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An Analysis of the Budgetary Performance of the Brazilian Ministry for Science, Technology and Innovation (MCTI) and the Impacts of the COVID-19 Pandemic, in the Period from 2007 to 2022

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Abstract

The purpose of this paper is to analyse the changes in budgetary performance of the currently named Ministry for Science, Technology and Innovation (MCTI)[1] during the implementation of Science, Technology and Innovation Policies (ST&IP) between the years 2007 and 2022. The reason for choosing the MCTI as the body for analysis is due to the representativeness of the resources it allocates to the fields of ST&I and because it is responsible for the formulating of public policies directed to those areas. From a methodological perspective, the paper was essentially based on the collection and analysis of data and records contained within the official public planning and budgeting systems and specifically reports on the MCTI budgetary performance, its thematic budgetary function and typical subfunctions. The results indicate the difference between "planned" and "executed" budget; a decrease in public investments in ST&I over the period analysed, due to reductions in the volume of budgetary resources allocated to the MCTI; the impact of the COVID-19

[1]The Ministry for Science and Technology (MCT) was established in 1985 and in 2011 the word Innovation was included in the name of the ministry, making it the Ministry for Science, Technology and Innovation (MCTI). In 2016, the MCTI merged with the Ministry for Communications and was renamed the Ministry for Science, Technology, Innovation and Communications (MCTIC). In 2020, the ministry was renamed the MCTI.

Pandemic and restrictions on spending imposed by the government, in contrast to the linear supply concept seen in the most recently implemented ST&I.

Keywords

Science, Technology and Innovation Policy, Public Policy, Budgetary Performance, ST&I

1. Introduction

Looking at the current scenario of contemporary society, with the profound social, cultural, economic and environmental changes taking place, the academic sphere and world literature have pointed out indications that Science, Technology and Innovation (ST&I) has become the preponderant instrument for sustainable economic and social development, with the ability to generate wealth, democratize opportunities and improve the quality of people's lives.

Within this scenario, the preparation and implementation of Science, Technology and Innovation Policies (ST&IP), in the context of a strong National Science, Technology and Innovation System (NST&IS), plays a fundamental role in countries' economic agenda, aimed at establishing or improving their technological capacity, encouraging private investment and augmenting technology transfer between the different agencies, such as research institutes (public and private), universities and companies (Brasil, 1988; Avellar, 2007).

In this context, as an instrument for analysing the performance, strengths and weaknesses of the innovation ecosystems in 132 countries, the Global Innovation Index (GII) guides ST&I developers and companies in the preparation of strategic plans to promote economic and social development. The GII is calculated according to the average of two subindices. The first is "Innovation Inputs", which assesses the economic elements that enable and facilitate the development of innovative activities, grouped into five categories: 1) Institutions; 2) Human capital and research; 3) Infrastructure; 4) Market sophistication; and 5) Business sophistication. And then there is the "Innovation Products" sub-index, which registers the effective results of innovative activities within the economy and is divided into two categories: 6) Knowledge and technology products; and 7) Creative products.

The top ten countries in the 2023 GII are Switzerland, Sweden, USA, UK, Singapore, Finland, Netherlands, Germany, Denmark, and South Korea. China is closing in on the top 10, by taking 17th place. Other emerging economies have been showing sound and consistent performance, as in the case of India and Turkey, which for the first time appear among the top 40 (WIPO, 2023). Brazil has been gotten good positions since 2015 (from 70th place in 2015 to 49th place in 2023), as shown in **Figure 1** and **Table 1** below.

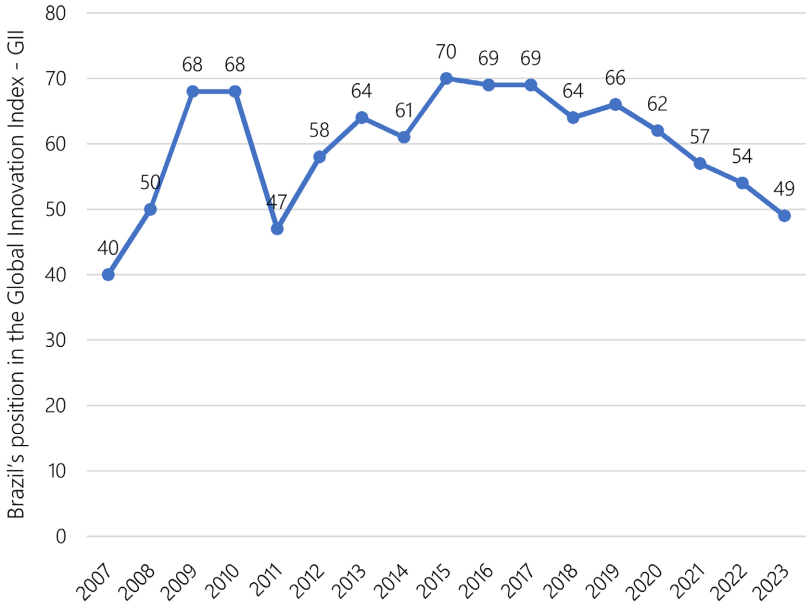

Figure 1. Changes in Brazil's position in the GII. Source: Authors, Adapted from INSEAD (2007, 2009, 2010, 2011, 2012, 2020), WIPO, Cornell University and INSEAD (2013, 2014, 2016, 2017, 2018, 2019), Cornell University, INSEAD and WIPO (2015) and WIPO (2021, 2022).

Table 1. Brazil's position and rating in the GII.

Year	Brazil's position in the Global Innovation Index—GII	GII
2007	40	2.84
2008	50	3.25
2009	68	2.97
2010	68	2.97
2011	47	37.75
2012	58	36.60
2013	64	34.90
2014	61	36.29
2015	70	34.95
2016	69	33.19
2017	69	33.10
2018	64	33.44
2019	66	33.82
2020	62	31.94
2021	57	34.20
2022	54	32.50
2023	49	33.60

Source: Adapted from INSEAD (2007, 2009, 2010, 2011, 2012, 2020), WIPO, Cornell University and INSEAD (2013, 2014, 2016, 2017, 2018, 2019), Cornell University, INSEAD and WIPO (2015) and WIPO (2021, 2022).

In Brazil, the ST&I policy prepared and implemented by the Ministry of Science, Technology and Innovation (MCTI) since the 1990s continue to be based on ST&I as a national development strategy, following the global trends, with the importing of ideas and models developed countries have come up with (Mazzetti, Gazolla & Marini, 2020).

Staying in the Brazilian scenario, Pelaez et al. (2017) highlighted the discontinuity of the ST&I implemented in the last few decades, due to both an inability to come up with any long-term State planning and systematic non-compliance with the laws that determine the allocation of public resources. The authors also emphasized the volatility of the public resources required to prepare a long-term public policy on ST&I, revealing a weakness in the country's democratic institutions.

Consequently, in order to comprehend the fluctuations in the volume of public resources required to implement the ST&I, the budget becomes a framing tool for government action, capable of analysing the effectiveness of the public policy performance. Its usefulness is presented from both an economic and a political perspective, in assessing the allocation of resources for the preparation of such policies and the alternatives available within the budget itself, inserted into the institutional political decision-making scenario (Abreu & Câmara, 2015).

Remaining within the sphere of public budgeting, budgetary performance represents one of the stages that is considered essential to analysing government performance in the implementation of public policies (Sanches, 2008). In order to enable budgetary performance, it is necessary to employ budgetary classification, which shows the government sphere, the body responsible, the areas of government activity, the public policy topic and what will be carried out, in terms of public expenses, as well as a qualitative description of the budget program. According to Carvalho (2017), the budgetary classification is divided into institutional, functional and planned. For this paper, the functional classification was chosen, which presents public expenditures in functions and subfunctions, according to the area of government activity, and is pertinent to the three government spheres: federal, state and municipal.

In the light of the above, we seek in this paper to analyse the variations in the MCTI's budgetary performance in implementing public ST&I policies between 2007, the year in which such policies started to be implemented, and 2022, the most recent year for which official data is available. Variations in the budgetary performance for both the MCTI function and its subfunctions will be analysed. The choice of MCTI budgeting is justified by its role in the designing and implementing of ST&I in Brazil and by the representativeness of the resources it allocates to the ST&I field in relation to the total allocated by the federal government.

With regard to the function and subfunctions used to analyse the variations in the MCTI's budgetary performance, the function "Science and Technology" was chosen because it embraces the body's institutional responsibility. The subfunc-

tions chosen for analysis were "Scientific Development", "Technological Development and Engineering" and "Dissemination of Scientific and Technological Knowledge", which represent the nature of the MCTI's area of activities.

This paper aims to fill the gap that exists in public administration regarding the failure to use budgetary performance as an instrument for controlling government activities in the field of ST&I, as well as helping to spread the adoption of budgetary performance as an effective instrument for analysis during the implementation of ST&I. The object to be studied is the national ST&IP, the acronyms, and the instruments used in this work, are shown below (Frame 1):

Frame 1. Acronyms, and instruments.

Portuguese Acronyms\Period	Portuguese Language	Portuguese Acronyms\Period	English Language
PACTI (2007-2010)	Plano de Ação em Ciência, Tecnologia e Inovação	PASTI (2007-2010)	Plan for Science, Technology and Innovation
ENCTI (2012-2015)	Estratégia Nacional de Ciência, Tecnologia e Inovação	NSTIS (2012-2015)	National Science, Technology and Innovation Strategy
ENCTI (2016-2019)	Estratégia Nacional de Ciência, Tecnologia e Inovação	NSTIS (2016-2019)	National Science, Technology and Innovation Strategy
ENCTI (2016-2022)	Estratégia Nacional de Ciência, Tecnologia e Inovação	NSTIS (2016-2022)	National Science, Technology and Innovation Strategy
-	MCTI Plano Estratégico de Ciência, tecnologia e Inovação	MCTI Strategic Plan (2020-2023)	MCTI Strategic Plan

Source: Authors.

This paper is organized into three main sections, in addition to this opening introduction and the final considerations. The next section describes ST&IP in the Brazilian context. Then, in the third section, there are details of the methodological procedures used to study the variations in the budgetary performance of the MCTI's spending. Finally, in section four, there is discussion of the results obtained.

2. The Policies of Science, Technology and Innovation in Brazil

2.1. Background

The country's national science, technology and innovation policy had its starting

point in the period of the Brazilian monarchy. Expansion was undertaken during the republican regime, with a surge in Brazilian scientific and technological research, motivated at the time by the technical-scientific revolution that drove the construction and expansion of scientific institutions (Motoyama, 2004).

Between the 1940s and 1990s, Brazil implemented a number of ST&I that sought to augment the supply of scientific and technological knowledge in the country, also known as "supply" policies, as pointed out by Pacheco (2007). It can be said that during that period, successive federal governments came up with ST&I that were efficient in defining a higher education and research infrastructure (Pelaez et al., 2017). That warranted the establishing of the Ministry for Science and Technology (MCT), under Decree No. 91,146 of March 15, 1985, as the body responsible for formulating and coordinating the national policy on ST&I.

2.2. Science, Technology & Innovation in Brazil and around the World

In the contemporary scenario, innovation is shown to be the driving force behind economic and social development (Freeman, 1995). To that end, the participation of the State, in partnership with the production sector and educational and research institutions, comprises the "Triple Helix" model of knowledge (Etzkowitz & Leydesdorff, 2000), which has proven to be essential to the fostering of cultural practices focused on science and technology, promoted through public policies.

