Differences (DiD), and the robustness tests. This method is an analytical tool used to measure the impact of governmental policies in science, technology and innovation. It assesses the effect of government policy changes on outcomes by comparing the change before and after the policy change with a comparable group that did not experience such an intervention. By comparing these two groups, Synthetic DiD provides a clearer picture of how effective certain policies have been in driving technological progress over time. This method has become increasingly popular for analyzing data related to science and technology policy due its ability to control for confounding factors that may influence results. Synthetic DiD can isolate the causal effect of public policies from other factors such as population characteristics or economic conditions, thus providing more accurate insights into the success or failure of governmental interventions like subsidies or support programs. The second part of the analysis is presented in Section 5.

The data used for the application was collected from four distinct sources: Incites (based on Web of Science/Clarivates)[[3]](#footnote-3), SCImago (based on Scopus/Elsevier)[[4]](#footnote-4), World Intellectual Property Organization (WIPO) IP Statistics Data Center[[5]](#footnote-5), UNESCO Institute of Statistics (UIS)[[6]](#footnote-6). A description of each dataset is presented on Appendix 3.

The scientific production of all the countries available in each database was used to create a panel with the evolution of these variable from 2000 to 2022. The missing values were interpolated, using values from previous and next years. Details of the data preparation can be accessed in: [*https://github.com/rod53/BrScienceSDID*](https://github.com/rod53/BrScienceSDID)*.*

The canonical version (without covariates) of the method was applied to each variable independently to access the effect of the treatments – each of the two policies – in the respective output. The model was applied on the software Stata, using the package *synth2*. The do file is also available on GitHub.

# The Brazilian case

The presidential elections in Brazil have had a profound effect on the nation's STI strategies. This can be attributed to the fact that the president holds an immense amount of influence over the budgetary allocations for research institutions, as well as other forms of public investment into scientific initiatives. Moreover, changes in the political landscape can lead to varying levels of support for existing scientific research agendas and policies, which can lead to fluctuations in levels of research output.

During the governments of Fernando Henrique Cardoso (1995-2002) and the first term of Luíz Inácio “Lula” da Silva (2003-2006), the national budget for STI remained on the same level and the national policies were based on the continuity of initiatives pre-existent.

The second term of Lula (2007-2010) and the subsequent governments of Dilma Rousseff (2011-2014 and 2015-2016) injected a substantial amount of money in higher education institutions and in research. During this period some new policies such as the Sciences Without Borders (*Ciências Sem Fronteiras – CSF*), Unified Selection System (Sistema de Seleção Unificada - SISU), and a very significative change in the Higher Education Student Financing Fund (*Fundo de Financiamento ao Estudante do Ensino Superior - FIES*) were implemented. The STI policies and investments were expanded.

In 2016, after the impeachment of Dilma, her vice-president, Michel Temer, assumed the office. The national plan for the new government was published only in 2018, two years after the president have taken the office. The new plan was underscored by the strengthening of University-Companies relationship. Expecting for a more significative participation of private equity, the government drastically reduced the money budget for STI. This retraction of R&D investments was aggravated during the government of Jair Bolsonaro. See Figure 3.

**Figure 3** – Evolution of Brazilian public investments in STI

Chart, line chart

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Source: I will remake this graph with an extended period and division of each presidential term

Some of the main policies implemented during the last years will be detailed below.

## Fundo de Financiamento ao Estudante do Ensino Superior (FIES)

The Higher Education Student Financing Fund (*Fundo de Financiamento ao Estudante do Ensino Superior - FIES*) is a student loan program implemented in 1999 to provide financial assistance for students enrolled in higher educational institutions. FIES financially supports educational endeavors that have potential to develop qualifications, research skills and international collaboration opportunities. The aim of this policy is to enhance the quality of education available in Brazil and make it more accessible for lower-income families. Through FIES, students are provided with low-interest loans that can be used to pay their tuition fees or purchase books and other study materials. The loans are also designed to aid students who wish to pursue advanced degrees such as doctoral studies or postgraduate programs.

