

International scientific cooperation and SDGs

Contributions from the mapping of Brazilian science for
the identification of common agendas

Policy paper



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Policy paper



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1. Main recommendations of this *policy paper*:

- To amplify the efforts at national and international levels for the permanent financing of scientific research as part of the actions to achieve the Sustainable Development Goals (SDGs).
- To promote the systematic mapping of Brazilian scientific production, seeking to identify opportunities and gaps for investment in strategic themes for the country and the world.
- Both Brazilian science and innovation diplomacy can play a decisive role in promoting international scientific cooperation that converges, in terms of themes and actors, with the priorities of Brazilian science and foreign policy.
- Latin American scientific collaboration lacks specific incentives aimed at diversifying and intensifying scientific collaboration among the countries in the region.
- The public policies implemented in the country must be aligned with the national targets of the SDGs and based on the promotion of knowledge and national scientific progress.
- There is a need to strengthen a set of instruments (policy mix) to support targeted and untargeted research, especially those conducted in interdisciplinary and multi-institutional collaborations.
- To ensure that scientific cooperation also embraces the historical and social dimensions of the countries, thereby promoting research in the humanities, social sciences, linguistics, letters and arts.

Keywords:

International scientific cooperation. Conceptual mapping. Sustainable Development Goals (SDG). Science.

2. Introduction

International scientific collaboration and sustainable development

Research, scientific development and technological innovation are key aspects for achieving the Sustainable Development Goals (SDGs) (ONU, 2015a) and the Agenda 2030 (ONU, 2015b). Following this common agenda and fulfilling international commitments around it still require greater efforts and initiatives at various levels. At an international level, interdisciplinary scientific cooperation has had a positive impact in the progress of knowledge on complex issues such as climate change or food production, as

well as promoting interaction among scientists and researchers over the world towards a positive agenda with robust and creative strategies to overcome societal challenges and historical debts. Figure 1 below illustrates not only the complementary and inseparability of the SDGs, but also their backbone: the constant search for partnerships to build a cooperation around this ambitious agenda.



Figure 1 - The Structure of the Sustainable Development Goals (SDGs)

Source: United Nations (UN).

At a national level, the established targets and their indicators are the concrete expression of the specific challenges of each country regarding the Sustainable Development Goals. According to the Center for Research on Science, Technology and Society (Ipea in Portuguese), the Brazilian targets for each of the SDGs were defined considering six main assumptions: i) adherence to global targets; ii) objectivity; iv) respect for national and international commitments; v) coherence with national plans; and vi) observance of regional, social, and identity inequalities. Thus, it is legitimate for the national targets of the SDGs to be considered strategic guidelines for initiatives, such as calls for proposals to promote research and planning, monitoring, and evaluation of public policies, as in fact has already been happening in Brazil and worldwide.

When reflecting on technical and scientific knowledge aspects necessary to achieve the SDGs, it is easily noticeable that a significant part requires simultaneous international efforts, as they indistinctly concern all countries around the globe. Therefore, several areas of knowledge related, for example, to biosphere issues (SDG 12, 13, 14), often require the sharing of research infrastructure and large international multidisciplinary teams given the complexity of the issues and researched objects. Sharing research infrastructure has been as important element of international scientific cooperation and one of the pillars of the science and technology internationalization process

globally for several decades.

In addition to the scientific and technological progress, the development of multilateral scientific collaboration on strategic global issues also has a crucial social and geopolitical impact. By performing as spaces for the dissemination and practice of the culture of peace and the strengthening of less asymmetrical partnerships, scientific research carried out in international cooperation contributes to the construction of the vision of future advocated by SDG 16 and 17. This is the case, for example, of the multilateral research in Antarctica that Brazil has taken part in for several decades, and of the large international telescopes around which large transnational scientific research networks have been established.

However, it is not only the large shared physical infrastructures that can serve as a prime arena for science cooperation and diplomacy. Indeed, scientific collaboration has a wide range of possibilities that can and should be fostered when connected to topics of common interest between different communities and countries. The mapping of themes and capabilities common to several countries in strategic subjects might be of great use in fostering and articulating international scientific cooperation around the 2030 Agenda and the Sustainable Development Goals.

3. The Science, Technology and Innovation Observatory and the monitoring of Brazil's international collaboration

The Science, Technology and Innovation Observatory (OCTI in Portuguese), a permanent activity of the Center for Strategic Studies and Management (CGEE), monitors the dynamics of Brazilian and international science, building overviews and indicators that can support research and decision-making by public and private agents. The OCTI also follows international research collaboration (IRC) themes in Brazil by analyzing indexed scientific production and competencies and qualifications of national researchers in all areas of knowledge.

