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Federal university practices to combat COVID-19: the relationship between public investment and implementation capacity

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This article aims to analyze the relationship between public resources invested in federal universities and their capability to respond to COVID-19. The article presents a categorization method to evaluate the practices of combating COVID-19 organized by federal universities. Data analysis indicates a positive relationship between the level of expenditures and the ability to implement research and extension projects, mainly for the development of technologies. The discussion presents consequences for the public policies of Science, Technology, and Innovation to strengthen the Federal System of Higher Education, to guarantee the necessary infrastructure to solve complex problems such as those generated by COVID-19.
Keywords: COVID-19; federal higher education system; education financing; science, technology and innovation; investment in science.

Práticas das universidades federais no combate à COVID-19: a relação entre investimento público e capacidade de implementação

Esse artigo busca analisar a relação entre os recursos públicos investidos nas universidades federais e sua capacidade de implementação de respostas à COVID-19. O artigo contribui, inicialmente, com um método de categorização para avaliação do direcionamento das práticas de combate à COVID-19 pelas universidades federais. A análise dos dados sinaliza uma tendência de relação positiva entre o nível de gastos executados e a capacidade de implementação de respostas por meio de projetos de pesquisa e de extensão, principalmente, para o desenvolvimento de tecnologias. Essa reorientação enseja uma discussão sobre desdobramentos para as políticas públicas de Ciência, Tecnologia e Inovação e para o fortalecimento do Sistema Federal de Educação Superior, de modo a garantir a infraestrutura necessária para a resolução de problemas complexos, como os gerados pela pandemia da COVID-19.
Palavras-chave: COVID-19; sistema federal de educação superior; financiamento da educação; ciência, tecnologia e inovação; investimento em ciência.

Prácticas de las universidades federales en la lucha contra la COVID-19: la relación entre inversión pública y capacidad de implementación

Este artículo busca analizar la relación entre los recursos públicos invertidos en universidades federales y su capacidad para implementar respuestas a la COVID-19. Por lo tanto, el artículo inicialmente contribuye con un método y una forma de categorización para evaluar la aplicación de prácticas para combatir la COVID-19 por parte de las universidades federales. El análisis de los datos señala una tendencia de relación positiva entre el nivel de gastos ejecutados y la capacidad de implementar respuestas a través de proyectos de investigación y extensión, principalmente para el desarrollo de tecnologías. Esta reorientación da lugar a una discusión sobre los desdoblamientos de las políticas públicas de Ciencia, Tecnología e Innovación y para el fortalecimiento del sistema federal de educación superior, a fin de garantizar la infraestructura necesaria para resolver problemas complejos como los generados por la COVID-19.
Palabras clave: COVID-19; sistema federal de educación superior; financiamiento de la educación; ciencia, tecnología e innovación; inversión en ciencia.

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1. INTRODUCTION

When a country faces a lethal enemy, such as a viral pandemic, the state and society seek support from science and research institutions to combat it. In Brazil, although the country has increased spending on science, technology and innovation (STI) in the last decade, breaking a long cycle of investment stagnation, the development level in basic research, applied research and patents creation is still below its full potential considering the vast natural and human resources present in Brazilian territory. This is a result of political inability to significantly increase spending on STI in relation to GDP, as an outcome of the discontinuity and insufficient investments in STI in the last 50 years, when explicit policies in the area were incorporated into the Federal Government's agenda (Pelaez, Invernizzi, Fuck, Bagatolli, & Oliveira, 2017).

The incorporation took place by structuring research funding from the 1970s onwards, with the creation of the National Council for Scientific and Technological Development (CNPq) and the Coordination for the Improvement of Higher Education (CAPES). The first with the function of promoting National Research and the second to enhance advanced education and human resources improvement for graduate and postgraduate programs. During this period, research funding in the country counted on the contribution of American private resources through international agreements, such as the one carried out by the Ministry of Education (MEC) and the United States Agency for International Development (USAID). In addition, funding agencies were created, such as the São Paulo State Research Support Foundation (FAPESP) and the Studies and Projects Financing Agency (Finep). These foundations contributed significantly to the implementation of new methodologies for financing research and innovation in Brazil (Bastos, 1997).

These funding agencies make up the current financing structure; however, they have suffered from the instability and discontinuity of STI policies across governments. Since 2016, the resources allocated to research funding through CNPq and Finep have suffered substantial declines, which has impacted the progress and viability of research and technological development (R&D) projects.