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## University for All Program (Programa Universidade para Todos - Prouni): 2005-today

The Prouni provides access to higher education opportunities for economically disadvantaged students throughout Brazil. It also ensures that science and technology related fields are prioritized in universities across the nation. This initiative works to reduce economic disparities by providing equal access to quality education for all citizens regardless of their income or background. Additionally, it promotes economic development through increasing scientific knowledge and technological advancement within Brazilian society. By combining increased accessibility with applying advanced research capabilities, the ProUni Program is making great strides towards furthering innovation in Brazil while laying a strong foundation for future generations.

## Unified Selection System (Sistema de Seleção Unificada - SISU): 2010-today

The Brazilian Science, Technology, and Innovation Policies have had a major impact on the nation's educational system. Through the implementation of the Unified Selection System (Sistema de Seleção Unificada - SISU), Brazil has created an online platform that allows students to apply for higher education institutions without leaving their homes. This program has been credited with increasing access to higher education by providing a more efficient and equitable selection process.

SISU is designed to provide equal access to all qualified applicants regardless of socio-economic background or geographic location. It uses data from high school grades and standardized tests to select promising candidates who are then admitted into higher education institutions based on their ranking. This approach ensures that students from diverse backgrounds receive fair consideration for admittance into universities, colleges, and technical schools.

## Ciências Sem Fronteiras (Sciences Without Borders)

Ciências Sem Fronteiras is a Brazilian program that seeks to promote scientific and technological innovation in the country. It was launched in 2011 by the Brazilian government as part of their National Strategy for Science, Technology, and Innovation (ENCTI). The program provides financial support for international research collaborations between Brazilian and foreign institutions. Through this initiative, Brazil has been able to increase its capacity for technological innovation by providing researchers with access to world-class research facilities. The program also offers scholarships to students who are interested in pursuing studies abroad. This allows them to gain experience at leading international universities while broadening their perspectives through exposure to different cultures. In addition, Ciências Sem Fronteiras has provided support for various scientific events such as conferences and workshops held in Brazil or abroad where researchers can exchange ideas and collaborate on projects.

This policy was not exclusive in Brazil. In the United States, for instance, President Obama announced the BRAIN Initiative in 2013 as part of his commitment to promoting scientific research and development. Similarly, China launched its own ‘Thousand Talents Program’ that same year which sought to attract foreign talent from around the world.

SUPLEMENTAR MATERIAL…

# Preliminary Results and Discussion

The main results of this study are represented on Table 1 and detailed on Appendix 1 and 2. During the discussion, the symbol \* will indicate significant effects (p-value ≤ 0,05), while \*\* will indicate partially significant effects (p-value ≤ 0,1). P-values above this threshold will be considered insufficiently different from zero.

Table 1 – Results of SDID, for Expansion and Retraction periods

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variables | Expansion (2006 – 2016) | | | |  | Retraction (2017 – 2021) | | | |
|  | ATT | Std. Err. | t | P>|t| | ATT | Std. Err. | t | P>|t| |
| Web of Science Docs | 9,320 | 2,470 | 3.770 | - |  | 4,380 | 2,050 | 2.140 | 0.032 |
| Docs in JIF Journals | 7,260 | 2,360 | 3.070 | 0.002 |  | 1,190 | 1,430 | 0.830 | 0.406 |
| Documents in Q1 Journals | 2,680 | 1,400 | 1.910 | 0.057 |  | -1,840 | 953 | -1.930 | 0.054 |
| Documents in Q2 Journals | -80 | 622 | -0.130 | 0.897 |  | 1560 | 762 | 2.050 | 0.040 |
| Documents in Q3 Journals | 1,260 | 522 | 2.420 | 0.015 |  | 632 | 445 | 1.420 | 0.155 |
| Documents in Q4 Journals | 3,560 | 326 | 10.920 | - |  | -729 | 328 | -2.220 | 0.026 |
| Documents in Top 1% | 122 | 77 | 1.580 | 0.114 |  | -97 | 125 | -0.780 | 0.438 |
| Documents in Top 10% | 72 | 539 | 0.130 | 0.893 |  | -753 | 463 | -1.630 | 0.104 |
| Times Cited | 64,200 | 70,600 | 0.910 | 0.363 |  | -207,000 | 65,700 | -3.150 | 0.002 |
| Citation Impact | -3 | 10 | -0.320 | 0.749 |  | 2 | 6 | 0.400 | 0.692 |
| Citations From Patents | -1,180 | 2,340 | -0.500 | 0.614 |  | -1,390 | 429 | -3.250 | 0.001 |
| Domestic Collaborations | 3,550 | 786 | 4.510 | - |  | 1,890 | 965 | 1.960 | 0.050 |
| International Collabs | 2,500 | 839 | 2.980 | 0.003 |  | -1,250 | 625 | -2.000 | 0.046 |
| Industry Collabs | 11 | 179 | 0.060 | 0.952 |  | 242 | 87 | 2.800 | 0.005 |
| All Open Access Docs | 5,110 | 811 | 6.300 | - |  | 102 | 3,840 | 0.030 | 0.979 |
| Gold Documents | -1,340 | 430 | -3.120 | 0.002 |  | -1,060 | 1,030 | -1.030 | 0.303 |
| Free to Read Documents | 787 | 297 | 2.650 | 0.008 |  | -98 | 273 | -0.360 | 0.719 |
| Green Submitted Docs | 1,850 | 494 | 3.740 | - |  | -3,380 | 341 | -9.920 | - |
| Green Accepted Docs | 397 | 230 | 1.730 | 0.084 |  | 56 | 1,040 | 0.050 | 0.957 |
| Green Published Docs | 1,220 | 416 | 2.930 | 0.003 |  | -5,500 | 2,120 | -2.590 | 0.009 |
| Green Only Docs | 33 | 515 | 0.060 | 0.948 |  | -696 | 509 | -1.370 | 0.172 |