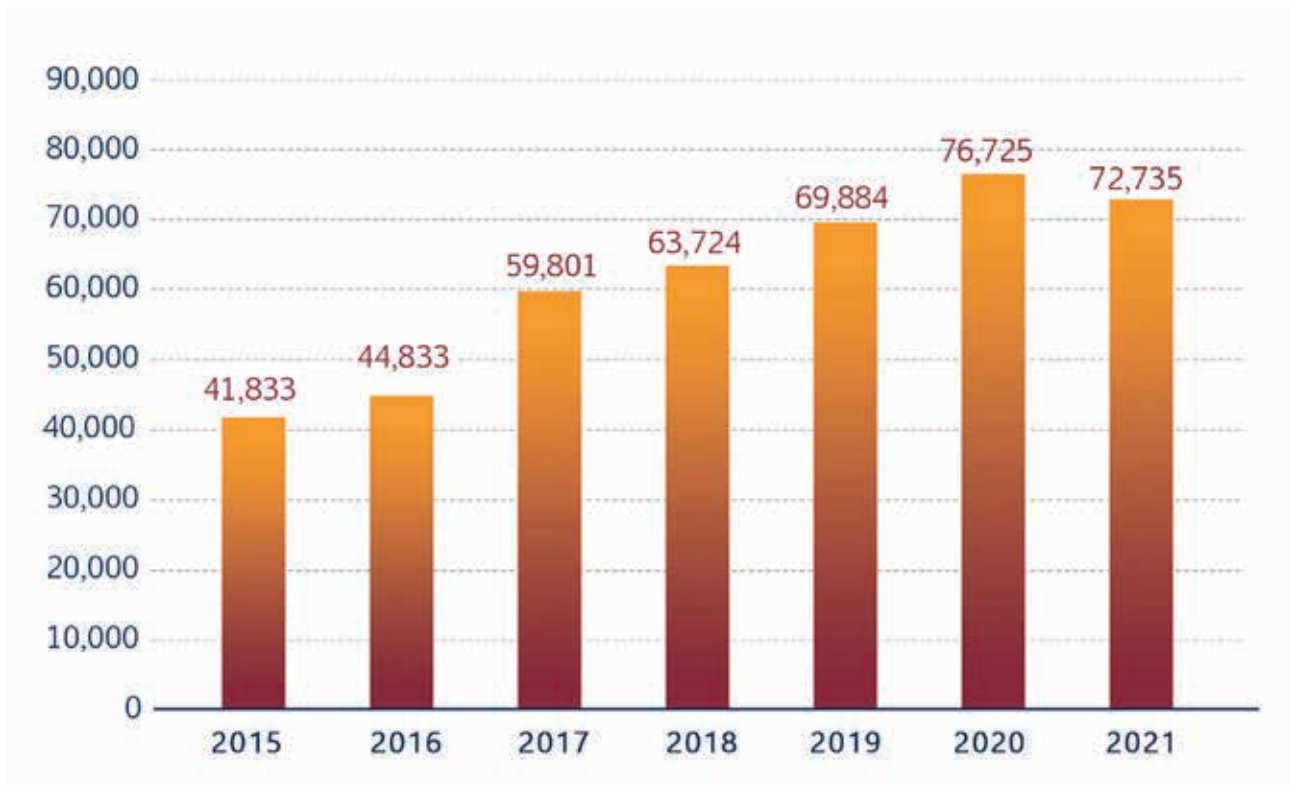
Co-authored publications between researchers from different countries are an indispensable indicator of international scientific cooperation and of the science internationalization process. Although there is variation in the average number of authors among the various fields of knowledge, the collectivization of scientific productions is a trend documented in the world literature¹. Therefore, monitoring the scientific production published in co-authorship with researchers from different countries is a strategic activity to analyze the internationalization of national research - including its preferred and emerging partners - as well as to identify thematic trends and

new opportunities for cooperation.

The OCTI Annual Bulletin 2021 (CGEE, 2022) presented an overview of the world scientific production indexed in the Web of Science (WoS) database and the presence and cooperation of authors linked to Brazilian institutions in this environment. In a simplified way, we will call "Brazilian papers", "Brazilian production" or "Brazilian authors" productions and authors that have, with at least one index among those responsible for the publications, affiliation to a Brazilian institution. The survey shows an absolute growth in the Brazilian production of papers, following the global trend. Graph 1 below illustrates this growth (CGEE, 2022).

¹ Several studies show the growth of co-authorship as a general norm in scientific productions, although social sciences and humanities (SSH) have a slightly distinct pattern. Regarding these trends, see, for example, Gingras (2016).

Graph 1 - Number of Brazilian scientific papers indexed in the *Web of Science* (WoS) per year, 2015 to 2021