In this respect, when Freeman (2004) was investigating the conditions capable of influencing international competitiveness, he confirmed that it depends primarily on government policies for the development of ST&I infrastructure. D Guellec and B Van Pottelsberghe de la Potterie (2004) consider that despite the complexity and non-linearity of the relationship between R&D and innovation, it is clear that, substantial advances in technology cannot occur without the work being performed systematically.

However, Seibert and Neto (2023) add that the degree of innovation in a country is not necessarily proportional to the amount invested but is relative to the priority that the country gives to this area. Similarly, Arcuri (2016) points out that, through increases or diminishing of the S&T budget, it is possible to observe the importance attributed to these activities by their respective governments.

Observing the historical data, using information organized by the MCTI (2023) and based on information from studies by the Organization for Economic Cooperation and Development (OECD), one can compare the budgetary spending on research and development activities among the ten largest economies in 2020, presented in **Table 2**, and between the presented **Table 3**, about the BRICS' nations, as cited in the report: Building Better Global Economic BRICS, from O'Neill (2001).

From the data presented in **Table 2** and **Table 3**, the USA, the Japan and the Germany—first, third and fourth among the largest economies in 2020—have

Table 2. National Spending on Research and Development (R&D) between 2000-2020, as a proportion of the Gross Domestic Product—GDP of the 10 countries with the largest economies in 2020.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
USA	2.63	2.65	2.56	2.56	2.50	2.52	2.56	2.63	2.77	2.81	2.74	2.77	2.68	2.71	2.72	2.79	2.85	2.91	3.01	3.18	3.45
China	0.89	0.94	1.06	1.12	1.21	1.31	1.37	1.37	1.45	1.66	1.71	1.78	1.91	2.00	2.02	2.06	2.10	2.12	2.14	2.23	2.40
Japan	2.86	2.92	2.97	2.99	2.98	3.13	3.23	3.29	3.29	3.20	3.10	3.21	3.17	3.28	3.37	3.24	3.11	3.17	3.22	3.21	3.27
Germany	2.41	2.40	2.44	2.47	2.44	2.44	2.47	2.46	2.62	2.74	2.73	2.81	2.88	2.84	2.88	2.93	2.94	3.05	3.11	3.17	3.13
UK	1.61	1.60	1.62	1.58	1.53	1.55	1.57	1.61	1.60	1.66	1.64	1.64	1.57	1.61	1.63	1.63	1.65	1.66	1.71	1.71	-
India	0.74	0.72	0.71	0.71	0.74	0.81	0.80	0.79	0.84	0.82	0.77	0.76	0.74	0.71	0.70	0.69	0.67	0.67	0.65	-	-
France	2.09	2.14	2.17	2.12	2.09	2.05	2.05	2.02	2.06	2.21	2.18	2.19	2.23	2.24	2.28	2.23	2.22	2.20	2.20	2.19	2.35
Italy	1.00	1.04	1.08	1.06	1.05	1.04	1.08	1.13	1.16	1.22	1.22	1.20	1.26	1.30	1.34	1.34	1.37	1.37	1.42	1.46	1.51
Canada	1.86	2.02	1.97	1.97	2.00	1.97	1.94	1.90	1.86	1.92	1.83	1.79	1.77	1.71	1.71	1.69	1.73	1.69	1.74	1.75	1.84
S. Korea	2.13	2.28	2.21	2.28	2.44	2.52	2.72	2.87	2.99	3.15	3.32	3.59	3.85	3.95	4.08	3.98	3.99	4.29	4.52	4.63	4.81

Source: Adapted from MCTI (2023).

Table 3. National Spending on R&D between 2000-2020, as a proportion of the GDP of the BRICS' nations.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	1.05	1.06	1.01	1.00	0.96	1.00	0.99	1.08	1.13	1.12	1.16	1.14	1.13	1.20	1.27	1.37	1.29	1.12	1.17	1.21	1.14
Russia	0.98	1.10	1.16	1.20	1.07	0.99	1.00	1.04	0.97	1.17	1.05	1.02	1.03	1.03	1.07	1.10	1.10	1.11	0.99	1.04	1.10
India	0.74	0.72	0.71	0.71	0.74	0.81	0.80	0.79	0.84	0.82	0.77	0.76	0.74	0.71	0.70	0.69	0.67	0.67	0.65	-	-
China	0.89	0.94	1.06	1.12	1.21	1.31	1.37	1.37	1.45	1.66	1.71	1.78	1.91	2.00	2.02	2.06	2.10	2.12	2.14	2.23	2.40
South Africa	-	0.72	-	0.76	0.81	0.86	0.90	0.88	0.89	0.84	0.74	0.73	0.73	0.72	0.77	0.80	0.82	0.83	0.75	0.68	-

Source: Adapted from MCTI (2023).

the highest proportions of investment in R&D and have maintained steady growth throughout the period analysed. South Korea and China, the second largest economy, stand out for the growth rate of their spending. On the other hand, India has spent proportionally less, compared to the other economies, looking at the two tables, revealing how countries that are placed lower in the economic ranking show a lower proportion of investments in R&D.

2.3. The Present Day Policy on S T&I in Brazil

The designing of ST&I in Brazil, carried out during the 2000s, was strongly influenced by the discussions that took place at the 2nd National Conference on Science, Technology and Innovation, held in September/2001, which emphasized the need to introduce the subject of innovation into policies on science and technology and to encourage innovation in Brazilian companies (Marini Jr. & da Silva, 2011). Another significant factor during the 2000s was the adoption of a new legal and regulatory framework that opened up new prospects for ST&I in Brazil. Notable within the scope of that new legal and regulatory framework was

the introduction of the Innovation Law (Law No. 10,973, of December/2004), regulated by Decree No. 5563, of October/2005, and the "Goods Law" (literally "Lei do Bem" in Portuguese language)—(Law No. 11,196, of November/2005), regulated by Decree No. 5798 of June/2006. Nowadays other innovation laws (known as "Legal Mark of ST&I") influence the Brazilian's policies (Law No. 13.243, of January/2016), regulated by Decree No. 9283 of February/2018.

Continuing with the government's objective of making innovation a strategic feature of the national development policy, in 2007 the MCT came up with the PASTI—2007-2010, covering the period from 2007 to 2010. The PASTI 2007-2010 was built around four strategic priorities: 1) expand, integrate, modernize and strengthen the SNST&I; 2) encourage action to promote the development of a structure that favors innovation in private companies; 3) consolidate research, development and innovation activities in sectors that are of strategic importance to the country; and 4) spread ST&I as a means of promoting social inclusion and development (Ministério da Ciência e Tecnologia, 2007). To bring these four strategic priorities to fruition, the PASTI 2007-2010 allocated investments for the period from 2007 to 2010, taken from the federal budget, and also emphasized the expansion and optimization of the public resources invested in ST&I, producing positive results in activities and strategies directed towards research, although falling short of the proposed targets (Leal, 2012).

Once the validity of the PASTI 2007-2010 had expired, the NSTIS 2012-2015 was introduced, which sought integration with other government policies, especially industrial ones, as well as promoting programs and projects in the field of ST&I, by increasing the participation of the various public and private agencies (Barros, 2017).

With regard to the structure of the NSTIS 2012-2015, supporting pillars were set up, along with priority programs to promote national scientific and technological progress. The NSTIS 2012-2015 supporting pillars comprised: promoting innovation within the production sector; a new public funding model for scientific and technological development; strengthening of research and the scientific and technological base; training and qualifications for human resources; and fine-tuning of the legal framework (MCTI, 2012).

To finance the supporting pillars and priority programs provided for under the NSTIS 2012-2015, resources were mainly to be provided by the MCTI, followed by other ministries, federal state-owned companies and state foundations in support of research (Araújo, 2012). However, the last couple of years of that NSTIS 2012-2015 saw cuts in funding for ST&I, due to the worsening fiscal crisis and contingencies regarding the MCTI budget (Jornal da Ciência, 2012).

The Brazilian government introduced the NSTIS 2016-2022, grounded in previous years' experience of the ST&I and the results of productive dialogues with the leading sectorial and regional agencies involved in the field of ST&I in Brazil. The NSTIS 2016-2022 sought to strategically guide the ST&I over the medium term and to support other public policies in the country, establishing among its

fundamental pillars the promotion of basic scientific and technological research; modernization and expansion of the ST&I infrastructure; expansion of the funding for scientific and technological programs and projects; qualifications and retention of human resources; and encouraging innovation in companies (Mazzetti et al., 2020).

For the NSTIS 2016-2022 to be successful, it was essential to have a strong and well-organized NST&IS, so that it would be possible to leverage scientific and technological progress in the country. What is more, the NST&IS was considered the supporting pillar for carrying out policies and programs in the ST&I field (MCTI, 2016). Notable in addition to the formulation of the NSTIS 2016-2022 were Law No. 13,243 of January 11, 2016, called the New Legal Framework for Science, Technology and Innovation, and Decree No. 8877 of October 18, 2016, which augmented the list of MCTI responsibilities within the field of ST&I. Also within the legal scenario, Decree No. 9283 of February 7, 2018, which regulated Law No. 13,243, introduced instruments to encourage innovation and scientific and technological research, for the purpose of empowering the country technologically.

With regard to the budget allocation for implementation of the NSTIS 2016-2022, there is a lack of definition of an amount to finance the ST&I area. The NSTIS 2016-2022 only showed the sources of funding for the ST&I area. It appears, therefore, that the guidelines set out in the NSTIS 2016-2022 are not being used to direct the planning and execution of the federal public budget and particularly the activities devised for the effective development in the country of ST&I. When evaluating budgetary planning and performance during the implementation of the NSTIS 2016-2022, one can see that there is a diminishing of the budget allocation for the ST&I area and a decrease in the public spending by the MCTI, which has raised concern within the scientific community and research institutions regarding the future of ST&I in Brazil.

In 2022, the MCTI Strategic Plan (2020-2023) was introduced, under Regulation No. 5695, of March 16, 2022, published in the DOU (official government gazette) of March 17, 2022, in response to a government structural overhaul brought about by the separation of the Ministry of Science, Technology and Innovation (MCTI) and the Ministry for Communications (MCom).

This strategic plan was organized around fifteen strategic objectives, spread over four areas (results, internal procedures, personnel and infrastructure and budgeting), with the aim of achieving the institutional mission and vision of the future.

Through the insertion of the last strategic objective, of optimizing budgetary and financial resources for carrying out the body's strategic priorities, the need arose to determine the level of credit applications sent to the central body for budgeting, in relation to the requests by units linked to the ministry, in an incipient attempt to improve the efficiency of the body's budgetary performance.

In this uneasy atmosphere, researchers have sought to address the reduction

in public investment in ST&I in their studies, by analysing the budgeting of the MCTI and the principal institutions supporting research in Brazil. Pelaez et al. (2017) found that the discontinuity in public and private investment in the R&D sphere was due to the prevailing scenario of economic recession experienced in the country, by the growing cuts in public investment in ST&I and by the ceasing of the tax incentives set out in the "Goods Law" for the 2016 financial year, under Provisional Measure No. 694/2015. De Negri and Koeller (2019) state that the evolution of the MCTI budget signals a significant reduction in the volume of resources available in the country for ST&I. Part of that reduction is caused by the low level of budgetary performance by the MCTI, as a result of the fiscal efforts of the federal government to reach its primary surplus target, but also due to the lack of spending priority for the area. According to Saraiva, Oliveira and Morejon (2020), the rupture in ST&I investment following the economic-institutional crisis in 2015, augmented the uncertainty regarding long-term results, forcing the institutions to adapt. Furthermore, the Coronavirus (SARS-CoV-2) pandemic, which led to the closure of laboratories and university campuses and the interruption of economic activity worldwide, profoundly altered the methods of knowledge generation, with the replacement of face-to-face activities by online formats, affecting research programs and other activities related to ST&I.