Source: author

The impact of both policies in the number of domestic collaborations (H2a) was positive in both periods, but the ATT in EXP (+3,550\*) was almost twice the value of RET (+1,890\*). On the other hand, the effect on international collaborations (H2b) was positive in the first period (+2,500\*), and negative in the second period (-1,250\*). Comparing the combined values of domestic and international collaborations, we observe a declining tendency in both, but it is more accentuated for second case. It is expected that domestic collaborations be less demanding than international, so these results indicate a shift where researchers were conducted to local partnerships due to the restrictions of the retractionist policy.

Regarding the industry collaborations (H3c), for EXP the effect was not significant, on the other hand for RET there was an increase of +242\* compared to the counterfactual. This result was expected, based on the focus given for the retractionist policy to private equity and applied research. This also reinforces the thesis for the substitutive relationship to public and private fundings (H1). The shortage of public fundings motivates researchers to look for alternatives in the other sector.

The findings on Web of Science Documents support the positive effect of EXP on the number of publications (H3a), with an increase of publication per year (+ 9,320\*) in comparison to the synthetic counterfactual. However, the negative effect on RET was denied, since during the last period the ATT kept positive, with 4380 extra publications per year. The effect was halved from one period to the other, what may indicate that a part of the measures and investments adopted in EXP might have decayed. It is expected that investments in equipment or infrastructure depreciate in time. Even intangible assets such as data collected may devalue in relation to its antiqueness.

The hypothesis of improvement of the quality of publications (H3b) was proved during EXP, with a significant increase in publications in JIF journals (+7,260\*), in Q1 Journals (+2,680\*\*), in Q3 Journals (+1,260\*), and in Q4 Journals (+3,560\*). The improvement, however, did not reach the top 1% and 10% publications, indicating that the very top journals may be more restrictive. Regarding the RET period, there was a reduction of the Q1 papers (-1,840\*\*) and of Q4 papers (-729\*), however the number of Q2 papers kept rising (+1,560\*), even during the retractionist policy period. This may be explained by the shift of projects and infrastructures that were previously producing Q1 publications to lesser qualified journals.

It is important to highlight that the best periodicals are oriented to basic sciences and theory. This represents a significative bias, once that even excellent research oriented to industry and applied knowledge will suffer to publish in these top journals.

Nevertheless, the citations of the paper represent a independent metric where the audience reproduces sources with recognized value for their works. The hypothesis of increase in the number of citations (H4a) was not statistically significant for EXP, which means that the effect was not enough different from zero in comparison to the synthetic control. However, for RET the effect was significant leading to a substantial reduction in the times that Brazilian papers were cited in relation to the counterfactual (-207,000\*). Regarding the quality of the citations (H4b), in both periods the citation impact was not significant.