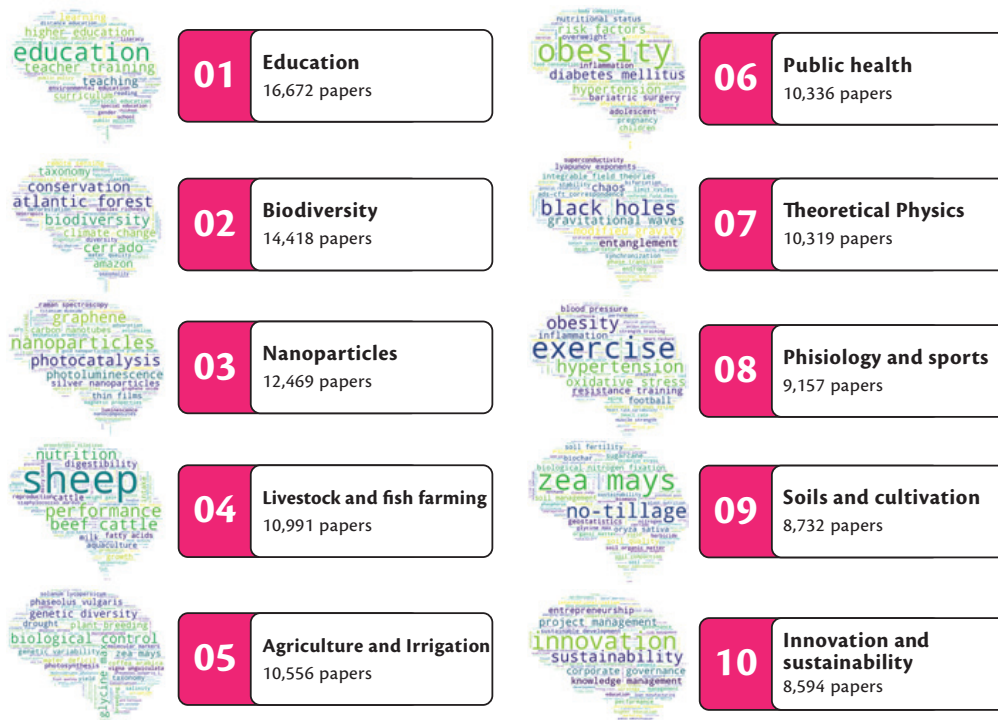


Source: *Web of Science* (WoS, 2020).
Data extracted on: Feb 22, 2022. Created by the authors.

The Bulletin shows that among the most frequent international co-authorship from the Brazilian point of view, the United States is in first place. Then, there is often a Brazilian presence in papers co-written with researchers from England, Spain, Germany, France, Italy, Canada, Australia, Portugal, and China. These co-authorship can be the result of an occasional bilateral cooperation between a researcher in Brazil and a peer located in a foreign institution. Co-authorship can also result from transnational research networks of which several countries are part simultaneously.

Also, the OCTI identifies the most frequent research topics and objects by monitoring national and international research. This comparative analysis indicates differences and particularities of the themes studied by researchers exclusively from Brazilian institutions and by researchers from multiple countries. Figure 2 below shows the most frequent themes in papers by Brazilian researchers in the WoS, regardless of national or international co-authorship.

Figure 2 - Top 10 clusters of the Brazilian scientific production network, according to the number of papers, from 2015 to 2020

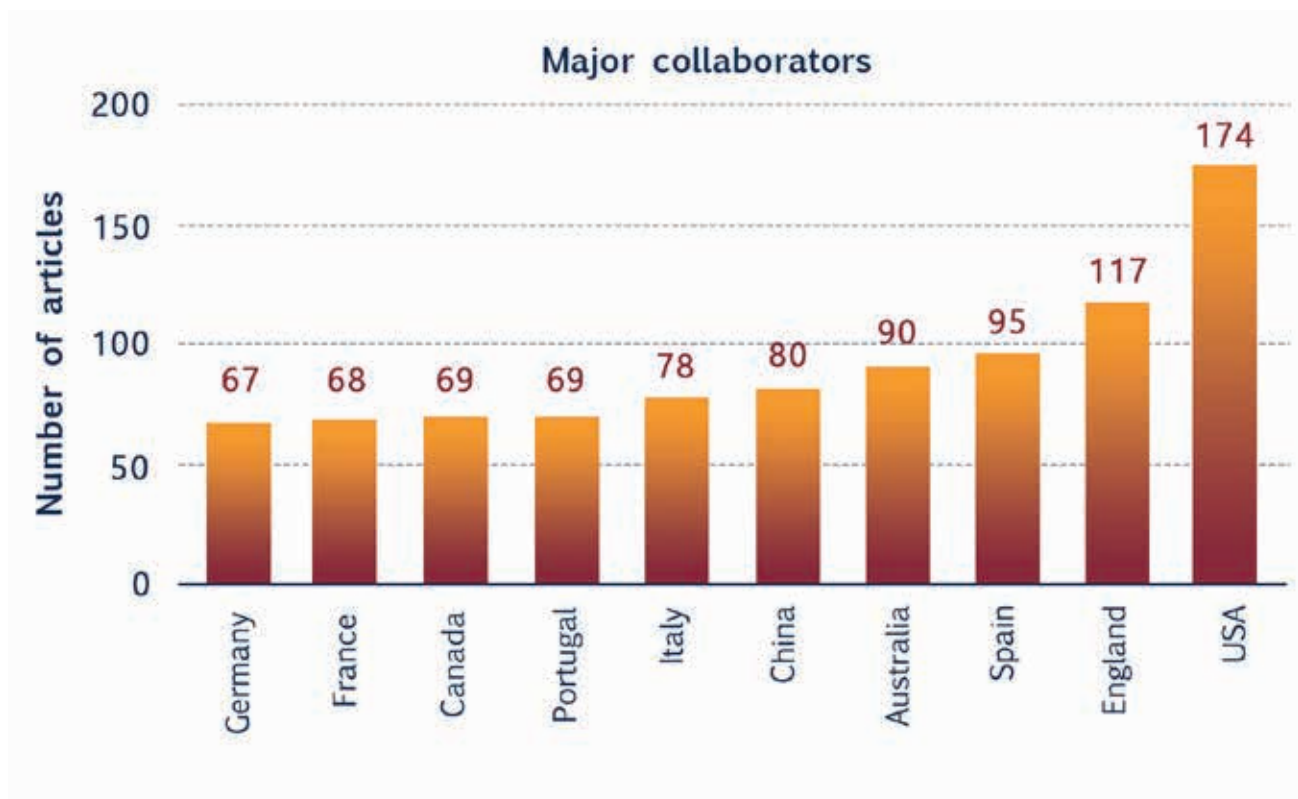


Source: WoS (2020).