With the public health emergency caused by the new coronavirus (COVID-19) and due to the lack of knowledge of its own characteristics and its rapid spread of infection in an increasingly interconnected world (Peeri et al., 2020; Naqvi, 2020), impacts of COVID-19 reestablish new configurations on State's performance in various sectors of economy, not only in health sector. In addition, according to Rodriguez-Morales et al. (2020), in Latin America countries, especially in Brazil, where the virus proliferates more than in its neighboring countries; there is the shortage and precariousness of public health systems, which requires more state investments in R&D and more communication efforts to combat the negative impacts of the disease. Considering the investment of public resources in federal higher education institutions (Ifes), members of the National STI System, since 2003 (Alves & Oliveira, 2014; Marini & Silva, 2011), the efficiency application of these resources by Ifes has been target of studies that seek, in some way, to verify how this investment returns to society (Alves & Oliveira, 2018; Lima, 2004; Marinho, 1998; Ohayon & Rosenberg, 2014). In the midst of the social isolation measures brought about by COVID-19, populations and international governments turn to research institutions, which can find solutions. In Brazil, research centers are concentrated in Ifes, especially in public universities.

Thus, this article aims to analyze how federal universities invest the governmental funds they receive in actions to combat COVID-19. Nevertheless, in order to comprehend the response capacity of federal universities to COVID-19 through research and extension projects, it is necessary, first, to understand the structure and funding of postgraduate programs and research in Brazil.

2. STRUCTURE AND FINANCING OF POSTGRADUATE PROGRAMS AND RESEARCH IN BRAZIL

The recent expansion of federal universities and, consequently, the expansion of the research network, was a result of Reuni (2007-2012) – Program to Support Federal University Restructuring and Expansion Plans. This Program played an important role in increasing public resources aimed at creating new universities, as well as in expanding existing federal universities (Ministério da Educação, 2009).

The growth of postgraduate studies in federal intuitions can be seen by the increase in the number of courses offered, which grew by 135% between 2004-2018, reaching 2,479 programs in 2017. In 2018, the number of courses decreased by 0.28% compared to the previous year, with the closing of six postgraduate programs at federal institutions, according to data from GeoCapes (Ministério da Educação, 2020).

From 2004 to 2018, the number of research professors in programs of federal institutions grew 192%. In 2018, 62,662 professors were in public institution programs. The number of students enrolled in postgraduate programs grew by 198% between 2004 and 2018, from 57,339 students to 170,803 in 2018. The number of graduates also grew by 156% in this period, with the graduation of more than 49 thousand researchers in 2018 (Ministério da Educação, 2020).

Important areas in combating COVID-19, such as Health, Biological Sciences and Engineering, grew more than 60% between 2004 and 2018. The Health area grew 81.3% between 2004 and 2018, being the largest area in terms of number of programs in federal institutions, with 338 master's and doctoral programs. The Biological Sciences area, another important area in the fight against the disease, had a growth of 64.4% in the number of courses at federal institutions. The Engineering area had an increase in the number of programs of 80.18% between 2004 and 2018 (Ministério da Educação, 2020), a central area for the development of personal protective equipment and respirators.

Analyzing the research structure demands evaluating resources invested in federal institutions for the financing of all education areas: teaching, research, extension and postgraduate programs. From 2004 to 2019, the increase in federal resources directed to education financing was significant, going from 2.03% to 5.32% in 2017, and reducing to 4.66% of the federal government total spending in 2019 (Controladoria Geral da União, 2020).

Since the first quarter of 2015, Brazil has entered an economic recession, and, in addition to the drop in GDP, data show a reduction in household consumption, employment and income (Rossi & Mello, 2017). This recession represented a decline in public resources invested in social policies, such as health and education, and the adoption by the federal government, since 2016, of a set of economic austerity policies. For Bassi (2018), Constitutional Amendment No. 95, also known as the Constitutional Amendment to the Public Expenditure Ceiling, represents in operational terms a limit on public expenditure to the Broad Consumer Price Index (IPCA) for twenty years. For Rossi and Dweck (2016), the accomplishment of a fiscal adjustment through constitutional amendment had

as great objective the untying of revenues from the budget for investments in health and education. For Rossi and Mello (2017), these austerity policies were not effective for the economic recovery and may represent a high social cost.

Investments in education are already being impacted by Constitutional Amendment No. 95. Under the impact of the Amendment, MEC had its spending reduced by 6.7 billion in 2019, compared to public spending in the area in 2017 (Controladoria Geral da União, 2020). The reduction affected the resources allocated to CAPES, which lost 1.2 billion in 2019, in relation to the expenditure executed in 2016 (Controladoria Geral da União, 2020). The reduction in public spending has affected the financing of research projects, as well as the distribution of masters and doctoral scholarships.

In the midst of the pandemic, CAPES structured the Emergency Strategic Program to Prevent and Combat Outbreaks, Endemics, Epidemics and Pandemics in order to support research projects related to postgraduate programs. The Program launched three notices, one directed to epidemics, another to drugs and immunology, and a third, to the area of telemedicine and medical data. The funds will be allocated to capital expenditures, funding and scholarships for master's, doctoral and post-doctoral studies. The total resources invested in the Program are around 110 million (BRL), diluted on an average 4-year-investment, due to the nature of the doctoral and master's scholarships that will be offered. This figure means less than 10% of CAPES budget cuts in 2019, when compared to the 2016 budget (Controladoria Geral da União, 2020). This investment is not enough to rebuild STI policy and to face complex problems such as those generated by COVID-19.