Therefore, the investments in EXP conducted to an increase in the quantity and quality of papers (H3), however were not able to affect the quantity or quality of citations (H4). In the RET period, the number of papers still increasing, and the number of citations decreased. This contradicts the intuition that the citations should increase with the rise of the number of publications. Therefore, it suggests that citations should be concentrated on the very high-quality papers (Top 1% and 10%), which were unaffected by both policies.

The number of citations from patents during EXP was not significant, but in RET the number was considerable and negative (-1,390\*). The hypothesis of positive impact of the public investment in STI to the quantity of patents (H6) could be refuted, by the fact that after many years of investment this variable have not presented additional effects against the counterfactual. However, the assessment of the impacts on patents are prejudicated by their substantial time of maturation. Very often patents may take 10 years to be completely approved [REF]. Additionally, the indicator is the “citation” of this patent, so after the whole process the patent has to be cited in a paper. Other confounder in this case is the increasing number of products and technologies open source, which do not necessarily formally register patents.

This discussion of patents will be incremented by the analysis of WIPO data.

Regarding the hypothesis of substitutive relationship between public and private investments (H1), this was proved by ADD DATA ANALYSIS OF PRIVATE VS PUBLIC, FROM UNESCO.

POLITICA TEMER DE PATENTES… SEM A VALIAR ANTERIORIDADE (JAIME)

Note: The H2a and H2b (effect on quantity and quality of high education) will be tested after an extra data collection about the number of universities and institutes of Brazil and the other countries for the period. If I don’t find the data, I will just take it of the study.

Investments could be cumulative, always increasing, since an upper level of infrastructure demands an upper level of maintenance costs.

Different maturity levels: nations with a low level of industrializations and public infrastructure demand PUBLIC investments, since internationally they are not appealing for PRIVATE equity.

GREEN PUBLICATION S:  [D:\Google Drive\Grimoire\My Papers\Schot & Steinmueller (2018) @RP, Three frames for innovation policy; R&D, systems of innovation and transformative change.pdf](file:///D:\Google%20Drive\Grimoire\My%20Papers\Schot%20&%20Steinmueller%20(2018)%20@RP,%20Three%20frames%20for%20innovation%20policy;%20R&D,%20systems%20of%20innovation%20and%20transformative%20change.pdf)

H1: industry, patents -> the metrics are adecademic and not practical, the best journals are theoretical….

**Table 2 – SDID Results**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Expansion (2006 – 2016)** | | | |  | **Retraction (2017 – 2021)** | | | |
|  | **ATT** | **SE** | **t** | **P>|t|** | **ATT** | **SE** | **t** | **P>|t|** |
| Web of Science Documents | 9320 | 2470 | 3.77 | 0 |  | 4380 | 2050 | 2.14 | 0.032 |
| Documents in JIF Journals | 7260 | 2360 | 3.07 | 0.002 |  | 1190 | 1430 | 0.83 | 0.406 |
| Times Cited | 64200 | 70600 | 0.91 | 0.363 |  | -207000 | 65700 | -3.15 | 0.002 |
| Citation Impact | -3 | 10 | -0.32 | 0.749 |  | 2 | 6 | 0.4 | 0.692 |
| Citations From Patents | -1180 | 2340 | -0.5 | 0.614 |  | -1390 | 429 | -3.25 | 0.001 |
| Domestic Collaborations | 3550 | 786 | 4.51 | 0 |  | 1890 | 965 | 1.96 | 0.05 |
| International Collaborations | 2500 | 839 | 2.98 | 0.003 |  | -1250 | 625 | -2 | 0.046 |
| Industry Collaborations | 11 | 179 | 0.06 | 0.952 |  | 242 | 87 | 2.8 | 0.005 |
| All Open Access Documents | 5110 | 811 | 6.3 | 0 |  | 102 | 3840 | 0.03 | 0.979 |
| Gold Documents | -1340 | 430 | -3.12 | 0.002 |  | -1060 | 1030 | -1.03 | 0.303 |
| Free to Read Documents | 787 | 297 | 2.65 | 0.008 |  | -98 | 273 | -0.36 | 0.719 |
| Green Submitted Documents | 1850 | 494 | 3.74 | 0 |  | -3380 | 341 | -9.92 | 0 |
| Green Accepted Documents | 397 | 230 | 1.73 | 0.084 |  | 56 | 1040 | 0.05 | 0.957 |
| Green Published Documents | 1220 | 416 | 2.93 | 0.003 |  | -5500 | 2120 | -2.59 | 0.009 |
| Green Only Documents | 33 | 515 | 0.06 | 0.948 |  | -696 | 509 | -1.37 | 0.172 |
| Documents in Q1 Journals | 2680 | 1400 | 1.91 | 0.057 |  | -1840 | 953 | -1.93 | 0.054 |
| Documents in Q2 Journals | -80 | 622 | -0.13 | 0.897 |  | 1560 | 762 | 2.05 | 0.04 |
| Documents in Q3 Journals | 1260 | 522 | 2.42 | 0.015 |  | 632 | 445 | 1.42 | 0.155 |
| Documents in Q4 Journals | 3560 | 326 | 10.92 | 0 |  | -729 | 328 | -2.22 | 0.026 |
| Documents in Top 1 | 122 | 77 | 1.58 | 0.114 |  | -97 | 125 | -0.78 | 0.438 |
| Documents in Top 10 | 72 | 539 | 0.13 | 0.893 |  | -753 | 463 | -1.63 | 0.104 |