In addition to the production in research areas where Brazil traditionally stands out, such as agriculture, dentistry, physics and microscopy, Figure 2 shows the relevance of Brazilian scientific production in areas related to major national and global challenges in science, technology and innovation, such as environment, education and health. OCTI publications (CGEE, 2021; 2022) also show that the largest specializations of Brazilian science, when compared to the world, are concentrated in parasitic diseases, tropical medicine, and dentistry. Specialization in areas such as geography, linguistics, educational research, information science, and library science are relatively high, despite the small relative coverage of these areas in the *Web of Science*.

Public Health is a very frequent research theme in scientific productions in international collaboration, which underlines its importance as a global societal challenge, particularly in SDG 3 and respective Brazilian targets. However, aside from fundamental social aspect related to Public Health, it also has a large technological innovation component, with emphasis on biomedical research. Among the countries with which Brazil collaborates the most in scientific production related to Public Health are, once again, the United States, followed by England, Spain, and Australia, as shown in Graph 2.

Graphic 2 - International collaborations on Public Health: *top* 10 most frequent partners in co-authorship with Brazil












Source: WoS. Created by the authors.

Note: The figures refer to the most frequent countries among the 14% of Brazilian articles most cited in 2018 and 2019.

Indeed, research in public health represents an important part of the world's scientific production, and its overall activity has grown crucially since the coronavirus pandemic and the global technological race around the development of vaccines and medication. According to the São Paulo Research Foundation (Fapesp in Portuguese), since the beginning of the pandemic, more than 500,000 studies on covid-related topics have been published. This volume represented 4% of all scientific production worldwide between 2020 and early 2022. This production boom

on coronavirus and other pandemic-related topics has affected "the balance of knowledge generation" worldwide, according to a recent study by the University of Manchester's Institute of Innovation Research (MARQUES, 2022). Also, according to the same study, the influence was not limited to the medical field: 6.4% of the scientific literature from Sociology and Law was on covid-19, in 2021. It is estimated that Brazil had 2.62% of its production related to the disease - the same level as Canada (2.68%) and Australia (2.56%).

Table 1 - Covid-19 in Brazilian journals

Journal	Area	%	Percentage of works on COVID-19
<i>Brazilian Journal of infectious Diseases</i>	Infectology	35%	
<i>Brazilian Journal of Public Administration</i>	Public policies and administration	33%	
<i>Clinics</i>	Medical and biomedical sciences	30%	
<i>Texto Livre Journal</i>	Interdisciplinary	29%	
<i>Work, Health and Education (TES)</i>	Education and Health	27%	
<i>São Paulo Medical Journal</i>	Health Sciences	27%	
<i>Brazilian Journal of Occupational Health</i>	Occupational health	25%	
<i>Brazilian Journalism Research</i>	Communication	25%	
<i>Brazilian Journal of Mother and Child Health</i>	Children's and women's health	24%	
<i>Journal of The Brazilian Medical Association</i>	Medicine	24%	

Source: Marques (2022).

0 25 50 75 100



















The importance of OCTI/CGEE's work goes beyond mapping the conjuncture experienced by the different fields of knowledge in the country and its interaction with what is developed in the rest of the world. In fact, one of the results of the Observatory's activity is the identification of themes that can be considered relevant and strategic in terms of scientific collaboration of Brazilian institutions with their counterparts abroad.

4. Identification of strategic themes in bilateral collaborations

The identification of relevant research topics to build strategic agendas for international cooperation is part of OCTI/CGEE's activities. Always pursuing scientific production on an international basis as reference, institutions and interested actors can benefit from a comparative analysis between two types of international collaboration: on one side, the themes identified in scientific productions arising from papers produced in bilateral collaboration (Brazil

and another country) and, on the other side, those produced in multilateral cooperation (several countries, including Brazil). Interesting differences can be identified in this comparison. To exemplify, we present the case analysis of productions that include Brazilian researchers and likewise from Spain, Canada, and Colombia. Table 2 below summarizes the data gathered regarding these co-authorship.