By the way, this study seeks to fill the gap in academia to analyze variations in the "planned" and "executed" budget of the MCTI, during the implementation of the Brazilian ST&IP. Thus, the discussion about the budget execution of the MCTI in this study permeates a broader issue, that is, the relationship between public investments spent on ST&I and the country's technological and scientific development, as a result of these ST&IP implemented between the years of 2007 to 2022.

Finally, the most recent ST&IP implemented in Brazil have sought to replace the linear concept of the innovation process with a more systemic view. However, the instruments used to implement the ST&IP were designed in accordance with the linear model of innovation, bringing about discrepancies between those instruments and the analytical categories used to support the preparation of the ST&IP, since the latter are based on the systemic model of innovation (Queiroz & Cavalcante, 2012).

3. Methodological Procedures

The paper considered data and information contained on the MCTI website, since that is the body responsible for planning and guiding the National Policy on ST&I, as well as the largest recipient of ST&I investment contributed by the federal government. Data referring to the MCTI budgetary performance were collected from the federal government's Integrated Planning and Budgeting System (SIOP), for the period from 2007 to 2022. Complementing the data collection process, use was made of information available in official documents con-

tained in the databases of the planning, implementation and control bodies of policies in the field of ST&I, such as thematic reports and assessments of government programs.

The functional classification of government spending was used as a cut-off, as it shows the grouping of the various areas of expenditure that are the responsibility of the public body and because it provides a more accurate view of the spending in a specific government area. For the purposes of this study, data referring to the resources allocated to the "Science and Technology" budgetary function were duly considered fundamental to the MCTI in Brazil and also the subfunctions of the function's budgeting, namely: "Scientific Development", "Technological Development and Engineering" and "Dissemination of Scientific and Technological Knowledge".

The data were organized in tables and figures in order to show the variations in the budgetary resources authorized under the Annual Budgetary Law (LOA) and in the spending effected by the MCTI. The resources authorized and the spending carried out were presented in the ST&IP implemented during the period from 2007 to 2022, in order to identify the priorities conferred by the federal government in such policies. Cross referencing was performed using the ST&IP implemented in the country during the period between 2007 and 2022, taking into consideration the PASTI (2007-2010), the NSTIS (2012-2015), NSTIS (2016-2019) and the MCTI Strategic Plan (2020-2023). The resources authorized and spending carried out in 2006 and 2011 were excluded, in order to focus the analysis on the valid periods of ST&I performance.

Finally, the analysis of ENCTI (2016-2022) will be carried out until 2019 due to the overlap with the policy entitled Strategic Plan (2020-2023), just as this plan will be analyzed until 2022 due to the data availability.

The collected data comprising the values of the time were updated using the Broad Index of Consumer Prices (IPCA), calculated by the Brazilian Institute for Geography and Statistics (IBGE), to enable comparability of values over the period analysed, as well as to eliminate the harmful impact of the loss of the currency's purchasing power over time.

The data analysis was processed on the basis of examination of the spending carried out, or rather, based on the budgetary performance of the MCTI, in its function of "Science and Technology" and the sub-functions studied in this paper, also portraying the percentage variations that occurred between the resources authorized by law and the spending carried out by the body during the implementation of the ST&IP in the period being studied.

Consequently, in the analysis of the data, it was possible to identify the low and high percentage variations that occurred during the budgetary performance of the MCTI, in its function and subfunctions studied in this paper, during the implementation of the ST&IP in the period studied. With regard to the data analysis based on budgetary performance, it was also possible to observe under which ST&IP there was an increase or decrease in the amount of authorized

budgetary resources and in the volume of spending carried out.

As a way of detailing the behavior of budget variables in relation to GDP, correlation assessment and decomposition analysis of changes in budget variables over time were used. Decomposition analysis is a statistical and analytical technique particularly useful for understanding the relative contributions of different factors or components to changes in an aggregate variable, for example, the growth of energy consumption (Kim, 2017).

Thus, decomposition analysis allows us to identify which factors are driving or slowing down the growth of a variable over time. There are several types of decomposition analysis techniques, each tailored to specific data characteristics and objectives, including the Logarithmic Mean Divisia Index Decomposition (LMDI) (Ang, 2005), that is used to analyze changes in a variable over time, taking into account the changing composition of its components.

4. Presentation and Discussion of the Results

This section presents data on the budgetary performances of the Brazilian ST&IP, the PASTI (2007-2010), the NSTIS (2012-2015), NSTIS (2016-2019) and the MCTI Strategic Plan (2020-2023), of the function "Science and Technology" and its subfunctions "Scientific Development", "Technological Development and Engineering" and "Dissemination of Scientific and Technological Knowledge" during the period between 2007 and 2022. **Table 4** below shows all the figures obtained. Then we discuss the variations that occurred in the budgetary performance during the implementation of the ST&IP considered in this study.

4.1. A Comparative Budgetary Performance of Brazilian ST&IP

4.1.1. Budgetary Performance under the PASTI (2007-2010)

Under the PASTI (2007-2010), the amount of public resources anticipated for the MCTI was around R$ 27.7 billion, contributed by partner ministries and state-owned companies, to meet the targets and fulfill the objectives set out. The MCTI stands out as the body responsible for coordinating the efforts to meet the determined goals and objectives under the plan, in addition to being the largest resource provider for putting the PASTI (2007-2010) into effect. The following figure presents the MCTI's budgetary performance during the implementation of this policy:

As can be seen in **Figure 2**, there was an increase in the budget allocation for the MCTI during the PASTI (2007-2010). In the last year of the program, the authorized resources reached R$ 8.34 billion, 47% more than in the first year of the program. It can be seen, therefore, in a preliminary analysis, that the MCTI acquired a notable role during the term of this program.

The percentage of the MCTI budget spending was less than 72%, despite improved performance in the years 2009-2010, compared to the biennium 2007-2008. The fact that the percentage of budget spending by the MCTI shows figures that are far from the ideal, which is 100%, can be explained by operational factors at the bodies responsible for implementing the ST&IP, in addition to

Table 4. Data for the budget executions under the Brazilian ST&IP: PASTI (2007-2010), NSTIS (2012-2015), NSTIS (2016-2019) and the MCTI Strategic Plan (2020-2023), of the function and subfunctions.

		Ministry for Science, Technology and Innovation (MCTI)			"Science and Technology" Function			"Scientific Development" Subfunction			"Technological Development and Engineering" Subfunction			"Dissemination of Scientific and Technological Knowledge" Subfunction		
ST&IP	Year	Resources Authorized under LOA—in R$ billion (A)	Executed Expense—in R$ billion (B)	Executed vs Authorized—Percentage % (B/A)	Resources Authorized under LOA in R$ billion (A)	Executed Expense-in R$ billion (B)	Executed vs Authorized—Percentage % (B/A)	Resources Authorized under LOA—in R$ billion (A)	Executed Expense—in R$ billion (B)	Executed vs Authorized—Percentage (B/A)	Resources Authorized under LOA—in R$ billion (A)	Executed Expense—in R$ billion (B)	Executed vs Authorized—Percentage % (B/A)	Resources Authorized under LOA—in R$ billion (A)	Executed Expense—in R$ billion (B)	Executed vs Authorized—Percentage % (B/A)
PASTI (2007-2010)	2007	5.69	3.69	64.8%	4.22	3.03	71.9%	1.11	0.91	81.6%	1.86	1.10	59.4%	0.13	0.03	22.6%
	2008	6.79	4.38	64.6%	4.79	3.59	74.9%	0.93	0.81	86.7%	1.83	1.17	64.4%	0.18	0.06	31.9%
	2009	6.88	4.95	71.9%	5.30	4.03	76.0%	1.13	1.01	89.5%	2.36	1.54	65.4%	0.10	0.04	39.2%
	2010	8.34	5.87	70.3%	7.12	4.77	67.0%	1.34	1.09	81.6%	3.55	2.04	57.5%	0.14	0.03	21.9%
NSTIS (2012-2015)	2012	10.17	6.09	59.9%	8.38	4.65	55.5%	2.17	1.48	68.3%	3.93	1.52	38.7%	0.16	0.02	13.4%
	2013	11.22	7.54	67.2%	9.22	6.03	65.4%	4.21	2.83	67.2%	2.65	1.34	50.4%	0.05	0.02	43.4%
	2014	10.87	7.48	68.9%	8.88	5.91	66.6%	4.49	3.10	69.1%	2.10	0.87	41.3%	0.05	0.02	37.9%
	2015	11.16	6.93	62.1%	9.05	5.17	57.1%	5.23	2.58	49.4%	1.51	0.57	38.0%	0.04	0.02	50.1%
NSTIS (2016-2019)	2016	9.85	6.51	66.1%	5.67	4.55	80.4%	2.50	1.93	77.2%	1.04	0.73	69.4%	0.04	0.02	53.1%
	2017	15.40	8.38	54.4%	5.65	4.49	79.5%	2.49	2.00	80.4%	1.11	0.66	59.8%	0.03	0.02	73.3%
	2018	12.81	8.88	69.3%	5.31	4.66	87.8%	2.28	2.04	89.4%	0.84	0.66	78.2%	0.02	0.02	73.5%
	2019	14.51	8.32	57.3%	5.42	4.74	87.4%	2.32	2.13	91.7%	0.89	0.66	74.4%	0.03	0.01	45.5%
MCTI Strategic Plan (2020-2023)	2020	14.22	7.60	53.5%	5.48	4.66	85.2%	1.79	1.58	88.0%	1.36	1.05	77.1%	0.03	0.01	45.6%
	2021	10.03	6.13	61.1%	5.06	4.11	81.1%	1.84	1.48	80.4%	1.07	0.72	67.2%	0.03	0.01	37.4%
	2022	8.83	7.38	83.6%	6.71	5.44	81.0%	2.72	2.25	82.8%	1.90	1.38	72.8%	0.05	0.03	55.0%

Source: Adapted from MCTI (2023).

political factors, as that period was marked by an expansionist fiscal policy, involving State intervention in the economy, in order to boost the country's economic development.