Another important agency in financing research in Brazil, the National Council for Scientific and Technological Development (CNPq), linked to the Ministry of Science, Technology, Innovation and Communication (MCTIC), has also been impacted by budget cuts. CNPq decreases its participation in the total resources invested by MCTIC: from 31.88%, in 2004, to 15.99%, in 2019 (Controladoria Geral da União, 2020). This proportional reduction in resources allocated to CNPq impacted research funding in Brazil, suspending some projects in progress at universities, some even directly related to combating epidemics.

Amid the budget cuts suffered by the Higher Education Federal System in recent years, Brazil was impacted by COVID-19 in March 2020. The pandemic demanded from federal universities the implementation of practices to combat the disease.

3. METHOD

This quantitative and exploratory study is based on secondary data collection on the institutional websites of federal universities and government databases. To analyze the relationship between public resources invested and the capability to implement responses to COVID-19, the following data collection protocol was adopted.

First, to contextualize and understand the practices of combating COVID-19 at federal universities, the following mechanisms, sources and collection criteria were observed:

1. The initial cut for data collection was the list of 27 institutions in the note of the National Association of Directors of Federal Institutions (Andifes), published on March 12, 2020, on the sharing of federal universities actions on COVID- 19.

2. Access to the institutional pages of these federal universities, in alphabetical order. On each site, first, the institutional section reserved for news related to COVID-19 was searched; when the section was not found, the news were collected directly from the institutional news section. The collection period covered news published in March and April 2020. Only actions published by universities on the institutional portal were considered. The practices perhaps developed and published only on sites of Centers, Programs and Research Groups were not included in this survey. This criterion was adopted due to the recognition of shares by the University.
3. Then, the collected news were categorized. The first categorization phase was carried out based on the categories created by two universities that created database for actions to combat COVID-19. This categorization was increased and expanded to the final version of this study, in order to include all practices identified in other institutions. The categorization of actions was performed after collection, and reviewed by the authors.

It is important to note that studies based on database analysis are subject to bias, which may occur due to issues of record consistency, categorization and method of analysis. It is necessary to consider that incomplete records or the categorization method itself may interfere with the results obtained. Thus, in view of more homogeneity in the results and conclusions, the following protocols were adopted:

a) Regarding data quality: it was respected the universities selection provided by Andifes and the full collection of shares or news in the reported period. Thus, even though it represents a sample, given the exploratory nature of this study, there is consistency in these records.
b) Considering categorization: use of categories a priori reviewed by researchers. Thus, as an expanded categorization was adopted based on what was identified in two universities, there was more consensus and consistency in action classification.
c) Regarding analysis: once there are consistent and properly categorized records, the analysis (counting) is performed with the support of software.

Below, the list of final categories for the university actions classification related to the COVID-19 pandemic.

a. Statistical monitoring in portals and COVID-19 Census: population surveys for case projection, data systematization and dissemination of technical analyzes related to COVID-19 in portals, enabling monitoring of cases, projections, aggregating analysis and intelligence for decision making.
b. Improvement of laboratory infrastructure: directing resources to the creation of new laboratories specialized in issues related to COVID-19.
c. Applications, platforms and algorithms: software development that supports problem solving, from chatbots, case records, to donations to help combat COVID-19.
d. Community support: social solidarity actions expanded in the context of the pandemic and directly aimed at communities and groups in vulnerability situations.
e. Local economy support: support to companies, involving public policies or transmission of direct knowledge to SMEs.

f. *Hospitals support*: direct support, through training or reinforcement of hospital infrastructure, through university hospitals or support to regional hospitals, due to the burden on the Public Health System.
g. *Online service*: creation of virtual service channels for the population, for medical and psychosocial guidance related to COVID-19.
h. *Development of hospital equipment*: creation of new equipment to combat COVID-19, involving low-cost and efficient technologies, such as respirators, ventilators and others.
i. *Development of drugs and vaccines*: research involving genetic sequencing and analysis of drugs for the prevention and treatment of COVID-19.
j. *Development of tests and clinical trials*: actions for protocols production and execution of tests and clinical trials related to COVID-19.
k. *Dissemination of cultural information to Society*: development of cultural content, regarding maintaining cultural actions for the population in social isolation due to COVID-19.
l. *Social, Economic and Environmental Impact Studies*: scientific research developed and disseminated institutionally to understand the impacts of COVID-19 in these three dimensions.
m. *R&D Promotion*: induction, alignment and support of new research and extension projects based on the degree of response to COVID-19.
n. *Field Hospital*: creation of field hospitals with university infrastructure to treat the effects of COVID-19.
o. *Guidelines in Crisis Councils*: scientific support to government councils created due to COVID-19, for decision making in the fields of Health, Economy, Society and Environment.
p. *Supply network participation*: University participation in collaborating with supply chains, whether in purchases, given access to raw materials; or production, such as converting alcohol to alcohol gel; or distribution; accessing these materials to the community.