Table 2
Brazil's co-authorship with Spain, Canada and Colombia

Brazil +	BR + Spain	BR + Canada	BR + Colombia
Total number of papers with international research collaboration (IRC)	18,580 	12,803 	6,800 
IRC papers with less than 10 countries	13,887 	10,056 	4,208 
Bilateral IRC papers cooperation	6,614 	4,872 	1,961 
% bilateral	36% 	38% 	29% 
Bilateral / (IRC <10)	48% 	48% 	47% 
(IRC <10) / total IRC	75% 	79% 	62% 

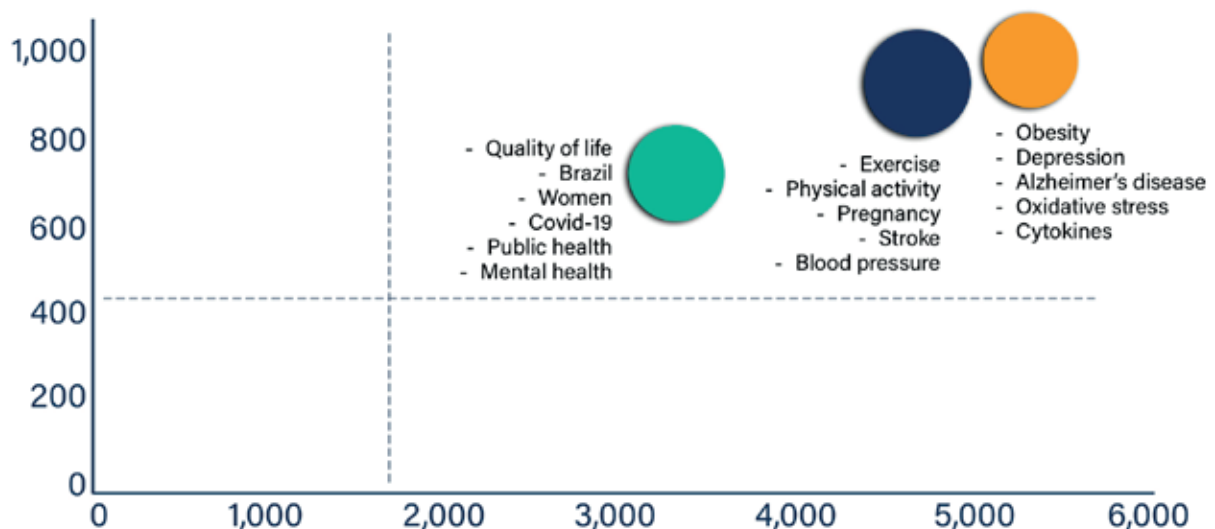
Source: WoS. Created by CGEE.

Table 2 indicates that in the three cases analyzed - Brazil's relations with Spain, Canada and Colombia - co-authorship in papers with several countries is much more frequent than co-authorship in bilateral papers. This indicates that most of the identified co-authorship comes from multinational networks and not from specific cooperation between institutions within two countries. This information is a fact to be taken into account for an analysis of consolidated and emerging themes, since, in collaborations with many authors, there is usually great heterogeneity in the engagement and participation of each of them. Thus, the investigation of bilateral research topics may have more to offer as a collaboration

potential than the analysis of topics coming from multinational scientific productions with several authors whose actual engagement are not possible to measure.

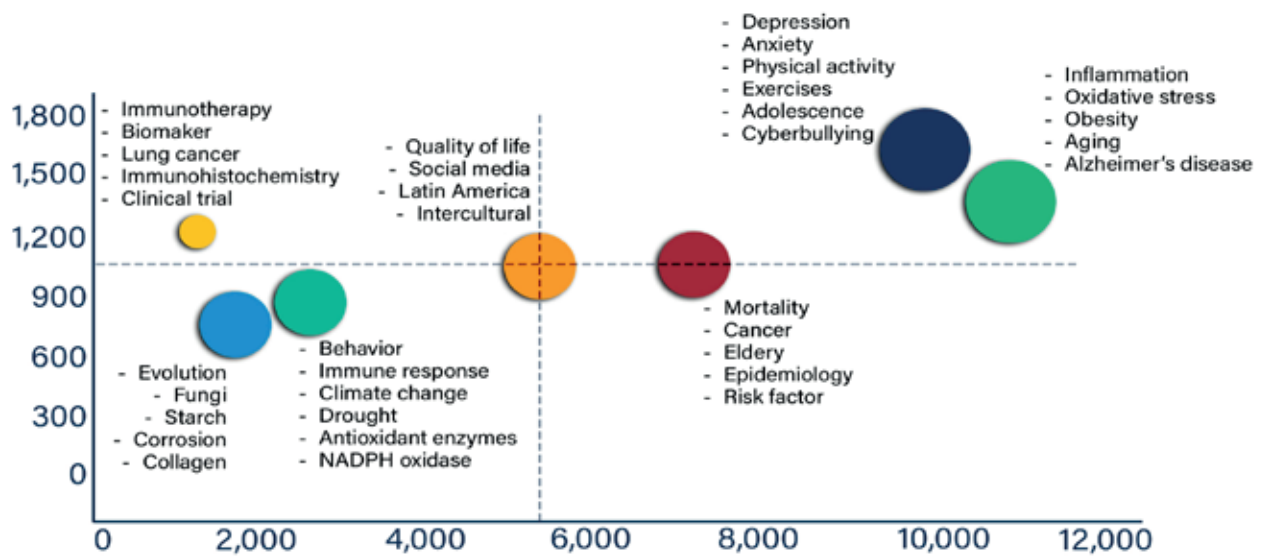
Following the OCTI methodology for this policy paper, we explored the scientific production from Brazil in collaboration with three different countries: Colombia, Spain and Canada. For each set of coauthored papers, the themes were gathered in thematic clusters – created by semantic similarity algorithms – and distributed in **strategic diagrams**, in which, to the right, in the upper quadrant, there are clusters with more central themes and above those with greater