A second factor in analysing the MCTI's budgetary performance is using the functional classification of the spending, as through this measurement it is possible to verify the amount of resources allocated to the science and technology function and the sub-functions considered to be priorities in the MCTI's performance. Figure 3 shows the budgetary performance under the PASTI

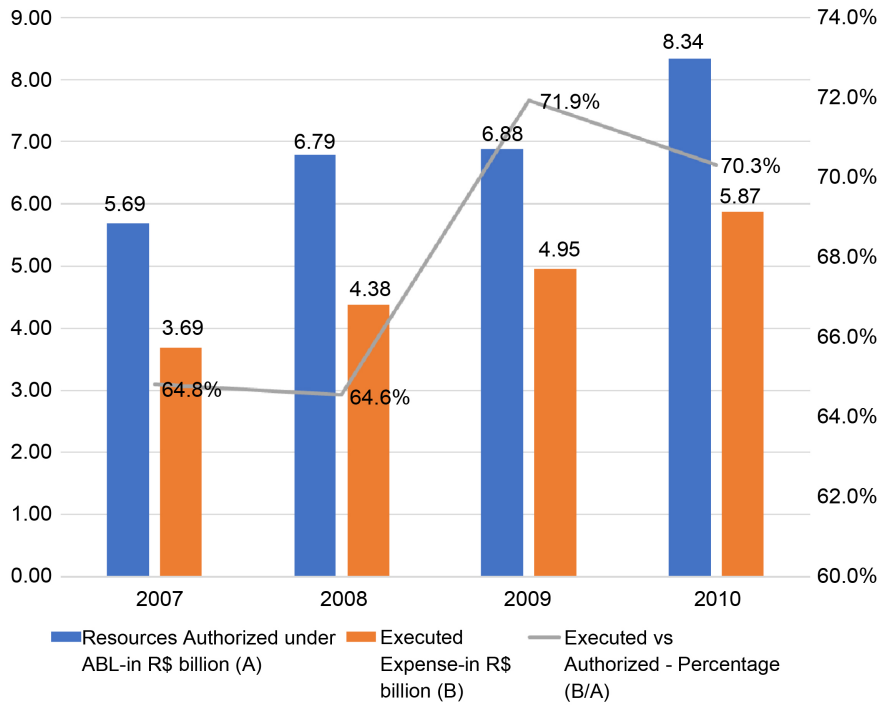

Figure 2. MCTI Budgetary Performance under the PASTI (2007-2010)—in R$ billion. Source: Adapted from SIOP (2023).

(2007-2010), specifically in relation to the "Science and Technology" function.

As can be seen in **Figure 3**, there was an increase in the budget allocation of resources for the "Science and Technology" function during the period covered by the PASTI (2007-2010), especially in 2010, when the amount of resources authorized under the LOA reached its peak value of R$ 7.12 billion—an increase of 69% from the first year to the last year of the program. The significant growth in spending incurred in the "Science and Technology" function followed the upward trend verified in the budget allocations during the period analysed.

The percentage of budgetary spending in the function showed figures that did not pass 76%, with an upward trend in the first three years, before falling to the lowest value in the final year, 2010 (67%), precisely in the year in which the highest amount of funding was authorized. The non-execution of the budget in full in this budget function reiterates the government's position of not prioritizing the ST&I area and the inability of the MCTI to execute its expenses, since during the PASTI (2007-2010) there was an expansion in the amount of budgetary resources allocated to that budgetary function.

The failure to spend the full budget on this budget function reflects the government's position of not prioritizing the ST&I area and the inability of the MCTI to complete its expenditure, for during the PASTI (2007-2010) period there was an expansion in the amount of budgetary resources allocated to that budgetary function.

In order to better understand the budgetary spending on the "Science and Technology" function, the following **Table 5** was drawn up, showing details

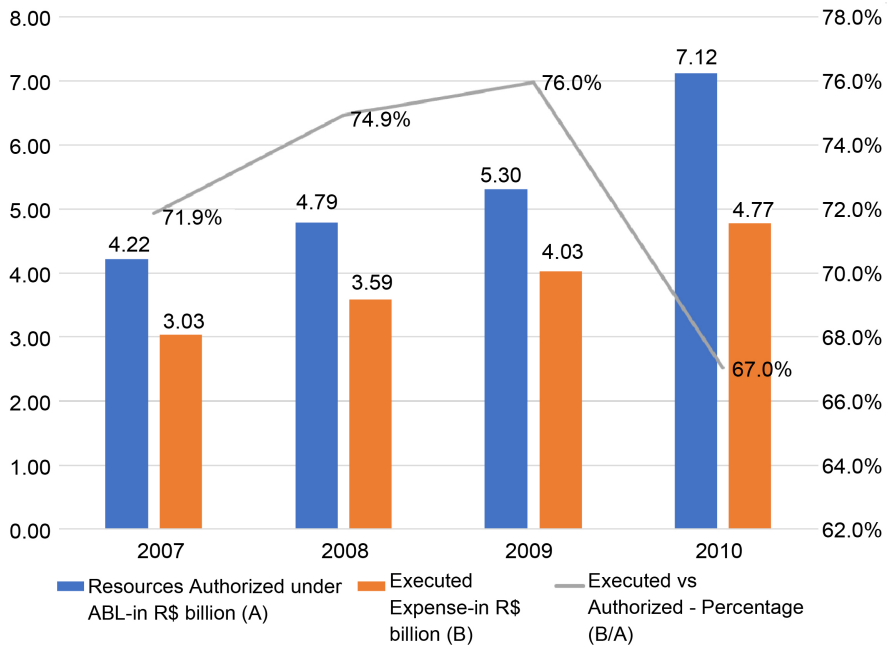

Figure 3. "Science and Technology" Function Budgetary Performance under the PASTI (2007-2010)—in R$ billion. Source: Adapted from SIOP (2023).

Table 5. PASTI (2007-2010) Budget Authorized vs Executed.

PASTI (2007-2010)		Resources Authorized under LOA-in R$ billion (A)	Executed Expense-in R$ billion (B)	Executed vs Authorized—Percentage % (B/A)
"Scientific Development" Subfunction	2007	1.11	0.91	81.6%
	2008	0.93	0.81	86.7%
	2009	1.13	1.01	89.5%
	2010	1.34	1.09	81.6%
"Technological Development and Engineering" Subfunction	2007	1.86	1.10	59.4%
	2008	1.83	1.17	64.4%
	2009	2.36	1.54	65.4%
	2010	3.55	2.04	57.5%
"Dissemination of Scientific and Technological Knowledge" Subfunction	2007	0.13	0.03	22.6%
	2008	0.18	0.06	31.9%
	2009	0.10	0.04	39.2%
	2010	0.14	0.03	21.9%

Source: Adapted from SIOP (2023).

grouped by subfunction of the resources authorized under the LOA compared to the spending actually carried out and the percentage of that spending as a proportion of the LOA allocation during the effective validity of the PASTI

(2007-2010).

Looking at the budgetary subfunctions depicted in the above table, there are certain variations in the amount of budgetary resources authorized during the implementation of the PASTI (2007-2010). Special attention may be given to the "Technological Development and Engineering" subfunction, in the years 2008 and 2010 (R$ 1.83 billion and R$ 3.55 billion, respectively), a difference of 94%.

There was a general downturn in 2008, except for the "Dissemination of Scientific and Technological Knowledge" subfunction, and growth between 2009 and 2010 in all the subfunctions, in this case due to the large volume of budgetary resources allocated to the MCTI for activities aimed at developing the infrastructure of research centers or other bodies in the fields of ST&I and engineering, as well as for activities aimed at the training and qualifications of human resources for research. Added to this, there is the instability in the volume of resources authorized under the LOA and in the spending throughout the implementation of the PASTI (2007-2010), leading to the budgetary resources not being used in full. Nevertheless, it should be noted that an average budget performance of 84.9% was achieved for the "Scientific Development" subfunction, against just 28.9% for the budgetary performance for the "Dissemination of Scientific and Technological Knowledge" subfunction, which emphasizes the difficulty of public sector managers in effecting the budgetary spending for that subfunction.

Moreover, in relation to the "Dissemination of Scientific and Technological Knowledge" subfunction, there was a notable increase in the amount of authorized budgetary resources in 2008, a sharp drop in 2009 (almost 45%) and a resumption of growth in the year 2010.

4.1.2. Budgetary Performance under the NSTIS (2012-2015)

The resources anticipated for the period covered by the NSTIS (2012-2015) amounted to R$ 43.4 billion, shared between the MCTI and other ministries—including the Ministry for Education (MEC), Ministry for Industry, Foreign Trade and Services (MDIC) and the Ministry of Defence (MD)—and with federal state-owned companies and state foundations in support of research (named FAPs in Portuguese language) that use state resources (MCTI, 2012). Comparing the PASTI (2007-2010) to the NSTIS (2012-2015), there is a significant increase in the resources authorized under the LOA, of around 57%. **Figure 4** shows the MCTI budgetary performance during the validity period of the NSTIS (2012-2015).

A certain stability can be seen in the volume of resources authorized under the LOA in the validity period of the program. However, there is a low proportion of spending by the ministry in 2012 and 2015, at 59.9% and 62.1% respectively.

When analysing the variations between the spending carried out and the resources authorized, one can see in **Figure 4** an average percentage of around 64.6% execution for the period analysed. Such data corroborate the analyses of

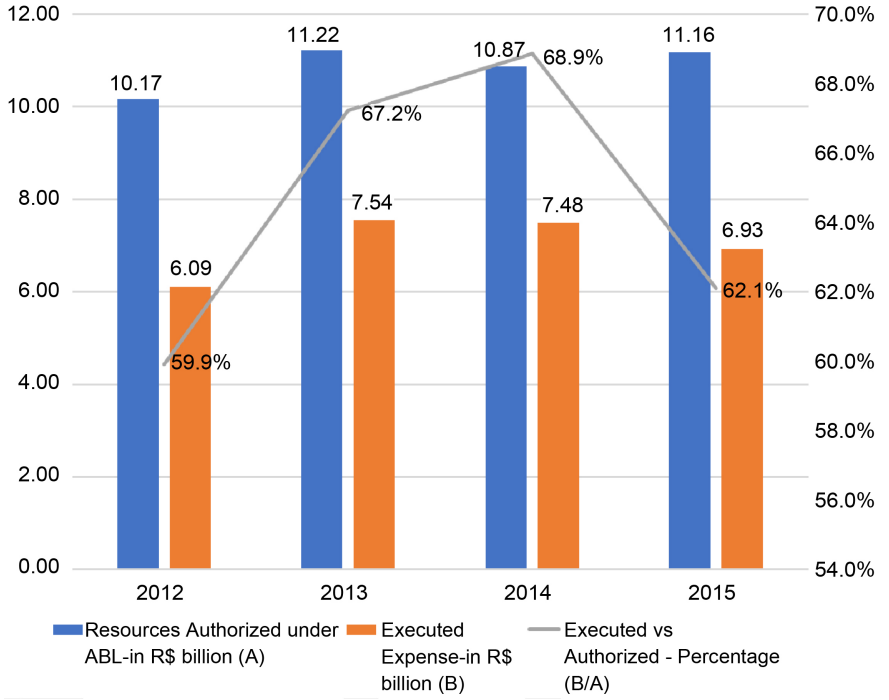

Figure 4. MCTI Budgetary Performance under NSTIS (2012-2015)—in R$ billion. Source: Adapted from SIOP (2023).

the MCTI budgetary performance during the PASTI (2007-2010) and indicate difficulties in implementing long-term programs and action in the field of ST&I.

In order to track the results of the resources budgeted and paid out in relation to the main function of the MCTI, "Science and Technology", a chart was drawn up that illustrates those changes during the validity period of the NSTIS (2012-2015).

Figure 5 shows that the resources authorized under the LOA for the "Science and Technology" budgetary function, following the example of the overall results for the MCTI resources, retained stable values during the period, which were 66% higher than the figures registered during the preceding PASTI (2007-2010) program.