The sixteen initial categories were grouped into a new, more comprehensive categorization, with five macro categories, shown in Box 1. The *Technology Development* macro category involves the creation of physical (vaccines, drugs, hospital equipment, PPE, etc.) and virtual technologies (statistics portals, applications, algorithms, etc.) as a way of generating capacity for analysis and direct response to COVID-19. The macro category *Direct Intervention in Society* involves the university's extensive practices, through which it directly integrates with social actors and broadens support for the effects of COVID-19. The macro-category *Dissemination of Information to Society* consists of the dissemination of scientific knowledge about COVID-19, elaborated in several areas, in language accessible to the population. The macro-category *Supply Network Participation* involves a type of emerging practice in universities, related to participation in purchase, production and distribution of the supply chain for COVID-19. Finally, the *Impact Studies Development* macro category covers the set of basic and applied research on Social, Economic and Environmental Impact of COVID-19.

BOX 1 CATEGORY DESCRIPTION

Macrocategories	Categories involved
Technology Development	Improvement of Laboratory Infrastructure Development of new PPE Development of Tests and Clinical Trials Applications, Platforms and Algorithms Development of Drugs and Vaccines Development of Hospital Equipment Statistical Monitoring in Portals and COVID-19 Census
Direct Intervention in Society	Community Support Hospitals Support Online Service Local Economy Support Field Hospital Guidelines in Crisis Councils R&D Promotion
Dissemination of Information to Society	Dissemination of Guiding Information to Society Dissemination of Cultural Information to Society
Supply Network Participation	Participation in the Input Purchase Network Participation in the Input Production Network Participation in the Input Distribution Network
Impact Studies Development	Social Impact Studies Economic Impact Studies Environmental Impact Studies

Source: Elaborated by the authors.

In a second step, to understand the investments made by the universities in the sample, data were collected directly from the Transparency Portal, referring to own and third party resources executed between 2016 and 2019. Federal universities were classified into four groups, considering the resource applied:

a. G1, composed of seven universities with spending below three hundred million (BRL), with a budget average of BRL $236,025,177 / year and a standard deviation of BRL $53,286,665 (variation coefficient of 22%);
b. G2, composed of seven universities with spending between 500 million and one billion (BRL), with a budget average of BRL $782,458,604 / year and a standard deviation of BRL $ 150,344,852 (variation coefficient of 19%)
c. G3, composed of nine universities with spending between one billion and two billion, with a budget average of BRL $ 1,534,681,414 and a standard deviation of BRL $259,417,023 (variation coefficient of 16%);
d. G4, composed of three universities with spending over two billion (BRL), with a budget average of BRL $ 2,704,600,529 and a standard deviation of BRL $ 848,502,583 (variation coefficient of 31%).

Universities were allocated according to the frequency of their spending. By the variation coefficient, it is observed that the groups have low variability, less than 30%, which indicates homogeneity in most groups. The only exception is Group 4, composed of 3 institutions, two with a budget in the range of 2 billion and one with a budget of 3.5 billion. However, as the objective is to classify universities according to the sum of public spending in low, medium, high and higher, it is understood that this classification represents the groups.

The two databases – practices of federal universities and the spending database performed by universities – were unified for analysis purposes, from the identification of practices based on the name of the university.

4. DISCUSSION

Two results from the analysis of federal universities practices and spending database are discussed in this section. 426 actions to combat COVID-19 were collected in the analyzed period. However, the objective of this study is not to quantify, but to identify the observed macro patterns, based on the occurrence and nature of the action. Other actions can be categorized and compared in new studies, considering the dynamics of the field.

4.1 How are the macro categories of practices distributed?

During data collection of the actions, which cover the first two months of COVID-19 in Brazil, the portfolio of practices developed by federal universities was observed in the five macro categories – explained in the following paragraphs. Therefore, based on the 426 practices collected, a sample was obtained that made it possible to infer a pattern of action in the Higher Education Federal System in Brazil, limited to the period analyzed and the institutions observed.

It was possible to observe that, of the total practices of federal universities, 40.87% were oriented towards the *Development of Technologies*. This means an expressive volume of resources aimed at improving laboratory infrastructure, development of new PPE, development of clinical tests and trials, applications, platforms and algorithms, development of drugs and vaccines, development of hospital equipment and statistical monitoring in portals and censuses from COVID-19. This result signals a contribution from research carried out by federal universities to combat the disease. These practices are in line with the relevance of these institutions in the development of innovations, since patents creation in Brazil is concentrated in federal universities, which have infrastructure and postgraduate programs.

It was also found that 23.96% of the mapped practices were oriented towards *Direct Intervention in Society*, with projects to support the community, support for hospitals, online assistance, support for the local economy, field hospital, guidance on crisis councils and R&D promotion. This implies a relationship between university and society, in strengthening ties and valuing university extension practice. In addition, the breadth of federal universities network in the national territory allows for the internalization of actions, since the pandemic effects are diffuse.

