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LATIN AMERICAN PROFILES OF PUBLIC POLICY INSTRUMENTS IN RESEARCH AND INNOVATION AND THE ROLE OF THE SDGs

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FOLEC
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1. INTRODUCTION

This paper sets out to perform a documentary analysis of the financial instruments for research and innovation available on the internet and offered in Latin American and Caribbean countries by state agencies at national level, and at state provincial level, in the case of Mexico and Brazil. The basic aim is to gain an overview of research and innovation orientations that are proposed as general public guidelines within the fields of science, technology and humanities in Latin America and The Caribbean. In response to global transitions on frameworks of understanding of the usefulness and use of research and innovation for the survival of the human species, a particular exploration is made of the orientation of these instruments to address what the UN by consensus has proposed as the 2030 SDGs. Many recommendations have already been made on the adoption of measures from all social and economic sectors to generate a collective transformation, and research and innovation are in the spotlight of different observers to identify possible orientations. This exercise seeks to find possible niches that are being generated as a result of governments' interest in at least generating some type of expectation regarding the promotion of more transformative and responsible research systems with the focus of analysis proposed by this text (Molas Gallart and Rafois, 2018; Panciroli et al., 2020.)

The work began by searching the websites of every national and provincial public agency involved in this type of activity: councils, ministries, agencies, funds, among others. We went from country to country, from the Rio Grande (on the border of Mexico and the United States) to Chilean and Argentine Patagonia. The data obtained is as follows:

Some 4070 calls for funding were found by 37 science and technology agencies in 10 Latin American and Caribbean countries, based on the information available on official websites from 2004 to June 2021. Table 1 specifies the distribution of agencies, countries and number of calls.

Table 1. Number of funding instruments by country and agency.

Country and Agency	No. Calls
Argentina*	**117**
Conicet	34
Mincyt	83
Brazil	**2743**
CNPq	501
FACEPE (Pernambuco)	9
Faespa (Paraná)	9
Fapdf (Distrito Federal)	16
Fapeal (ALAGOAS)	69
Fapeap (Amapa)	5
Fapeg (Goiás)	155
Fapema (Maranhão)	264
Fapemat (Mato Grosso)	34
Fapemig (Minas Gerais)	77
Fapepi (Piauí)	27
Fapergs (Rio Grande do Sul)	172
Faperj (Rio de Janeiro)	312
Fapes (Espírito Santo)	212

Fapesc (Santa Catarina)	145
Fapesp (São Paulo)	453
Fapesq (Paraíba)	19
Fapt (Tocantins)	3
Finep (Ministerio)	51
Funcap (Ceará)	109
Fundect (Mato Grosso do Sul)	101
Chile	**763**
Conicyt	763
Colombia	**385**
Minciencias	385
Costa Rica	**8**
Micitt	8
Mexico**	**343**
Coetcytjal (Jalisco)	182
Concytep (Puebla)	103
Concyteq (Querétaro)	3
Coqcyt (Quintana Roo)	4
Coscyt (Baja California)	1
Icti (Chiapas)	5
Icti (Michoacan)	45
Panama	**247**
Senacyt	247
Paraguay	**113**
Conacyt	113
Peru	**209**
Fondecyt	209
Uruguay	**42**
Anii	42
Grand total	**4970**

Source: Vélez Cuartas, G and Torres Arroyave, D (2021).

* Web Scarping was partially used for the information from Argentina, and for the rest, information was requested directly from CONICET.

** Conacyt, the main research investment agency in Mexico, was excluded from the study because it was not possible to access information on the internet or by direct request.

Ecuador, Bolivia, Venezuela, Honduras and El Salvador were excluded due to lack of information. International agencies and specific university funds play an important role in their research systems, making them different from traditional state funding models for STI development. Belize and The Guianas were left out of the scope of the study.

In considering the information recovered, two types of analysis were carried out. One for countries with complete national and state information, as was the case of Brazil, Argentina, Chile, Colombia, Uruguay, Panama, Paraguay, Peru and Costa Rica. For the cases of Brazil and Mexico an analysis was made of the state provincial agencies, excluding the major funding agencies CNPq, Finep and Conacyt, respectively, to give relevance to the subregional characteristics of the STI systems.

The volume of information requires computational processes in capture and analysis (Posada, 2019), accompanied by processes of rapid reading of documents to identify or mark two important characteristics for this study: the type of call or orientation of the instrument, that is, what type of activity it funds, and whether there is any type of explicit link with the SDGs in the areas proposed.