There is a low percentage for the spending performance, involving expenses related to that function during the validity period, notably in the years 2012 (55.5%) and 2015 (57.1%). This suggests a weak effort by the federal government to carry out activities related to "Science and Technology", since the percentage of spending carried out is even lower than that under the previous program.

In order to better understand the budgetary spending on the "Science and Technology" function, the following Table 6 was drawn up, showing details of the resources authorized under the LOA, grouped by subfunction, compared to the spending actually carried out and the percentage of that spending as a proportion of the LOA allocation during the validity period of the NSTIS (2012-2015).

For the budgetary subfunctions depicted in the table above, there are variations

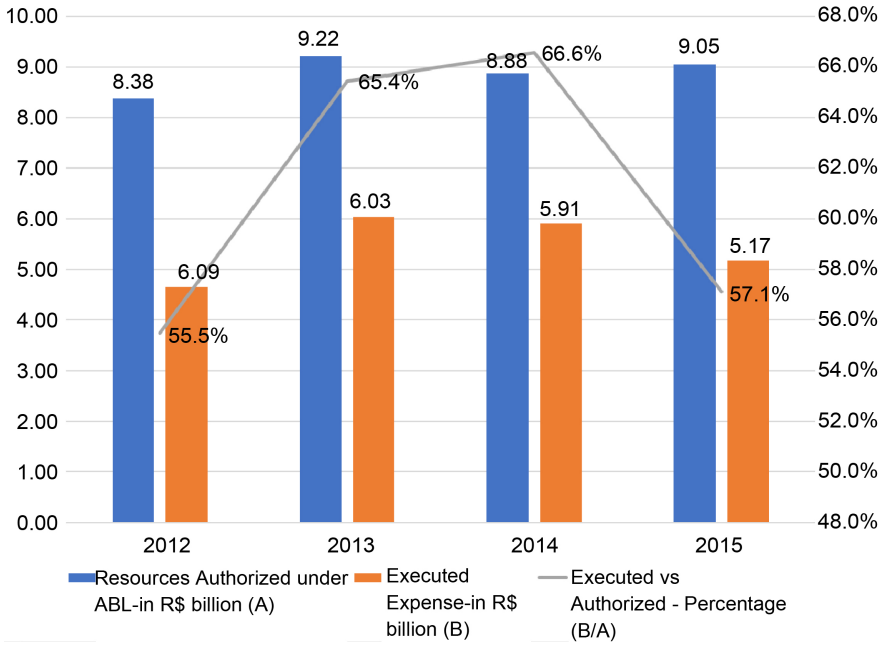

Figure 5. "Science and Technology" function budgetary performance under the NSTIS (2012-2015)—in R$ billion. Source: Adapted from SIOP (2023).

Table 6. NSTIS (2012-2015) budget authorized vs executed.

NSTIS (2012-2015)		Resources Authorized under LOA—in R$ billion (A)	Executed Expense—in R$ billion (B)	Executed vs Authorized—Percentage (B/A)
"Scientific Development" Subfunction	2012	2.17	1.48	68%
	2013	4.21	2.83	67%
	2014	4.49	3.10	69%
	2015	5.23	2.58	49%
"Technological Development and Engineering" Subfunction	2012	3.93	1.52	39%
	2013	2.65	1.34	50%
	2014	2.10	0.87	41%
	2015	1.51	0.57	38%
"Dissemination of Scientific and Technological Knowledge" Subfunction	2012	0.16	0.02	13%
	2013	0.05	0.02	43%
	2014	0.05	0.02	38%
	2015	0.04	0.02	50%

Source: Adapted from SIOP (2023).

in the amount of budgetary resources authorized during the implementation of the NSTIS (2012-2015). Special attention may be given to the "Scientific Development" subfunction, which showed significant growth in budgetary resources

between the years 2012 and 2013 (by about 94%), with further growth being maintaining in the years 2014 and 2015.

Drastic budget reductions can be seen for the "Technological Development and Engineering" subfunction over the course of the duration of the program from 2014 to 2015 alone, the reduction was around 28%, and if we consider the highest allocation value in the period (in 2012, the allocation of R$ 3.93 million), the reduction was 62%.

Similar reductions can be seen in the "Dissemination of Scientific and Technological Knowledge" subfunction. Between 2012 and 2013, the budget reduction was 71%, and continued at a low level during the remaining years of the program. So, a decline can be seen in the federal budget allocated to the dissemination of ST&IP, particularly during the implementation of the NSTIS (2012-2015).

The spending for the subfunctions "Scientific Development" and "Technological Development and Engineering" under the NSTIS (2012-2015) indicates a general decrease when compared to the spending for these subfunctions in the previous period—63.5% compared to 84.9% and 42.1% against 61.7%, respectively.

The budgetary subfunction "Scientific Development" was the one that achieved the best budgetary performance during the NSTIS (2012-2015) validity period—the percentage of budgetary performance reached the level of 69% in the 2014 fiscal year, while it also presented the highest average spending proportion (63.5 %) during its validity period.

The subfunction "Dissemination of Scientific and Technological Knowledge" showed a brief improvement (36.2% compared to 28.9%). However, the budgetary performance for this subfunction is the lowest among the subfunctions studied, demonstrating that the government's non-priority was decisive in the allocation of budgetary resources and in the spending carried out in relation to promotion of ST&IP in Brazil and, consequently, in the failure of the MCTI in disseminating scientific and technological knowledge developed in the country and abroad. In 2012, budget performance showed just 13% spending.

As with the data for the "Science and Technology" function and the data from the MCTI itself, the weak effort by the federal government to carry out activities related to the ST&I field is widely recognised. In short, during the implementation of the NSTIS (2012-2015), one can see the irregularity in the allocation of budget resources, as well as the failure to spend the full amount linked to the budgetary function and subfunctions analysed in this paper, suggesting low technical and managerial capacity in the federal government for budgetary planning and performance.

4.1.3. Budgetary Performance under the NSTIS (2016-2019)

Unlike the ST&I employed in previous periods in Brazil, the NSTIS (2016-2019) did not determine the volume of budgetary resources allocated to cover its spending. The NSTIS (2016-2019) determined only the budgeting of the federal direct

administration, the resources of the federal executive agencies, the budgets of the units of the Federation and the resources managed by the regulatory agencies, as the sources of funding (MCTI, 2016). It should also be mentioned that the NSTIS (2016-2019) highlighted the MCTI as one of the ministerial budgets with the greatest spending on ST&I.

The resources anticipated for the period covered by the NSTIS (2016-2019) amounted to R$ 52.6 billion, shared between the MCTI and other ministries —including the Ministry of Education (MEC), Ministry for Industry, Foreign Trade and Services (MDIC) and the Ministry of Defence (MD), as well as with federal state-owned companies and state foundations in support of research (FAPs), using state resources (MCTI, 2012). Comparing to the NSTIS (2012-2015), there was an increase in the resources authorized under the LOA, of around 21%.

Figure 6 below, summarizes the budget performance of the MCTI and specifically the annual allocation of resources authorized under the LOA and the spending carried out by the ministry during the validity of the NSTIS (2016-2019), discounting the overlapping with the MCTI Strategic Plan.

Analysis of the MCTI budgetary performance indicates oscillations in the volume of resources authorized under the LOA up to the 2019 fiscal year. With regard to the spending carried out by the MCTI, an upward trend can be seen, following the sharp drop in the 2016 fiscal year, due to the worsening of the Brazilian economic crisis. There was an increase in 2017, followed by relative stability from that year onwards.

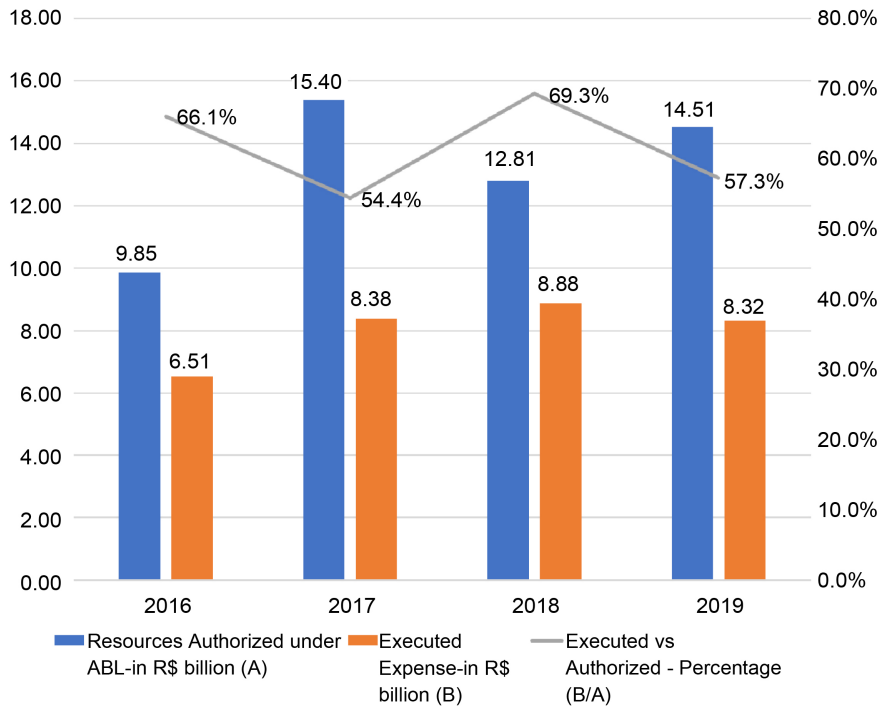

Figure 6. MCTI budgetary performance under NSTIS (2016-2019)—in R$ billion. Source: Adapted from SIOP (2023).

Considering the MCTI budgetary spending, a lower amount is noted in 2016, due to the budget reduction in that year, followed by stability in the succeeding years.

Analysing the variations in spending carried out and resources authorized, one can see an average percentage of around 61.0% in spending, during the period analysed. That figure is lower than those recorded under the previous programs—PASTI (2007-2010) and NSTIS (2012-2015), which indicates difficulties in implementing long-term programs and activities in the field of ST&I. In percentage terms, there are oscillations, with figures varying between 54.4% and 69.3%, indicating uncertainties and the body's inability to follow through, with repercussions for the field of ST&I in the country.

In order to follow the results of the resources budgeted and paid out in relation to the main function of the MCTI, "Science and Technology", a chart was drawn up that illustrates the changes during the validity period of the NSTIS (2016-2019).

Figure 7 shows that, unlike the general performance of the MCTI resources, the resources authorized under the LOA for the "Science and Technology" budget function saw a 38% reduction in relation to the previous program, which indicates a loss of share for the "Science and Technology" function in the total resources authorized under the LOA for the MCTI.

However, there was an increase in the percentage of spending carried out, compared to the previous program, with an average figure of 83.7%, driven mainly by the last two years of the program's validity.