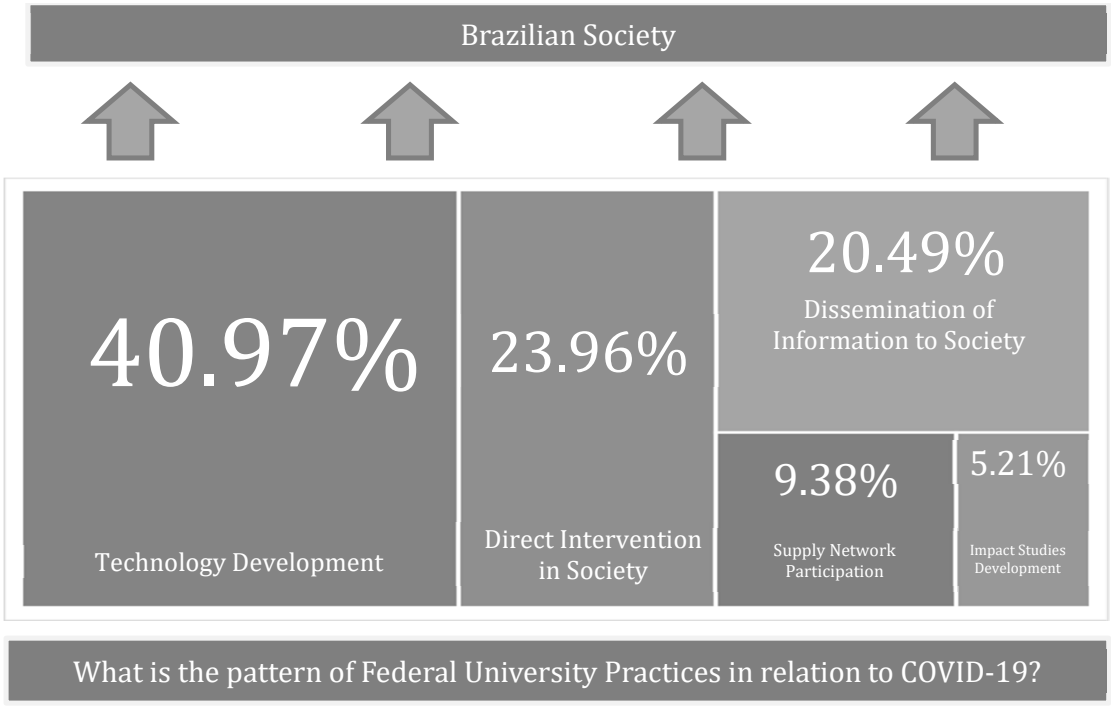
The *Dissemination of Information to Society* represents 20.49% of the practices, through projects to support local communities based on scientific guidelines, combating disinformation and the direct

impacts of COVID-19, as well as promoting cultural information. As a pandemic that also depends on individual behavior to mitigate its effects (Anderson, Heesterbeek, Klinkenberg, & Hollingsworth, 2020), access to scientifically based information represents a critical point in combating this disease.

It was noticed that 9.38% of practices were related to *Supply Network Participation*, mostly for producing and obtaining alcohol gel and PPE. This is a new practice, which has benefited from the infrastructure of university laboratories, demonstrating the capability to work in collaborative networks with the private sector, for the development of national supply chains, mainly in the medical and pharmaceutical fields. The last macro-category, *Impact Studies Development*, corresponds to 5.21% of the practices, which are related to scientific studies important for understanding these phenomena.

The analysis of the practices to combat COVID-19 developed by federal universities showed that these institutions have physical and human infrastructure to quickly implement actions that integrate research and extension in solving complex problems with an impact on different areas, such as Health, Economy, Environment and Society. The finding of 65% of practices oriented to *Technology Development* and *Direct Intervention in Society* opposes the narrative according to which the federal university would be an institution closed in itself, and little oriented to the local reality. The percentages obtained, as shown in Figure 1, may vary in the future with a new data collection, but, considering the proportional distribution identified in the macro categories, it is possible to state that the Higher Education Federal System in Brazil has acted effectively in combating COVID-19, due to its technological development and its capability to intervene directly in society.

FIGURE 1 CONFIGURATION OF FEDERAL UNIVERSITIES PRACTICES IN COMBATING COVID-19



Source: Elaborated by the authors.

4.2 How these practices relate to expenditures by federal universities?

Table 1 indicates a positive correlation between federal practices and the volume of public funds invested. In other words, globally, the larger the university's budget, the greater its capacity to develop actions to combat COVID-19, provided that the resources for solving complex problems are well directed, which require multidisciplinary competence and advanced knowledge level.