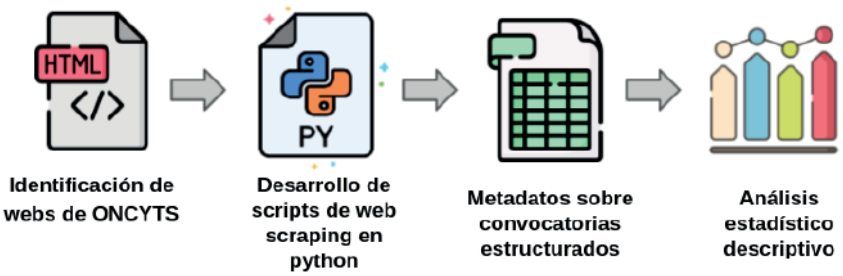
The methodology is divided into two stages. In the first stage information was gathered with an automated system known as web scraping. This type of methodology facilitates the generation of extensive surface information which makes it possible to map available information (Caballero et al., 2019.) The use of broader instruments than those offered by scientometrics is becoming a major trend in the public policy evaluation literature (Ráfols and Stirling, 2021.) Aside from the rankings and comparisons by volumes, the maps allow for a different orientation for decision-making. This orientation is based more on the decisions made over time and the possibilities they offer to a country or a group of scientific organizations, rather than finding, by default and due to lack of material, that the situation resembles another country or organization, or other types of background. Therefore, this is the tool chosen for gathering and structuring metadata from the existing research calls for funding on official webpages of Latin American research and innovation funding agencies.

The second stage of the methodology is based on the distant reading (Caballero et al., 2019) of the funding instruments of different agencies. Distant reading identifies words or single grams, bigrams or duets and trigrams or trios of occurrences in the texts of the calls. In this respect, it is possible to recognize both call types and areas offered for funding. The classification by types was applied to all identified texts, and the identification of areas was done only considering the research and innovation calls for proposals focused on the SDGs. Below are the steps of the methodology applied.

2. STEPS OF THE TWO STAGES OF INFORMATION COLLECTION AND ANALYSIS

In stage 1, metadata from agencies' calls was gathered through a process of web scraping or automated extraction of information of the agencies' webpages. This process has four steps. The first is the identification of the agencies' webpages. This includes work to search official webpages using keywords on internet search engines, as well as consulting with experts from the countries in which there are problems in finding sites that contain agencies' calls. The second step is to develop scripts, one per agency, in Python language to automate the collection of information from existing calls on those webpages.

Figure 1. Stage 1: Automated gathering of metadata of agencies' calls.



Identification of webpages of ONCYTS (National Organizations on Science and Technology)
Development of web scraping scripts in Python
Structured calls for funding metadata
Descriptive statistical analysis
Source: Compiled by author.

The third step is structuring and cleaning the metadata, placing it in a dataset of all calls within the science system. The fourth and last step of this first stage is the descriptive analysis of the metadata identified where the texts are marked by type of activity funded according to the goals or objectives of each one (see Figure 1.) Table 2 shows the distribution of calls and activities targeted by the funding:

Table 2. Number of calls by type.

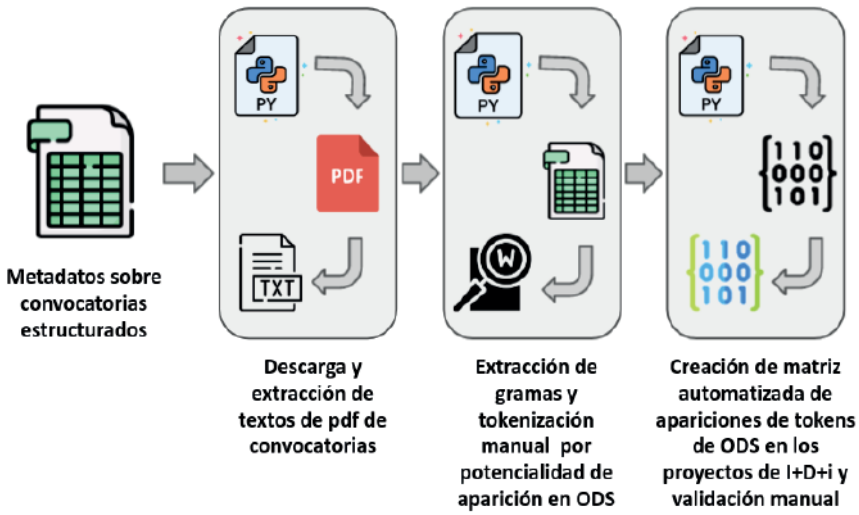
Type	Number
Research-Innovation	2632
Training	1055
Subsidies	756
Events	212
Scientific outreach	185
Indices-Evaluation	68
Competition-Prize	62
Grand total	**4970**

Source: Vélez Cuartas, G and Torres Arroyave, D. (2021)

It is important to note that the categories were constructed based on the information found in the goals and objectives of the calls and was proposed as a strategy for grouping together the texts gathered. The heuristic criterion was empirical and derived from the information obtained. Below is a general description of the computational process used.