In order to better understand the budgetary spending on the "Science and

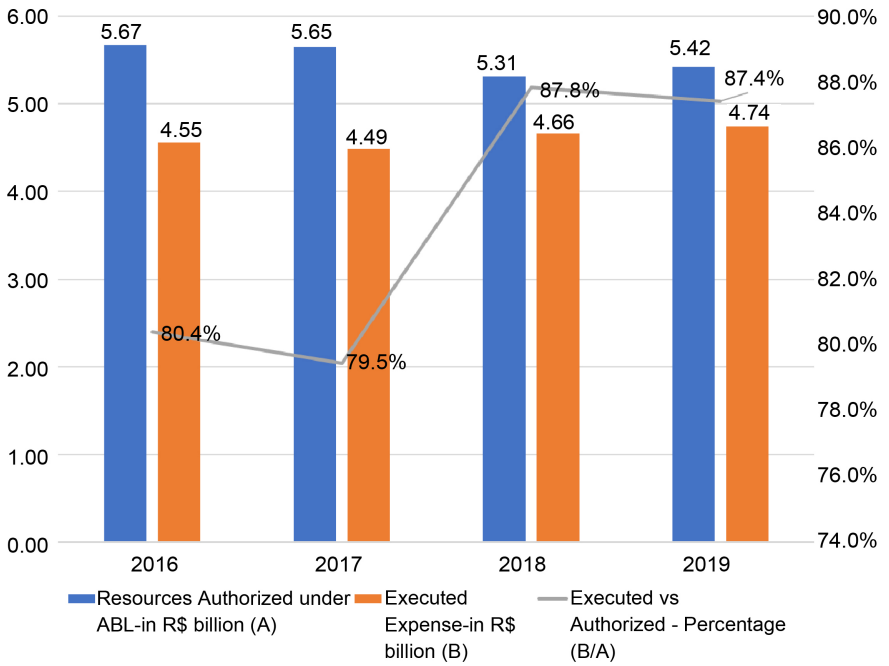

Figure 7. "Science and Technology" function budgetary performance under the NSTIS (2016-2019)—in R$ billion. Source: Adapted from SIOP (2023).

Technology" function, the following Table 7 was drawn up, grouped by subfunction, showing the resources authorized under the LOA in comparison with the spending actually carried out and the percentage of that spending as a proportion of the ABL allocation during the validity period of the NSTIS (2016-2019).

For the budgetary subfunctions depicted in the table above, there are few variations in the amount of budgetary resources authorized during the implementation of the NSTIS (2016-2019). Exceptions can be observed in "Technological Development and Engineering", which showed a 24.1% drop in the 2018 budget figure compared to 2017, and there are successive declines in the budget for the "Dissemination of Scientific and Technological Knowledge" subfunction, with annual decreases of around 26%.

From the point of view of spending carried out, the same stability can be seen as in the volume of authorized resources, except for the examples mentioned above.

As for the variations in resources authorized and spending carried out for the subfunctions analysed, a certain degree of stability can also be seen, with a positive highlight being the high percentage of spending in the "Scientific Development" subfunction, which averaged 84.7%, an amount that is greater than the spending percentages for the same subfunction under previous programs. The same can be noted for the "Technological Development and Engineering"

Table 7. NSTIS (2016-2019) budget authorized vs executed.

NSTIS (2016-2019)		Resources Authorized under LOA—in R$ billion (A)	Executed Expense—in R$ billion (B)	Executed vs Authorized—Percentage % (B/A)
"Scientific Development" Subfunction	2016	2.50	1.93	77%
	2017	2.49	2.00	80%
	2018	2.28	2.04	89%
	2019	2.32	2.13	92%
"Technological Development and Engineering" Subfunction	2016	1.04	0.73	69%
	2017	1.11	0.66	60%
	2018	0.84	0.66	78%
	2019	0.89	0.66	74%
"Dissemination of Scientific and Technological Knowledge" Subfunction	2016	0.04	0.02	53%
	2017	0.03	0.02	73%
	2018	0.02	0.02	73%
	2019	0.03	0.01	45%

Source: Adapted from SIOP (2023).

subfunction and the "Dissemination of Scientific and Technological Knowledge" subfunction, with average spending of 70.5% and 61.3%, respectively, of the budget approved by law. These are substantial improvements, which suggest improved efficiency in the ability to follow through on spending, although still far from the ideal, which is 100%.

In short, the NSTIS (2016-2019) was marked by a certain stability of the budgeted amounts and even acknowledging the impact of budget cuts for Science and Technology in 2016, there is stability and a progressive improvement in the percentage of resource spending as a proportion of the budget allocation.

4.1.4. Budgetary Performance under the MCTI Strategic Plan (2020-2023)

The resources anticipated for the period covered by the MCTI Strategic Plan (2020-2023) amounted to R$ 44.5 billion, shared between the MCTI and other ministries—including the Ministry for Education (MEC), Ministry for Industry, Foreign Trade and Services (MDIC) and the Ministry of Defence (MD)—and with federal state-owned companies and state foundations in support of research (FAPs) that use state resources (MCTI, 2012). Compared to the NSTIS (2016-2019), there was a decrease in the resources authorized under the LOA, of around 15%.

Figure 8 below, summarizes the budgetary performance of the MCTI and specifically the annual contribution of resources authorized under the LOA and the spending carried out by the ministry during the validity of the MCTI Strategic

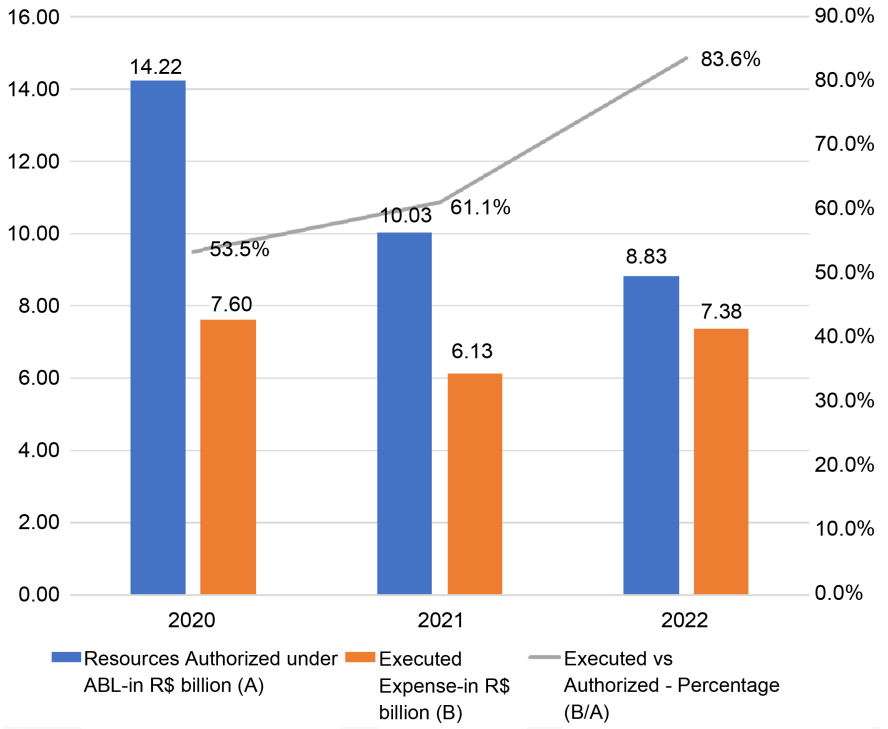

Figure 8. MCTI budgetary performance under MCTI strategic plan (2020-2023)—in R$ billion. Source: Adapted from SIOP (2023).

Plan (2020-2023), which is to say, between the years 2020 and 2022.

Analysis of the MCTI budget performance indicates a reduction in the volume of resources authorized under the LOA, between 2020 and 2022. With regard to the spending carried out by the MCTI, there was a considerable reduction in the year 2021, with the figure of R$ 6.13 billion even lower than the R$ 6.51 billion observed in 2016, the year in which the Brazilian economic crisis worsened. The reduction in the budgeted amount and spending in 2021 was due to the economic downturn in Brazil and around the world brought about by the pandemic.

Analysing the variations in spending carried out and resources authorized, one can see an average percentage of around 64.0% in spending, for the period analysed between 2020 and 2022. That figure is slightly higher than the average recorded under the previous program, but there is nothing that points to effective changes in the ability to carry out budget spending. In percentage terms, there was significant improvement, with the figures rising from 53.5% to 83.6%, which despite the prevailing uncertainties suggests an improved spending ability by the body, although the initial low levels reflected on the ST&I field in Brazil, despite the huge improvement in the budget performance for the year 2022.

In order to track the results of the resources budgeted and paid out in relation to the main function of the MCTI, "Science and Technology", a chart was drawn up that illustrates those changes during the validity period of the MCTI Strategic Plan (2020-2023), which ended in 2022, with the change of government.

Figure 9 shows that, following the overall trend of the MCTI resources, the resources authorized under the LOA for the "Science and Technology" budget function saw a reduction of 22% in relation to the previous program, which indicates a loss of share by the "Science and Technology" function in the total resources authorized under the LOA for the MCTI. As observed in the MCTI budgetary performance data, there was a reduction in the amounts of the resources authorized under the LOA in the years 2020 and 2021, due to the negative impact of the global economic crisis caused by the pandemic.

However, there was a tendency to maintain the proportion of spending carried out, compared to the previous program, with an average figure of 82.37%.

In order to better understand the budgetary spending on the "Science and Technology" function, the following Table 8 was drawn up, grouped by subfunction, showing details of the resources authorized under the LOA, compared to the spending actually carried out and the percentage of that spending as a proportion of the LOA allocation during the validity period of the MCTI Strategic Plan (2020-2023), which ended in 2022.

For the budgetary subfunctions depicted in the table above, there are considerable variations in the amount of budgetary resources authorized during the implementation of the MCTI Strategic Plan (2020-2023). Special attention may be given to the variations between the years 2021 and 2022, explained not by the overall increase itself, but due to the drastic reduction in the amounts made

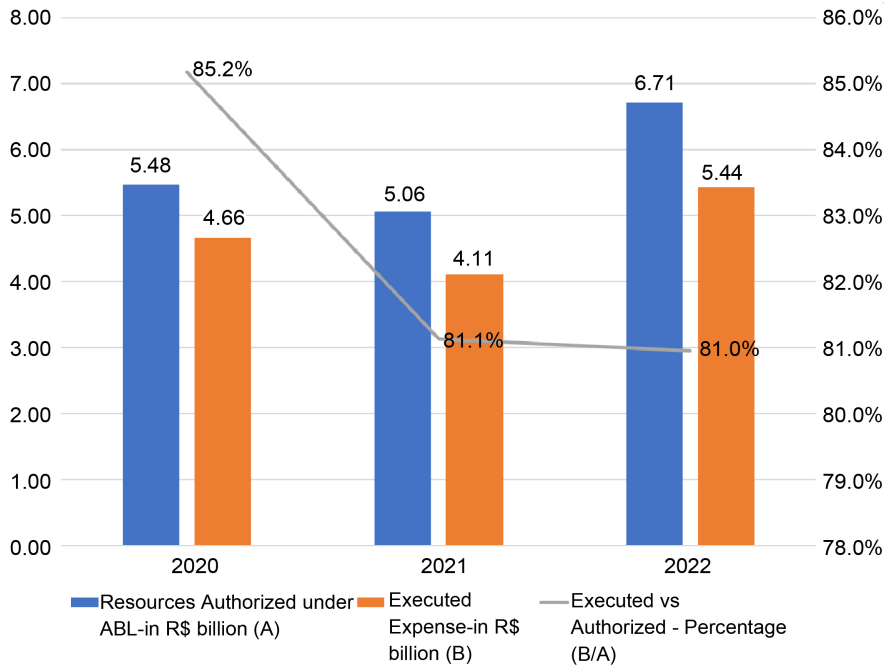

Figure 9. "Science and Technology" function budgetary performance of the MCTI Strategic Plan (2020-2022)—in R$ billion. Source: Adapted from SIOP (2023).