The institutions in G1 and G2 groups (budget below 1 billion) correspond to about 19% of the *Technology Development Practices*, while the institutions G3 and G4 (budget above 1 billion) account for 81% of these practices. In the same group, universities with the lowest volume of resources account for 17% of *Direct Intervention Practices in Society*, while those with the highest volume account for 82% of actions.

In the *Practices of Dissemination of Information to Society*, the proportion is 23% for the first group and 76% for the second group. In the case of *Supply Network Participation Practices*, the proportion is practically 42% and 48% for each group respectively. In *Impact Studies Development Practices*, that is, impact studies on COVID-19, the proportion was 69% for high budget and 31% for low budget universities.

In terms of total actions, the proportion is 22% for the group with low budget universities and 78% for the group with the largest budget. Thus, what can be seen in Table 1, in global standards, is that there is a positive relationship between the resource executed and the capacity related to *Technology Development Practices*, *Direct Intervention in Society*, *Dissemination of Information to Society*, *Supply Network Participation*, and *Impact Studies Development Practices*. This analysis also shows that the lowest proportionality of G4 practices over G3 is due to the number of institutions, since G4 has only three institutions, while G3 has nine. However, bearing in mind that the volume of G4 practices is higher than that of G2 and G1, it is inferred that there is a positive relationship between the expenditure executed and the response capacity based on the practices to combat COVID-19. Although the objective of this study is not the percentage accuracy itself, since it has a time cut, and evidently these percentages will suffer some fluctuation in new collections and analyzes, it is pointed out that the global standard, by the 80%-20% distribution, denotes a tendency to the relation of the expenditure with the responsiveness.

TABLE 1 RELATIONSHIP BETWEEN PRACTICES AND VOLUME OF RESOURCES EXECUTED

Practices related to COVID-19	Expenditure executed*				Total
	G1	G2	G3	G4	
Technology Development	5.11%	13.87%	64.23%	16.79%	100.00%
Direct Intervention in Society	5.68%	11.36%	57.95%	25.00%	100.00%
Dissemination of Information to Society	7.79%	15.58%	49.35%	27.27%	100.00%
Supply Network Participation	2.63%	39.47%	34.21%	23.68%	100.00%
Impact Studies Development	0.00%	31.25%	62.50%	6.25%	100.00%
Total Geral	5.34%	17.13%	56.18%	21.35%	100.00%

* G1 to G4 refer to groups of institutions defined by budgetary expenses in ascending order (detailed in the method).
Source: Elaborated by the authors.

4.3 What developments do these relationships lead to?

Based on data, there is a significant trend identified, which should be expanded with the census of Federal Universities Practices. Therefore, the preliminary results make it possible to propose an initial model, configured from the following perspective of analysis: what led to the implementation of these practices by the Higher Education Federal System?

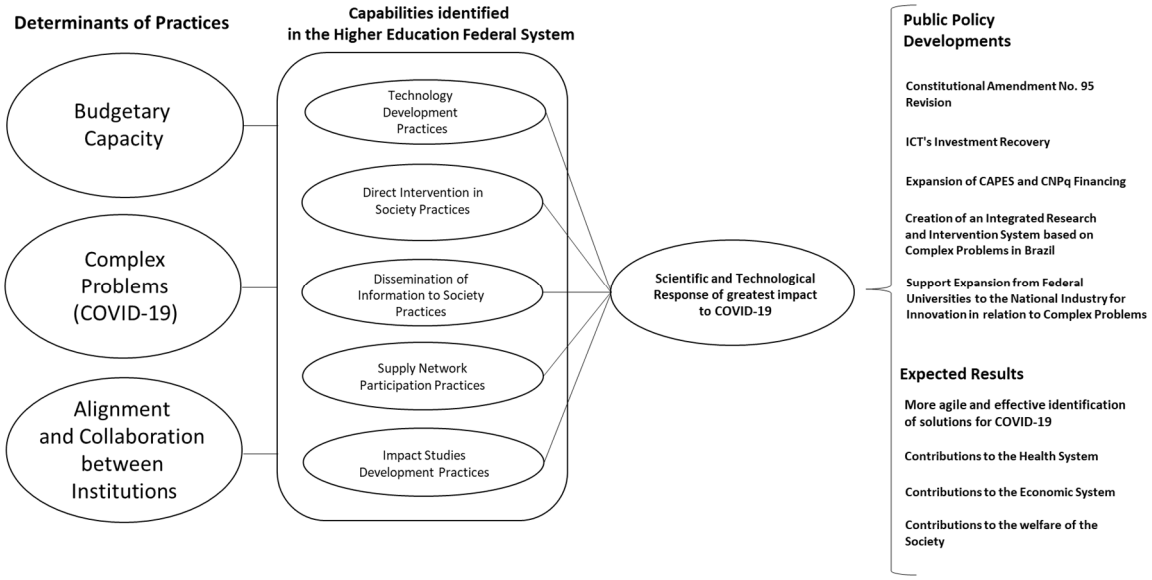
There are three relevant external factors, or determinants: the first determinant was the need generated by COVID-19 – a complex problem that requires new knowledge –, since the responses to the new disease are not yet available. The second determinant observed was alignment and collaboration between institutions; according to a note from Andifes, this was a nationally recognized problem that had the coalition of several agents. It may also be mentioned that the volume of resources executed is critical considering the extent of practices identified. The third determinant points out that the greater the volume of public resources invested, the greater the capacity for scientific and technological response to COVID-19. In addition to the budget, it is necessary to create a network of institutions aimed at solving a common problem.