In stage 2, an analysis was made of content or distant reading of the research and innovation calls of the agencies. This has three steps. Only the research and innovation calls were chosen, considering the need to observe territorial and thematic orientations of research and not instruments of training and support for activities, but direct funding of research activities, programs and projects. The first step was the extraction of the text available in the research and innovation calls: from the dataset of the metadata taken in stage 1, research and innovation projects were filtered with a Python script. All the PDFs were downloaded into differentiated folders of the projects for their subsequent extraction from the text in files with text (txt.) format.

Figure 2. Stage 2: Process of distant reading of agencies' research and innovation calls.



Structured calls for funding metadata
Download and extraction of pdf texts of calls
Manual extraction of grams and tokenization by potentiality of appearance in SDGs
Creation of automated matrix of appearances of SDG tokens in R+D+I projects and manual validation
Source: Compiled by author

In the second step the text (txt.) files from the research and innovation projects were taken as entry and the grams (individual words in the texts) of four or more letters were extracted, excluding punctuation marks, numbers and special characters such as accents, diereses, commas, etc. Then the grams were classified considering the words and concepts present in the 17 SDGs, both in Spanish and in Portuguese. In the third step, these grams were taken as marks that permitted the search for these in the texts and were put into a matrix that contains 34 columns (2 per SDG): in the first, the number of marks or words occurring related to each SDG was assigned; the second column features the targets where said SDG occurred in the call analyzed (see table 3.)

Table 3. Example of classification matrix for the calls for funding according to their relation to SDGs

ID call	Name SDG 1	Goal SDG 1	Name SDG 2	Goal SDG 2	... SDG 17
Text 1	15	1.1	0		...
Text 2	4	1.2	30	2.6	...

Source: Compiled by author.

The analytical method made it possible to find the relationship between a given text and the areas covered by the 17 SDGs and their respective targets, as well as making it possible to find the relationship between different SDGs in a single call and the difference between occurrences that can be expressed as relevance of each SDG in the calls analyzed. The data from this research is open and is organized into two datasets available at zenodo.org:

- Calls of Ministries or Departments of Science, Technology and Innovation of Latin America—Dataset: https://zenodo.org/record/5236557
- Calls of science, technology and research—Latam—Text: https://zenodo.org/record/5236557

Limits of the methodology

The methodology uses exclusively computational methods to capture the information available on the internet. There was no verification with government agencies on the existence of other documents or instruments available and published off the internet. Nor was any verification made of the completeness of the information available on the webpage, and there is a possibility that additional documents or instruments could have been obtained through physical files available in state offices. The webpages did not show any update policies, so part of the information could have been taken down from the platforms under the policies of the pertaining governmental organizations.

Although it is something that can be deduced from the methodology, it is important to stress that the volume of instruments of one country does not necessarily imply that a matching volume of resources is available for the calls analyzed. The elements identified as SDGs respond to an exploratory study of terms used and referring to concepts found in the SDGs. This does not necessarily imply that the instruments are intended to participate in a strategy oriented at the SDGs, only that there is correspondence between the SDGs and the areas cited in the calls. The mix of computational methods with visual observation methods may lead to errors in the cases considered or in the identification of the population; however, from a statistical perspective, the trend can compensate for the errors in specific cases.