Table 8. MCTI Strategic Plan (2020-2023) budget authorized vs executed.

MCTI Strategic Plan (2020-2023)		Resources Authorized under LOA—in R$ billion (A)	Executed Expense—in R$ billion (B)	Executed vs Authorized—Percentage % (B/A)
"Scientific Development" Subfunction	2020	1.79	1.58	88%
	2021	1.84	1.48	80%
	2022	2.72	2.25	83%
"Technological Development and Engineering" Subfunction	2020	1.36	1.05	77%
	2021	1.07	0.72	67%
	2022	1.90	1.38	73%
"Dissemination of Scientific and Technological Knowledge" Subfunction	2020	0.03	0.01	46%
	2021	0.03	0.01	37%
	2022	0.05	0.03	55%

Source: Adapted from SIOP (2023).

available in the budgets of 2020 and 2021, the period that saw the greatest impact brought about by the pandemic.

From the point of view of spending carried out, one can see the same upward trend for 2022, for the same reasons mentioned above. Special attention may be

given to the 143.8% increase in spending carried out for the "Dissemination of Scientific and Technological Knowledge" subfunction, due to the amount returning to the levels seen under previous programs.

As for the variations in the resources authorized and the spending undertaken for the analysed subfunctions, a certain degree of stability is also observed in the years under analysis, except for the figures presented for the "Dissemination of Scientific and Technological Knowledge" subfunction, which showed an average of 46.0%, a lower figure than that observed under the previous program. The other subfunctions maintained the percentages of spending carried out at levels similar to those of the previous program.

In summary, the MCTI Strategic Plan (2020-2023) was marked by a drastic reduction in the amounts of resources authorized under the LOA in 2020 and 2021, due to the crisis brought about by the pandemic. One can observe a certain stability in the percentages of spending carried out in relation to the budgeted expenses of the subfunctions "Scientific Development" and "Technological Development and Engineering", with 83.8% and 72.4%, respectively, thus indicating a tendency to maintain the improvement in the budgetary performance of those subfunctions, which was not the case for the "Dissemination of Scientific and Technological Knowledge" subfunction.

4.2. A Comprehensive Analysis of MCTI Budget

This section will present an analysis of the evolution of the budget executed by MCTI between 2007 and 2022, taking into account the influence of the different programs carried out over the years during the period, as well as the impact of the pandemic on investments in Science and Technology in Brazil. Figure 10 illustrates the behavior of the budget executed by MCTI over the years.

The Figure 10 shows a growth trend since the first year of the programs,

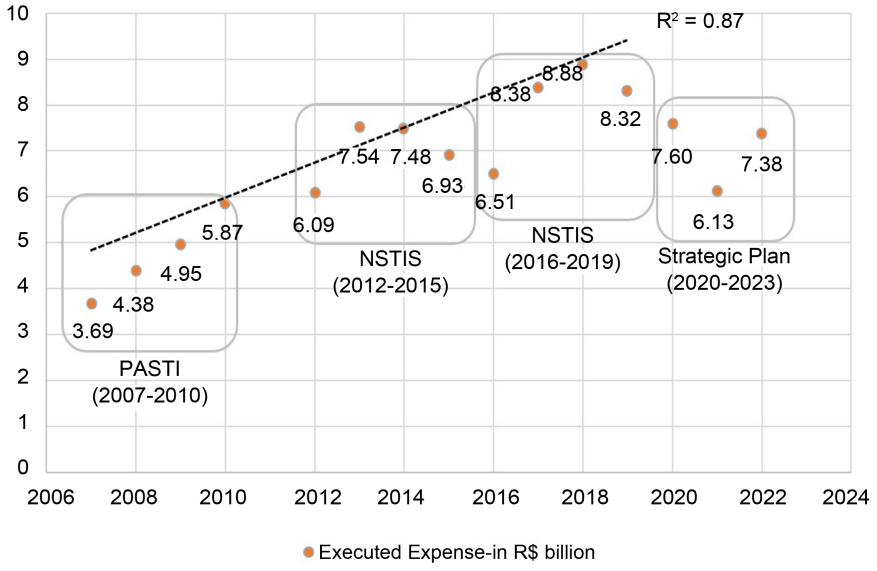

Figure 10. Evolution of "Executed Expenses" by MCTI (2007-2022). Source: The authors.

when observing a linear model that explains 87% of the variance of the "Executed Expense" variable between the years 2007 and 2019—the value of the coefficient of determination (R^2) is equal to 0.87. An exception can be observed in 2016, which presented a much lower value (6.51 billion) than the value predicted by the model (around 7.7 billion), which can be explained by the political and economic crisis seen in the country in 2015.

Beyond the year 2019, it is observed that this growth trend was not observed, highlighting the effect that the pandemic had on executed expense from 2019 onwards. It is expected that in the years following 2022, the values will show the same evolution trend observed in the years prior to 2019. The amount of executed expenses in year t (EE_t) depends primarily on two factors, the authorized resource amount (AR_t) and the usage intensity (UI_t), as indicated in Equation (1).

$$EE_t = AR_t \times UI_t \tag{1}$$

where the usage intensity is the ratio between the Executed expense and Resource Authorized ($UI_t = EE_t / AR_t$).

As indicated in Equation (2), the variation in resources implemented ($\Delta EE_t = EE_t - EE_{t\text{-}1}$) between years t and t-1 is given by the sum of the effects of changes in each individual factor:

$$\Delta EE_t = \Delta EE\left(AR_t\right) + \Delta EE\left(UI_t\right) \tag{2}$$

where corresponds to the activity effect, in which executed expenses increase with an increase in authorized resources, i.e., the effect on the executed expense of the change in authorized resource between t and t-1 corresponds to the intensity effect, which is caused by a change in the intensity of resource utilization, i.e., the effect on the executed expense of the change in usage intensity between t and t-1.

Applying LMDI decomposition (Ang, 2005) to Equation (1) yields the following expressions for calculating the activity and intensity effects in each year t:

$$\Delta EE\left(AR_t\right) = \frac{EE_t - EE_{t-1}}{\ln\left(EE_t\right) - \ln\left(EE_{t-1}\right)} \ln\left(\frac{AR_t}{AR_{t-1}}\right) \tag{3}$$

$$\Delta EE\left(UI_t\right) = \frac{EE_t - EE_{t-1}}{\ln\left(EE_t\right) - \ln\left(EE_{t-1}\right)} \ln\left(\frac{UI_t}{UI_{t-1}}\right) \tag{4}$$

The accumulation of intensity and activity effects over the duration of each program period resulted in the bar chart illustrated in **Figure 11**. For example, the blue, orange, and gray bars for the PASTI program (2007-2010) correspond, respectively, to the total executed expenses variation $\Delta EE_{t\in[2007,2010]}$, the activity effect $\Delta EE\left(AR_{t\in[2007,2010]}\right)$ and the intensity effect $\Delta EE\left(UI_{t\in[2007,2010]}\right)$ during the period program, whose values are obtained by the following equations:

$$\Delta EE_{t\in[2007,2010]} = \Delta EE\left(AR_{t\in[2007,2010]}\right) + \Delta EE\left(UI_{t\in[2007,2010]}\right) \tag{5}$$

$$\Delta EE\left(AR_{t\in[2007,2010]}\right) = \sum_{t=2007}^{2010} \frac{EE_t - EE_{t-1}}{\ln\left(EE_t\right) - \ln\left(EE_{t-1}\right)} \ln\left(\frac{AR_t}{AR_{t-1}}\right) \tag{6}$$

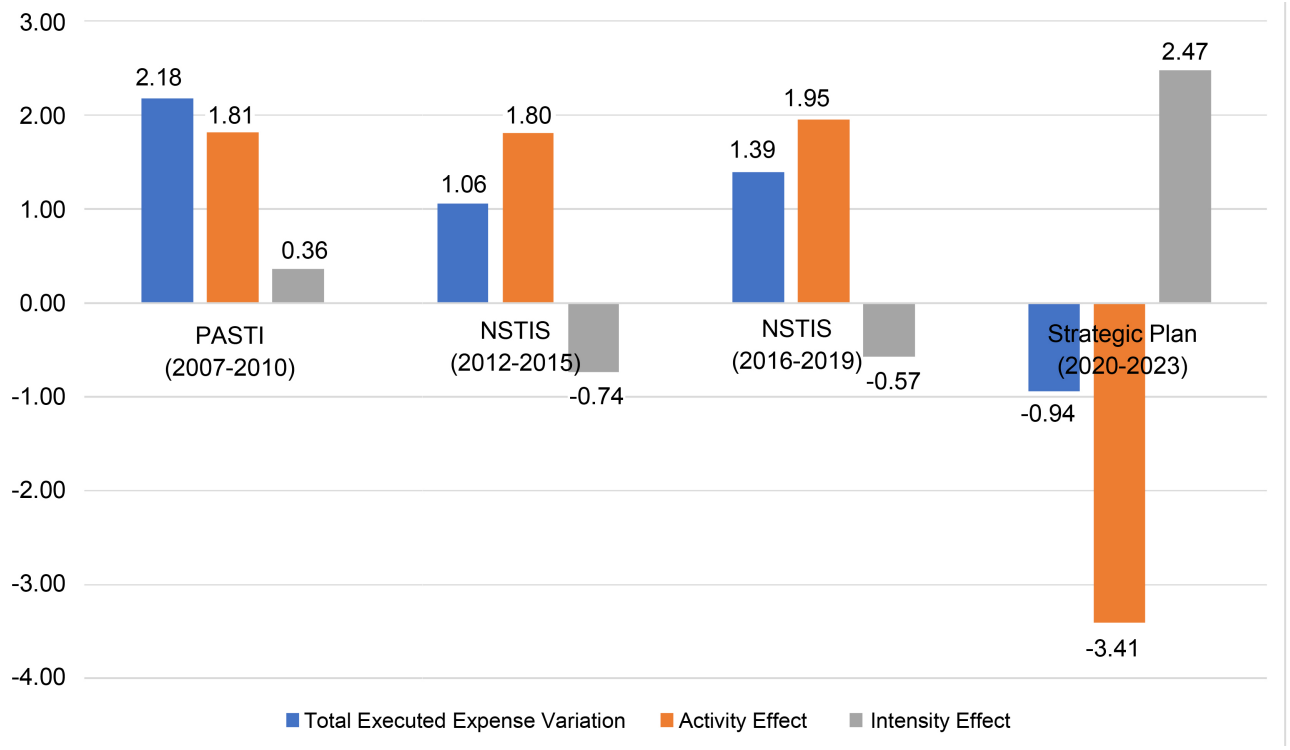

Figure 11. Total variations in "executed expenses", "activity effect" and "intensity effect" by program. Source: The Authors.

$$\Delta EE\left(UI_{t\in[2007,2010]}\right)=\sum_{t=2007}^{2010}\frac{EE_t-EE_{t-1}}{\ln\left(EE_t\right)-\ln\left(EE_{t-1}\right)}\ln\left(\frac{UI_t}{UI_{t-1}}\right) \quad (7)$$

Figure 11 illustrates how much of the variation in "Executed Expenses" was driven by variation in "Authorized Resource" and how much was driven by variation in the intensity of resource use in each program. Furthermore, it should be noted that the blue bar is the sum of the orange and gray bars, as previously indicated in Equation (5).