Source: author

WOS: efeito menor em RET devido ao efeito retardado de decaimento dos investimentos em EXP

GOLD/GREEN: Contratintuitivo, deveria aumentar, mas o pesquisador com $$$ parece preferir publicar em GREEN do que em GOLD

Q1/Q2: Efeito de decaimento dos investimentos refletidos em JQ1EXP

Parece que EXP reforçou significativamente as publicações

# Conclusions

Summarize all the paper.

Recall Research Questions: How investment effects on scientific production can support policy makers decisions?

THEORY CONTRIBUTION: public investment has a direct impact on the scientific production. Although, some few variables, such as XXX YYY, have an inverse relation.

PRACTICAL CONTRIBUTION: Policy makers should consider these effects on the formulation of public policies. Practical example.

For emergent countries, with low levels of industrialization and public infrastructure, public policies reinforcing the investment are necessary, because they are not appealing for private equity.

Limitations and future studies

THINK TANK:

This work represents contribution to theory of the SDID method, as it applies the method in a sequential manner, to compare two different policies.

On the national level This challenge is Park & Lee (2020), The Determinants of Foreign Direct Investment in R&D. [Complementariedade](https://lume.ufrgs.br/bitstream/handle/10183/213599/001118123.pdf?sequence=1&isAllowed=y). This study focus on public investments.

Sociotechnical. **Quanto maior os investimentos maior os retornos**. REF.

Synthetic Control Method (SCM) is an econometric technique that has been widely used for research in the economic and social sciences areas (ABADIE, 2021). The central idea of the method is to create a synthetic counterfactual from the approximation of the control group with the treated unit. Some examples of studies are Kreif et al. (2016) and Peri & Yasenov (2017).

In order to do so Brazil up and down. Policy. Aims to qualify and instrumentalize the public manager decisions. QUESTION

Interesse para universidades que querem aumentar de ranking

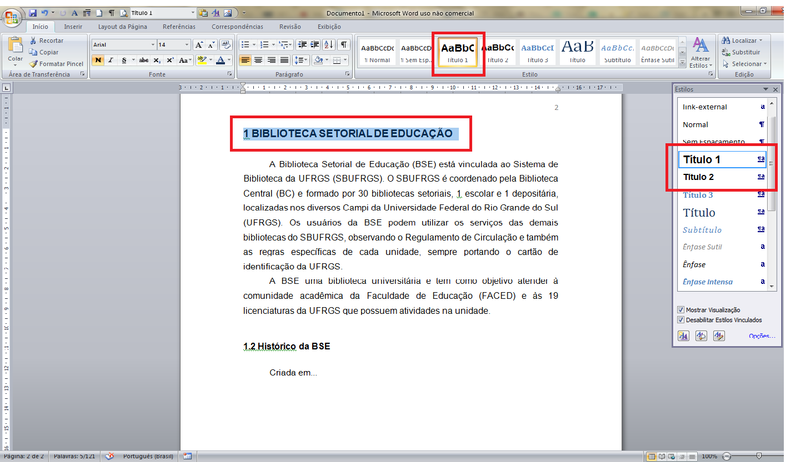
Para empresas que querem investir em R&D

Mencionar o Paradigma Transformativo (Mackenzie & Knipe, 2006)

Coniderar o Flexible Pattern Matching apresentado em INOV pelo Corti.