Lastly, the various countries differ in their adoption of digital devices for management processes, not only in the form of the circulation of information issued, but also in curating the metadata to be able to capture the information, update policies, etc. So it is not enough to say that it was not possible to find information on these countries in the designed searches. It is likely that valuable information has been missed, as occurred with countries like Mexico where it was impossible to access CONACYT information, or

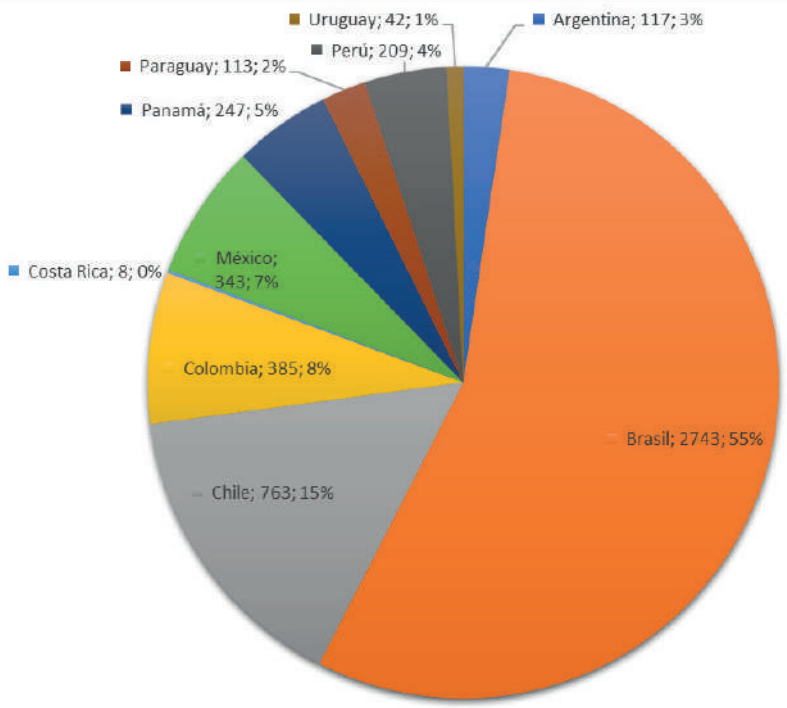
Costa Rica and Argentina, where it was necessary to complement the information with specific requests to agencies to send us the particular information from their calls.

3. RESULTS AND DISCUSSION

Public policy instruments for funding Research and Innovation in 37 Latin American Agencies

The number of instruments for funding research and innovation activities is conditioned by different factors. The size of the population can be directly related to the amount of money available for R&D investment, as evidently occurs in the case of Brazil, but in reality there does not seem to be a representative correlation between the place they occupy in investment in the countries in Latin America and the number of instruments available, as can be seen in Figure 3 and table 4.

Figure 3. Distribution of instruments found by country.



Source: Vélez Cuartas, G and Torres Arroyave, D (2021).

The number of instruments (calls in Figure 3) does not necessarily reflect the potential for national investment in R&D (table 4), for example, if we contrast the cases of Colombia, Chile and Argentina. However, the proportion of investment enables a comparison between STI funding structures. In this regard, the governments of Brazil, Argentina, Chile, Costa Rica and Paraguay invest more compared to other sectors in their countries, as observed in column 3 of table 4. Elsewhere, governments such as those of Uruguay and Colombia are below a third of their funding potential, which makes the scope of their instruments relative in defining the country's orientation, regardless of the number of instruments generated.

Table 4. Statistics on R&D expenditure by country in 2018.

Country	% No. Calls	% of GDP on R&D	Proportion of government investment	R&D Spending (US$ million)
Brazil	54.60%	1.16%	53.59%	21,878.83
Argentina	2.30%	0.50%	65.12%	2,594.45
Chile	15.20%	0.35%	48.09%	1,042.53
Colombia	7.70%	0.25%	27.05%	825.95
Peru	4.20%	0.13%	N/D	282.03
Uruguay	0.80%	0.42%	28.24%	249.5
Costa Rica	0.20%	0.39%	93.80%	231.85
Paraguay	2.20%	0.15%	72.74%	59.07
Panama	4.90%	N/D	N/D	N/D

Data: Ricyt:

http://app.ricyt.org/ui/v3/comparative.html?indicator=GASTOxPBI&start_year=2010&end_year=2019

However, in considering R&D investment figures and the weight of each country, it is possible to infer governmental concerns over the intensification of some types of activity conceived as necessary for the development of science and technology internally. From the information found, Brazil, Argentina and Uruguay allocate over 50% of their resources to funding research and innovation projects. Chile and Colombia are close to 50% but give priority not only to the training of new researchers but also to the divulgation of science to a greater extent. Colombia and Chile give greater priority than Brazil and Argentina to training instruments, but we must consider that the absolute weights in investment are much greater in Argentina and Brazil than in Chile and Colombia. It could be said that there is a greater effort in investment in these areas, although the money is much less. Peru generates a greater number of calls in research and innovation, but its budget is shared out among different types of activities. Panama and Paraguay give far greater priority to training instruments for new researchers. Costa Rica invests 100% in research and innovation instruments. It is important to consider that the information gathered from this country is based on the data provided by the MCTT and the data obtained, as with the data for Argentina, was sent directly by the funding agency offices.