The relationships observed and proposed in this model, expressed in Figure 2, lead to the unfolding of public policies that interfere in these three determinants: in relation to budgetary capacity, there is a need to revise Constitutional Amendment No. 95, to recover investments in STI and expanding CAPES and CNPq funding.

Regarding the determinant of complex problems orientation, currently, a greater allocation of financial and human resources is observed for structuring practices to combat COVID-19 in federal universities. Thus, the creation of an Integrated Research and Intervention System aimed at other complex and systemic problems in Brazil is also a possible future development. Of the total practices identified in this sample and time frame, 64.93% are oriented towards technology development and direct intervention in society. Although depending on fluctuations, this percentage shows an important orientation related to the potentialities and responsiveness to complex problems in an active way. It was also found that it is vital the alignment and collaboration between institutions that lead to the expansion of support from federal universities to the national industry for innovation, especially in relation to complex problems that need integrated responses and solutions, such as the pandemic.

Due to the identified practices nature, it is expected that they result in more agile and effective identification of systemic solutions for COVID-19, contributing to the health system, the economic system and the well-being of society. Therefore, building a new perception of the federal university is pointed out as fundamental. The perception of an important institution not only in developing moments, but also in constituting a support and base network for overcoming crises and moments of uncertainty and turbulence. Thus, the results of this study show that the budget cuts suffered by federal universities represent a threat to the solution of complex problems that may affect Brazilian society.

FIGURE 2 STRUCTURE OF PRACTICES TO COMBAT COVID-19 FOR THE HIGHER EDUCATION FEDERAL SYSTEM



Source: Elaborated by the authors.

5. CONCLUSION

Increasingly, investments in Higher Education and in Science, Technology and Innovation are necessary to solve complex problems, such as those triggered by COVID-19. These demand integration of knowledge between different areas such as health, engineering, sociology and economics, and the articulation of different actors. The investments made in the last 16 years in national labor formation for STI, as well as the expansion of the staff of researchers and postgraduate programs contributed significantly to expand the responsiveness of the Higher Education Federal System in building solutions in different areas to combat the impacts of COVID-19 in Brazil.

One of the main results observed in the study is identifying a direct relationship between the Universities that received greater public investment and their degree of response in terms of technological development projects, direct intervention, and dissemination of knowledge to society, purchasing, production and distribution network of inputs and supplies, and knowledge production for impact studies. These findings, however, do not represent an argument and a simple solution that only investment "per se" is a predictor of responsiveness; in other words, that just increasing investment represents a direct increase in the response capacity. As discussed in the model, in addition to the budgetary capacity to manage investments received, orientating these resources around complex problems, by creating prioritization and focus, are equally important. In addition, it is necessary to note that there are practices adopted by Universities that depend on the collaboration of resources between the Institutions. Therefore, the point presented in the analysis is not about the individual budget of each institution, but the capability of the Higher Education Federal System as a whole.

And regarding this capability, it is highlighted the structural impacts of Constitutional Amendment No. 95, urging the investment recovery in STI institutions and in the expansion of CAPES and CNPq.

Thus, the Federal University, through the Higher Education Federal System, which has historically been charged for the return on investment made by Brazilian society, demonstrated, based on the results obtained, that it has the capacity to provide institutionalized, organized and integrated responses with different research institutions from Brazil and the World and oriented to their local and regional community, based on these determinants and in the analyzed categories.

The COVID-19 pandemic, due to its high degree of diffusion, spread rapidly across the country, promoting transformations in the social field, in health and in the economy. Hence, the results show that the Higher Education Federal System is being important for building solutions in the most different fields, mitigating the effects of this crisis. In addition, these practices can leave a future legacy regarding the institutionalization of preventive actions to solve new complex problems.

In addition, this study contributes with a methodology for comparing and evaluating the practices of Universities to combat COVID-19. Considering the dynamics of new actions created, future research is recommended, analyzing the implementation capacity based on these categories, as well as identifying new relationships, such as dimensions of governance and relationship with society. We also recommend future studies expanding the sample, analyzing practices in addition to those linked to institutional media, and analyzing implementation from the spending lines at Universities.

Finally, considering the systemic need for wide implementation of practices aimed at the development of technologies, direct interventions in society based on STI and dissemination of information that act on the behavior of individuals, it is necessary to consider the Higher Education Federal System, including scientists and researchers, as a strategic asset for Brazil.