Diagram 1 - Distribution of the main thematic clusters of the bilateral scientific production Brazil - Canada



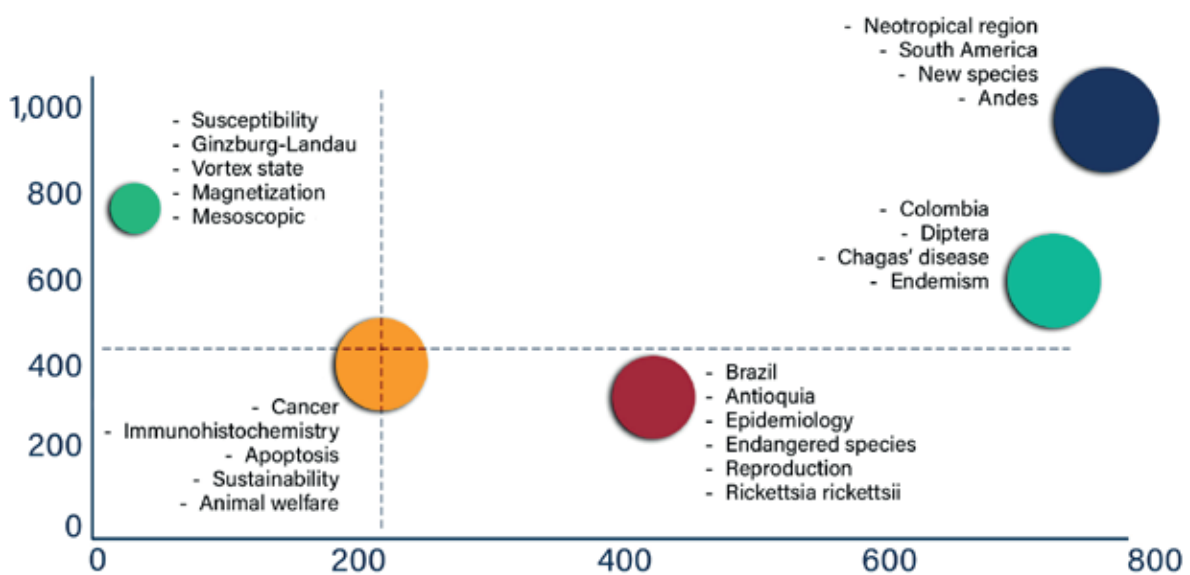
Source: WoS. Created by CGEE.

Diagram 2 - Distribution of the main clusters of the bilateral scientific production
Brazil - Spain



Source: WoS. Created by CGEE.

Diagram 3 - Distribution of the main clusters of the bilateral scientific production
Brazil - Colombia



Source: WoS. Created by CGEE.

recurrence². Thus, from this distribution, one can identify both recurrent and consolidated research themes (placed in the upper right quadrant), as well as niche themes (upper left quadrant) of each set of scientific productions published in co-authorship between Brazil and its partner. The simple visualization of the distribution of clusters by quadrants in the three diagrams (Brazil/Colombia; Brazil/Spain; Brazil/Canada) already suggests differences in the bilateral dynamics analyzed.

As started earlier, the clusters located farthest to the right and highest on the diagrams are considered consolidated themes. This means that these are themes that frequently appear in the

analyzed publications and are usually studied by several researchers over time. Therefore, they are areas of consolidated cooperation. This is the case of health scientific production, an outcome of the cooperation between Brazil and Canada (Diagram 1). There is a consolidation of several Mental Health and Neuroscience topics, including Alzheimer's disease and depression. There are also health studies apart from the biomedical field, such as physical exercises and obesity. Certainly, the studies on covid, that were multiplied in recent years, are in the center of the diagram indicating its emerging centrality.

In fact, Canadian biomedical research and neuroscience or brain-related

Figure 3 - Word cloud of bilateral scientific production Brazil and Canada



Source: WoS. Created by CGEE.

² The construction of these diagrams and the use of the main metrics were inspired by Cobo *et al.* (2011, p. 146-166).

and epidemiology are noticeable. In fact, health research contributions reinforce a picture of relevance that interfaces with several SDGs, ranging from ending hunger to the need for environmental preservation. In addition to that, the increased interest in mobile medicine research, via cell phone devices, has opened new horizons for this research field in the world.

Also, research in collaboration with Brazil and Spain presents a set of approaches on deep learning, quantum computing, and microplastics. These issues signal challenging scenarios for the future, with the potential to fill the gap between the most innovate industrial scales and Latin American countries and their ability to break the pollution trails on the planet.

As possibly emerging themes, research on climate change and drought emerge as significant topics, showing a collaboration expansion between the two countries for studies on ecosystems and environmental risks. Moreover, the area of food sciences, the eighth largest area with bilateral production between the two countries, has expanded collaborative productions, focusing on research on bioaccessibility and functional foods. This thematic set has a notable interface with SDG 2, Zero Hunger and Sustainable Agriculture. The ability to produce food with higher nutritional value and its assessment for food security are essential tools to meet

this challenge.