Table 5. Proportion of calls by type of activity funded.

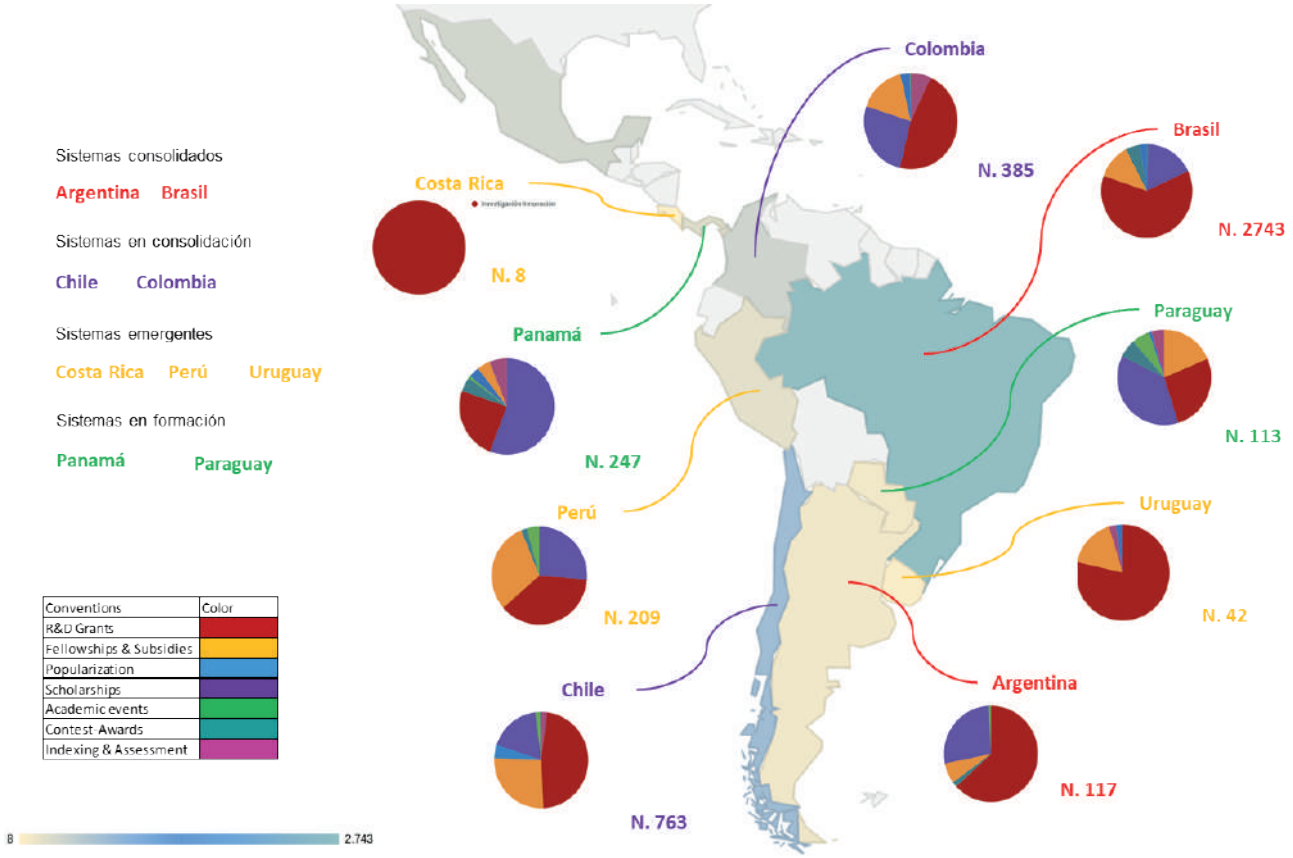
Country/Call	Total/relative proportion
Argentina	**2.53%**
Competition-Prize	1.71%
Events	0.85%
Training	27.35%
Research-Innovation	63.25%
Subsidies	6.84%
Brazil	**59.28%**
Competition-Prize	0.58%
Scientific outreach and dissemination	2.44%
Events	5.07%
Training	17.46%
Research-Innovation	62.16%
Subsidies	12.29%
Chile	**16.49%**
Competition-Prize	0.52%