REFERENCES

Alves, C. G. M. F., & Oliveira, M. A. (2014). Análise do investimento e produção em C&T no Brasil entre 2002 e 2010. *Revista Eletrônica de Ciência Administrativa*, *13*(2), 156-171.

Alves, C. G. M. F., & Oliveira, M. A. (2018). Análise de eficiência em ciência e tecnologia das universidades públicas e institutos federais localizados no Estado do Rio de Janeiro: um estudo pré-crise econômica de 2014. *Revista Economia & Gestão*, *18*(49), 46-66.

Anderson, R., Heesterbeek, H., Klinkenberg, D., & Hollingsworth, T. (2020). How will country-based mitigation measures influence the course of the COVID-19 epidemic? *The Lancet*, *395*(10228), 931-934.

Bassi, C. M. (2018, August). *Implicações dos Novos Regimes Fiscais no Financiamento da Educação Pública* (Texto para discussão, 2407). Brasília, DF: Ipea. Retrieved from https://www.ipea.gov.br/portal/images/stories/PDFs/TDs/td_2407.pdf

Bastos, E. M. C. (1997). O sistema brasileiro de C&T e o novo paradigma de desenvolvimento econômico. *Revista de Administração Pública*, *31*(3), 116-132.

Controladoria Geral da União. (2020). *Portal da Transparência do Governo Federal*. Brasília, DF: Autor. Retrieved from http://www.portaltransparencia.gov.br/

Lima, M. B. (2004). Proposta de avaliação dos impactos de investimentos em ciência e tecnologia a partir da abordagem do desenvolvimento sustentável. *Revista Alcance*, *11*(2), 295-313.

Marinho, A. (1998). O aporte de recursos públicos para as instituições federais de ensino superior. *Revista de Administração Pública*, *32*(4), 83-93.

Marini, M. J., & Silva, C. L. (2011). Política de Ciência e Tecnologia e Desenvolvimento Nacional: reflexões sobre o plano de ação brasileiro. *Desenvolvimento em Questão*, *9*(17), 9-38.

Ministério da Ciência, Tecnologia, Inovações e Comunicações. (2016). Ministério da Ciência, Tecnologia, Inovações e Comunicações. *Estratégia Nacional de Ciência, Tecnologia e Inovação 2016-2022*. Brasília, DF: Autor. Retrieved from https://portal.insa.gov.br/images/documentos-oficiais/ENCTI-MCTIC-2016-2022.pdf

Ministério da Educação. (2009, October 30). *Relatório de Primeiro Ano - Programa de Apoio a Planos de Reestruturação e Expansão das Universidades Federais (Reuni)*. Brasília, DF: MEC/SESu/DIFES. Retrieved from http://portal.mec.gov.br/index.php?option=com_docman&view=download&alias=2069-reuni-relatorio-pdf&category_slug=dezembro-2009-pdf&Itemid=30192

Ministério da Educação. (2020). *Geocapes*. Brasília, DF: Author. Retrieved from https://geocapes.capes.gov.br/geocapes

Naqvi, A. (2020). COVID-19: Visualizing regional socioeconomic indicators for Europe. *International Institute for Applied Systems Analysis* (IIASA Report). Laxenburg, Austria: IIASA.

Ohayon, P., & Rosenberg, G. (2014). Análise dos indicadores de ciência, tecnologia e inovação no âmbito da Fundação Oswaldo Cruz (Fiocruz). *Revista do Serviço Público*, *65*(3), 297-319.

Peeri, N. C., Shrestha, N., Rahman, M. S., Zaki, R., Tan, Z., Bibi, S. … Haque, U. (2020, February 21). The SARS, MERS and novel coronavirus (COVID-19) epidemics, the newest and biggest global health threats: what lessons have we learned? *International Journal of Epidemiology*, *dyaa033*, 1-10. Retrieved from https://doi.org/10.1093/ije/dyaa033

Pelaez, V., Invernizzi, N., Fuck, M. P., Bagatolli, C., & Oliveira, M. R. (2017). A Volatilidade da Agenda de Políticas de C&T no Brasil. *Revista de Administração Pública*, *51*(5), 788-809.

Rodriguez-Morales, A. F., Gallego, V., Escalera-Antezana, J. P., Méndez, C. A., Zambrano, L. I., Franco-Paredes, C. ... Cimerman, S. (2020, May-June). COVID-19 in Latin America: the implications of the first confirmed case in Brazil. *Travel Medicine and Infectious Disease*, *35*, 101613. Retrieved from https://doi.org/10.1016/j.tmaid.2020.101613

Rossi, P.; Dweck, E. (2016). Impacts of the new fiscal regime on health and education. *Reports in Public Health*. *32*(12), e00194316. Retrieved from https://dx.doi.org/10.1590/0102-311x00194316

Rossi, P. & Mello, G. (2017, April). *Choque recessivo e a maior crise da história: a economia brasileira em marcha ré*. (Nota do Cecon, n. 1). Campinas, SP: UNICAMP.

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