While Spain and Canada, both member countries of the Organization for Economic Cooperation and Development (OECD), have high economic and social indicators, Colombia's situation is different. Brazil and its South American neighbor share the structural challenge of promoting scientific research and development in very heterogeneous societies, from a social and cultural standpoint, and with recurrent economic constraints. Furthermore, both countries have a tropical climate and its particular diseases. It is therefore not surprising - among the consolidated themes presented in Diagram 3 - that it is possible to identify health studies that focus on Chagas' disease and dengue, tropical diseases that have been the focus of historical attention in both countries, which, naturally, is not the case in non-tropical countries.

It is possible to see from the word cloud in Figure 5 that the collaborative scientific production between Brazil and Colombia often addresses the Latin American context and Colombia itself. The research involves epidemiology, in the health field, and taxonomy, in the environmental sciences, and the presence of both is quite frequent. Research topics related to tropical or neotropical diseases, such as dengue and Chagas' disease, but also tuberculosis and the human immunodeficiency virus (HIV)

are also highlighted, suggesting a health cooperation anchored in regional climate and biodiversity. A possibly emerging theme identified in the publications is genetic improvement and environmental conservation.

Brazil and Colombia also share the challenge of housing the largest tropical forest on the planet and a significant part of isolated or recently-contacted indigenous populations. However, studies related to the ethnography of these peoples are not visible in the surveys that were carried out. Conversely, in the 2020 OCTI *Annual Bulletin 2020* (CGEE, 2021), it was highlighted that Brazil has

enormous importance in the international scientific production on biodiversity, but the most frequent collaborations do not occur with Amazonian countries such as Colombia, but with more economically developed countries with which we do not share biomes or climates. This is a strategic cooperation for the Amazon Region development and protection of the forests and “life on earth” itself, as stated in SDG 15. Furthermore, this type of international cooperation between countries for studying and protecting shared biomes presents the additional challenge of the protection and governance systems around data extraction, storage, and protection.

Figure 5 - Word cloud of bilateral scientific production Brazil and Colombia



Source: WoS. Created by CGEE.

Initiatives that promote shared and secure governance structures around strategic data are therefore desirable.



5. Conclusions

- The analysis of the scientific production indicates a huge potential for expanding bilateral and multilateral Brazilian scientific collaboration in consolidated and emerging themes of strategic interest for the countries involved, and also for the sustainable development global agenda.
- International scientific cooperation has an important role in the 2030 Agenda (UN, 2015b) and, in particular, for SDG 17 - Partnerships (UN, 2015a). This transversal and structuring objective to promote the partnerships and cooperation necessary for the implementation of the 16 other goals. Scientific diplomacy can create a great impact in advancing knowledge on different topics of the 2030 Agenda (UN, 2015b), and also offering solutions, either technological or not, for the acceleration and success of the SDGs.
- According to scientific diplomacy, science is an instrument and also a source of soft power and international insertion. Therefore, the promotion of international scientific collaboration should be the object of attention and support in terms of scientific and foreign policy. On the other hand, the industry also has its dynamism and competitive advantage anchored in investment in research and development, in the global technology race, and in the promotion of scientific-technical promises that push industries' investments and market value.
- From the Brazilian States standpoint, the weaknesses of health systems, evidenced by the coronavirus pandemic, must be addressed with a set of investments and restructuring of public policies based on evidence and scientific knowledge. The existence and availability of data and analyses validated by an autonomous and robust scientific community is a key factor in the success of these policies. International scientific cooperation can contribute to expand the scope of innovations, as long as it is built upon the sharing of data and knowledge among those involved.
- Scientific research occupies a central position regarding the efforts to build initiatives for sustainable development. Thus, not only the production of scientific knowledge can provide solutions and innovations to concrete challenges, it can also collaborate in monitoring and in the evaluation and comparison of the implementation of the SDGs from different national perspectives.
- The expansion of national scientific capabilities is paramount for scientific sovereignty. These studies should cover multiple subjects and strategic

themes and combine basic and applied science. As far as international research collaboration is concerned, strengthening already consolidated networks might be a first step, but expanding the actors and the research areas is also fundamental.

- To expand the availability of resources, at national and international levels, for the permanent funding of scientific research as part of: i) efforts to achieve sustainable development goals; and ii) as recognition and support of the constant progress of knowledge.
- The activities developed under or to support innovation diplomacy (CGEE, 2022) or scientific diplomacy should seek to contribute to and articulate around the sustainable development goals and common international commitments. It should also contribute to the international and national scientific efforts from the particularities of national innovation systems, taking advantage of networks (of researchers and institutions) consolidated and under construction.
- The expansion of the infrastructures of major international scientific cooperation projects should be the subject of multilateral commitment, aiming at knowledge advance and constructive, peaceful and equitable interactions, in line with the values present in the 2030 Agenda (UN, 2015b).
- To incorporate the international promotion of Brazilian research in the humanities and social sciences into the goals of science and innovation diplomacy programs. In other words, ensuring that the expansion of bilateral or multilateral scientific cooperation embraces all areas of knowledge, including the historical and social dimensions of scientific and technological development.
- The mapping and monitoring of Brazil's insertion, in terms of its international research collaboration, can be useful to Brazilian science and innovation diplomacy in its task of promoting global cooperation among actors in innovation ecosystems, identifying opportunities and trends in the international scientific production.
- In line with SDG 17 (UN, 2015a), scientific cooperation and international scientific diplomacy actions should contribute to the "exchange of data and human capital, taking a systemic look at territories and exponential perception of global cooperation."
- Brazil's pattern of international scientific collaboration demonstrates the need for stimulating Latin American collaboration in response to Target 17.6, which includes improving regional cooperation and "access to science, technology and innovation, and enhance knowledge sharing on mutually agreed terms".