In the PASTI plan (2007-2010), the increase in "Executed Expenses" was due more to an increase in "Authorized Resources" than to the intensity of use of this resource.

In the NSTIS (2012-2015) and NSTIS (2016-2019) plan, the increase in "Executed Expenses" results from an increase in "Authorized Resources". On the other hand, there is a reduction in the intensity of use of the resource, when compared to the PASTI Program (2007-2010).

In the MCTI Strategic Plan (2020-2023) there is a drastic reduction in execution resulting from a reduction in "Authorized Resources" probably due to the effect of the pandemic. However, there is a substantial increase in the intensity of resource use. In percentage terms, there is a use of 53.5% of "Authorized Resources" in the first year (2020) for a use percentage of 83.6% of "Authorized Resources" in 2022. In this same period, there is a drastic reduction in "Authorized Resources"—14.22 billion in 2020 and 8.83 billion in 2022, which indicates that at a time when resources became scarce, the intensity of use increased.

Aiming to understand the impact of variations in "Executed Expenses" during the period between 2008 and 2022, a graph was created that illustrates in Figure 12 the behavior of variations annually, compared to annual variations in GDP.

Some observations can be made from the Figure 11 and Figure 12 previously presented. The first is that no significant correlation was identified between the values of annual GDP variations and the variations in the variables involved. The highest correlation coefficient identified was 0.55 between GDP Variation and "Executed Expenses", when considering the period between 2008 and 2019, the year before the pandemic. When considering the following years (until 2022), this value decreased, indicating a weak correlation between the variables, during the pandemic period.

Second, it is possible to see an abrupt drop in GDP in 2015 and 2016, which had clear consequences for "Executed Expenses". In 2020, probably due to the pandemic, there was an abrupt drop in GDP and successive drops in "Executed Expenses", until 2021, showing a significant increase in 2022. Regarding these points, it is inferred that, even though there is no strong correlation between GDP and "Executed Expenses", an influence of GDP "Executed Expenses" can be seen in the years following the declines.

Third, it is possible to observe specificities presented in the years 2013, 2017 and 2022, without apparent interference from GDP, when a significant increase in "Executed Expenses" was noticed. While in 2013 and, mainly, 2022, a strong influence of intensity of use was noticed, in 2017 there was a strong influence of

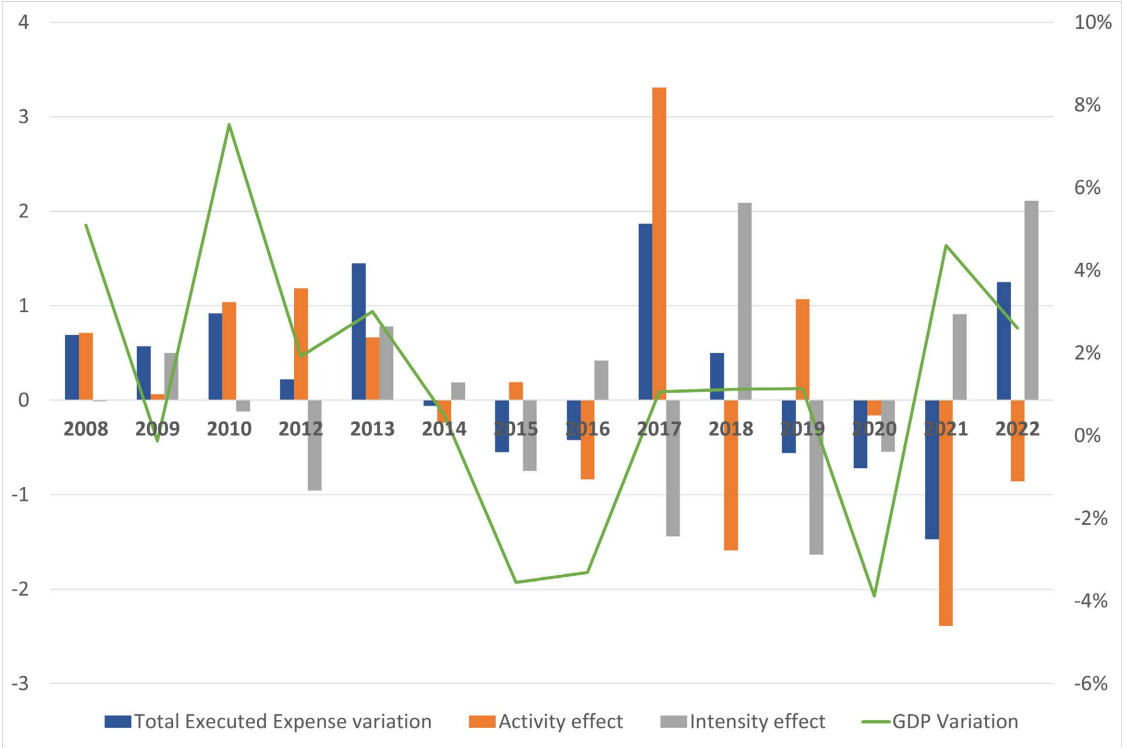

Figure 12. Total Variations in "Executed Expenses", "Activity Effect", and "Intensity Effect" in contrast to Annual GDP Variations. Source: The Authors.

"Authorized Resources".

Finally, it is observed that in the post-pandemic period, the "Executed Expenses" rose again and an increase in the intensity of use of available resources was also observed from 2021 onwards. Taking as a basis the entire period, from 2008 to 2022, there was a relatively strong correlation of −0.74 between intensity of use and "Authorized Resources", indicating a greater intensity of use of resources when they are scarce.

5. Conclusion

In view of the arguments presented, in this paper, we sought to analyse the variations in the budgetary performance of the MCTI during the implementation of the ST&IP during the years from 2007 to 2022. The methodological procedure used the criterion of functional classification of the spending to show the most significant oscillations in the budget allocation to the field of ST&I, based on the "Science and Technology" budget function and its subfunctions: "Scientific Development", "Technological Development and Engineering" and "Dissemination of Scientific and Technological Knowledge".

Furthermore, the analysis of variations in the budgetary performance of the MCTI, of the function: "Science and Technology" budget and of the subfunctions described in this paper, focused on the period of implementation of the PASTI (2007-2010), the NSTIS (2012-2015) and the NSTIS (2016-2019), as they represent the ST&IP with the longest duration. The main results obtained are explained below.

Analysis of the variations in the MCTI's budgetary performance during the validity of the PASTI (2007-2010), NSTIS (2012-2015), NSTIS (2016-2019) and MCTI Strategic Plan (2020-2023) showed that there was no homogeneity in the distribution of budgetary resources for the MCTI, as well as a lack of regularity in the spending of those resources, which suggests a low level of priority by the federal government in relation to the field of ST&I.

When analysing the budgetary performance during the implementation of the PASTI (2007-2010), there was shown to be irregularity in the distribution of budgetary resources and in the spending on the MCTI subfunctions described in this study. This may explain the incomplete budget spending, despite the relative stability during the period. The exception was the "Science and Technology" budgetary function, which showed continual growth, in absolute terms, in the allocation of budgetary resources and in the spending carried out during the period, demonstrating that the federal government considered the importance of the science, technology and innovation policy in its budgeting. However, the MCTI's inability to spend the budgetary resources on its "Science and Technology" budgetary function could be the reason why the variations in budgetary performance for this function failed to account for the total resources available.

The notable feature of the PASTI (2007-2010) was the low level of budgetary performance for the typical subfunction "Dissemination of Scientific and Tech-

nological Knowledge", despite it being one of the four strategic priorities built into that plan. It is also opportune to mention the growth during the period and the stability over the years 2008 and 2009 in the contributing of budgetary resources destined for the MCTI, offsetting the increase in spending carried out and thus reflected in the variations in budgetary spending that did not reach the full resources available.

For the NSTIS (2012-2015), there is an oscillation in the volume of resources authorized under the budgeting law and in the spending carried out by the MCTI, in its "Science and Technology" budgetary function and in the subfunctions analysed in this study. Moreover, there is a little variation in budgetary spending, especially in the "Science and Technology" budgetary function and in the two subfunctions "Scientific Development" and "Technological Development and Engineering", compared to the variations that occurred under the PASTI (2007-2010). It should be noted that the low level of variations in budgetary performance is linked to the uncertainty surrounding the MCTI budget, imposed by the federal government, and the inability to fulfill spending on the field of ST&I, and not just to the worsening of the country's fiscal crisis from 2015 onwards.

In summary, the oscillations or volatility of the budgetary resources and the spending carried out during the implementation of the NSTIS (2012-2015), particularly for the MCTI's budgetary two subfunctions "Scientific Development" and "Technological Development and Engineering", may have compromised action considered to be critical for the national scientific and technological development strategy.

Finally, the NSTIS (2016-2019) and the MCTI Strategic Plan (2020-2023), like the PASTI (2007-2010) and NSTIS (2012-2015), also showed inconsistency in the allocation of budgetary resources and in the spending carried out by the MCTI itself, in its "Science and Technology" budget function and in the subfunctions studied in this paper. In the specific case of the NSTIS (2016-2019) there is a drastic reduction in the amount of budgetary resources and spending carried out up to 2019, despite obtaining the greatest consistency in budgetary performance variations.

The NSTIS (2016-2019) and the MCTI Strategic Plan (2020-2023) were also affected by the increasing budget cuts imposed by the federal government on the financing of ST&I and by the inability of the MCTI to follow through in its spending. In such a scenario, the NSTIS (2016-2019) agenda has been systematically interrupted, bringing about a decline in the funding for scientific and technological projects and programs. Notable during this period was a drastic reduction in the amounts made available under the 2020 and 2021 budgets, the period that saw the greatest impact of the Coronavirus (SARS-CoV-2) pandemic.

In view of the results obtained in this paper, it can be seen that the federal government has been unable, over the period from 2007 to 2022, to incorporate

within its budget planning and performance a number of fundamental pillars set out in the ST&I, due to the volatility of the budgetary resources and the MCTI's inability to follow through on spending in the field of ST&I, thus preventing the development of a long-term public policy for science, technology and innovation.

The analysis presented in this study is relevant in highlighting the fluctuations between "planned" and "executed budgets", revealing the possibility of using it as a tool for in-depth analysis of the causes of these differences. Once there is a public policy determining the monitoring of historical series, such as the one presented in this research, the need to justify variations when defining budgets as well as justifications for what is executed would become mandatory.

Additionally, the research highlights the need to monitor the MCTI's budget execution through a process of technical and managerial training of the teams responsible in the bodies that are part of the ministry for the implementation of ST&IP, as well as the need to build government bodies with effective capacity to influence decisions in MCTI bodies to better implement the implementation of public policies and, with this, promote the scientific and technological development of the country.

The analysis presented in this study is relevant in highlighting the oscillations between the "planned" and "executed" budget and the possibility of using it for in-depth analysis of the causes.

The results also presented herein may be significant to explain the oscillations in the country's Global Innovation Index (GII) and simultaneously to guide ST&I developers.

In that sense, for future research the suggestion is to deepen the studies on the variations in budget performance in the "Science and Technology" function and the subfunctions "Scientific Development", "Technological Development and Engineering" and "Dissemination of Scientific and Technological Knowledge" in another ministries, in order to analyse the effects on the implementation of ST&IP on a consolidated basis.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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