Consider Seven Strategies for Sensemaking, by Langley (1999) “Templates and Turns in Qualitative Studies of Strategy and Management” para escrever o Timeline das políticas brasileiras.

Ilustração 1 – Adoção de estilo nos títulos das seções



Fonte: Elaborado pela BSE.

Tabela 1 – Exemplo de Tabela

|  |  |  |
| --- | --- | --- |
| **Faixa etária (anos)** | **Número (n)** | **Porcentagem (%)** |
| 10-15 | 5 | 16,8 |
| 16-20 | 10 | 33,4 |
| 21-26 | 7 | 23,4 |
| 26-30 | 8 | 26,4 |
| **Total:** | 30 | 100 |

Fonte: Dados da pesquisa.

**Quadro 1** – Ordem dos elementos do artigo científico

|  |  |
| --- | --- |
| Elementos pré-textuais | Título no idioma do documento (obrigatório) |
| Título em outro idioma (opcional) |
| Autor(es) (obrigatório) |
| Resumo no idioma do documento (obrigatório) |
| Resumo em outro idioma (opcional) |
| Elementos textuais | Introdução (obrigatório) |
| Desenvolvimento (obrigatório) |
| Considerações finais (obrigatório) |
| Elementos pós-textuais | Referências (obrigatório) |
| Glossário (opcional) |
| Apêndice (opcional) |
| Anexo (opcional) |
| Agradecimentos (opcional) |

Fonte: Elaborado pela BSE com base na NRB 6022/2018.

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# Appendix 1 – Graphs of SDID results in EXP period

|  |  |
| --- | --- |
| g y1 = Web\_of\_Science\_Documents  ATT  SE  R2  RMSPE  SC weights  Time weights  **THIS DATA WAS CALCULATED BUT I HAVE TO FIND OUT HOW TO PRINT IT IN STATA** |  |
| g y2 = Times\_Cited |  |
| g y3 = Green\_Only\_Documents |  |
| g y4 = Documents\_in\_JIF\_Journals |  |
| g y5 = International\_Collaborations |  |
| g y6 = All\_Open\_Access\_Documents |  |
| g y7 = Gold\_Documents |  |
| g y8 = Citation\_Impact |  |
| g y9 = Citations\_From\_Patents |  |
| g y10 = Average\_Percentile |  |
| g y11 = Free\_to\_Read\_Documents |  |
| g y12 = Industry\_Collaborations |  |
| g y13 = Impact\_Relative\_to\_World |  |
| g y14 = Domestic\_Collaborations |  |
| g y15 = Green\_Submitted\_Documents |  |
| g y16 = Green\_Accepted\_Documents |  |
| g y17 = Green\_Published\_Documents |  |
| g y18 = Documents\_in\_Q1\_Journals |  |
| g y20 = Documents\_in\_Q2\_Journals |  |
| g y21 = Documents\_in\_Q3\_Journals |  |
| g y22 = Documents\_in\_Q4\_Journals |  |
| g y23 = Documents\_in\_Top\_1 |  |
| g y24 = Documents\_in\_Top\_10 |  |

# Appendix 2 – Graphs of SDID results in RET period

# Appendix 3 – Glossary of Data

1. G9 countries: Canada, China, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States [↑](#footnote-ref-1)
2. Available on: *https://siop.mec.gov.br/* [↑](#footnote-ref-2)
3. Available in: *https://incites.clarivate.com/.* [↑](#footnote-ref-3)
4. Available in: *https://www.scimagojr.com/* [↑](#footnote-ref-4)
5. Available in: *https://www3.wipo.int/ipstats/* [↑](#footnote-ref-5)
6. Available in: *http://data.uis.unesco.org/* [↑](#footnote-ref-6)