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Acronyms and abbreviations found in this publication

CGEE | Center for Strategic Studies and Management (Centro de Gestão e Estudos Estratégicos)

HIV | Human Immunodeficiency Virus

Ipea | Center for Research on Science, Technology and Society (Instituto de Pesquisa Econômica Aplicada)

OCDE | Economic Cooperation and Development Organization (Organização para a Cooperação e Desenvolvimento Econômico)

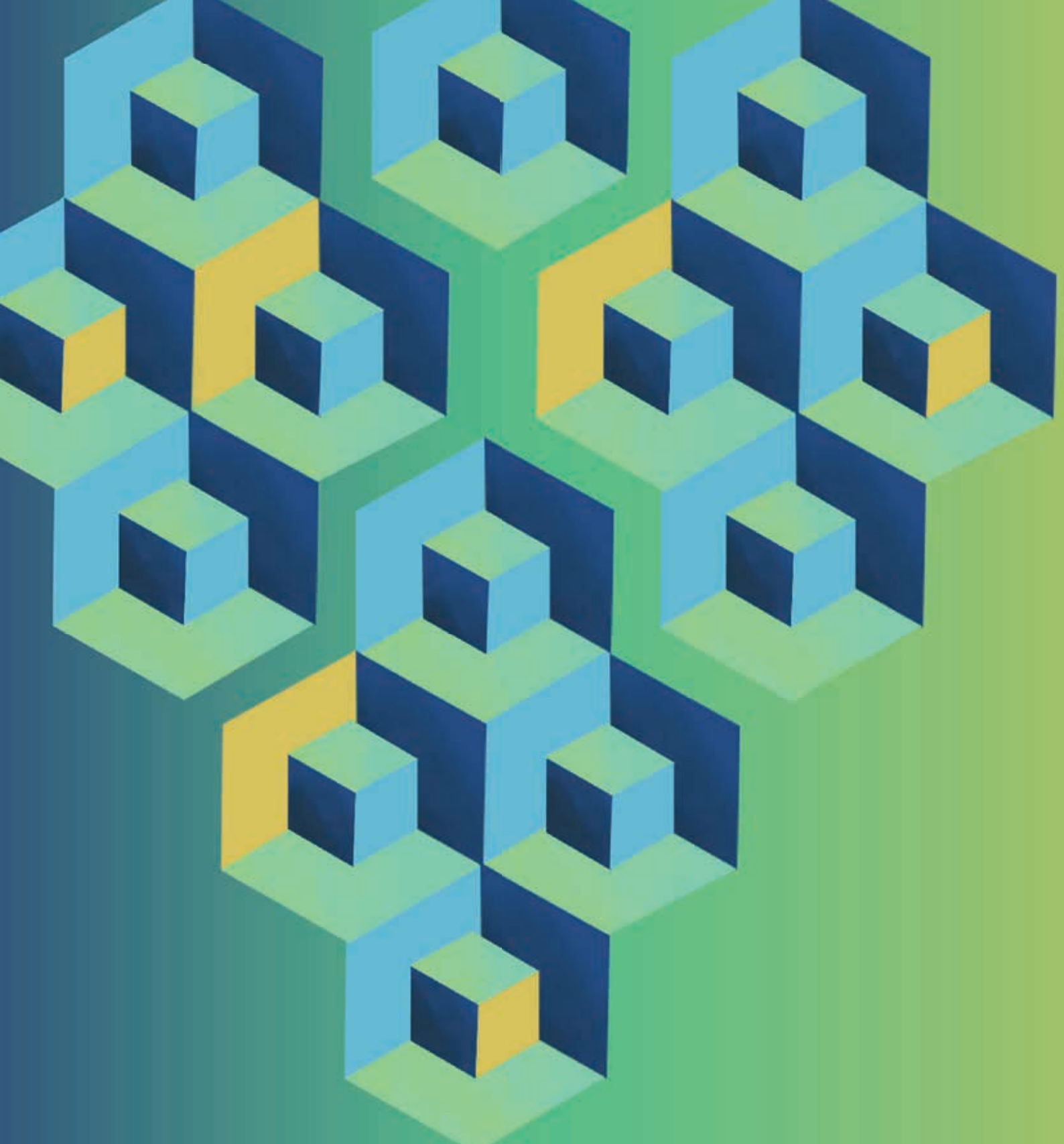
OCTI | Science, Technology and Innovation Observatory (Observatório de Ciência, Tecnologia e Inovação)

SDG | Sustainable Development Goals

UN | United Nations Organization

SCI | Science Citation Index

WoS | Web of Science



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