Scientific outreach and dissemination	4.46%
Events	1.57%
Training	17.82%
Indices-Evaluation	1.97%
Research-Innovation	47.31%
Subsidies	26.34%
Colombia	**8.32%**
Scientific outreach and dissemination	3.38%
Events	0.26%
Training	26.23%
Indices-Evaluation	7.01%
Research-Innovation	46.75%
Subsidies	16.36%
Costa Rica	**0.17%**
Research-Innovation	100.00%
Panama	**5.34%**
Competition-Prize	4.86%
Scientific outreach and dissemination	3.64%
Events	0.81%
Training	55.87%
Indices-Evaluation	6.07%
Research-Innovation	24.29%
Subsidies	4.45%
Paraguay	**2.44%**
Competition-Prize	6.19%
Scientific outreach and dissemination	0.88%
Events	6.19%
Training	37.17%
Indices-Evaluation	4.42%
Research-Innovation	26.55%
Subsidies	18.58%
Peru	**4.52%**
Competition-Prize	1.91%
Events	4.31%
Training	26.32%
Research-Innovation	37.32%
Subsidies	30.14%
Uruguay	**0.91%**
Scientific outreach and dissemination	2.38%
Indices-Evaluation	2.38%
Research-Innovation	78.57%
Subsidies	16.67%
Total general	**100.00%**

Source: Vélez Cuartas, G and Torres Arroyave, D (2021)

A heuristic classification instrument that considers the weight of absolute funding and the number of types of instruments produces quite interesting analyses. See Figure 4.

Figure 4: Classification of research and innovation systems according to the proportion of instruments offered and the size of absolute R&D investment.



Source: Vélez Cuartas, G and Torres Arroyave, D. (2021). Data from RICYT: http://app.ricyt.org/ui/v3/comparative.html?indicator=GASTOxPBI&start_year=2010&end_year=2019

Consolidated systems
Argentina - Brazil
Systems in the process of consolidation
Chile - Colombia
Emerging systems
Costa Rica - Peru - Paraguay
Systems in the process of formation
Panama - Paraguay

Four types of systems can be identified: consolidated, in the process of consolidation, emerging and in the process of formation. Consolidated systems are oriented towards research and innovation activities as their action horizon. There is significant government investment to generate knowledge and a greater trickle-down capacity over the system of innovation products from an economic or social perspective. Brazil (1,724,419 documents in lens.org[1]; 0.008 documents per capita) and Argentina (268,291 documents

1 Lens.org contains information about the following databases:
Microsoft Academic - www.academic.microsoft.com
CrossRef - www.crossref.org
ORCID - www.orcid.org
PubMed - www.ncbi.nlm.nih.gov/pubmed
Impactstory - www.impactstory.org
CORE - www.core.ac.uk
European Patent Office (EPO) - www.epo.org
United States Patent and Trademark Office (USPTO) - www.uspto.gov
IP Australia - www.ipaustralia.gov.au
World Intellectual Property Organization (WIPO) - www.wipo.int
Only Microsoft Academic is considered the largest base in the world after the registers contained in Google Academic (Martín-Martín et al., 2021). For the region, Microsoft Academic already contains the publications of Redalyc and Scielo in its archives. For this study the totality of data available at Lens.org was considered, which includes information from the nineteenth century.

in lens.org; 0.0005 documents per capita) are those of greater investment in research in the region. Although the volumes of documents and calls produced are different, the size of the population and the economic proportions make it possible to speak of consolidated systems with capacities to contribute to the economy and solve social problems. It is important to note that although Argentina has a similar level of output of documents and similar population to Colombia, with a similar number of researchers, investment in research is three times that of Colombia, which would make it possible to generate greater capacities in STI. However, Argentina does not reach Brazilian levels as a more consolidated economy.

The systems in the process of consolidation allow us to observe the possibilities of a major generation of capacities. There is a variety of instruments to generate a stronger scientific culture based on incentives for scientific outreach and training. However, differences can be found: whereas Chile has a greater governmental participation in the design of these instruments, Colombia only funds a third of the research instruments through the government (as can be seen in table 4.) The results and differences are important from the point of view of distribution of R&D per capita and number of publications and citations globally. For example, Chile has 210,842 documents (0.01 documents per capita), while Colombia has 268,973 documents (0.005 documents per capita) (lens.org, September 2021; World Bank, https://datacommons.org/, September 2021.) Colombia and Chile follow similar paths in terms of number of instruments and close funding but the governmental orientation of these makes an important difference in terms of capacity for production of published scientific knowledge.

Costa Rica (40,771 documents in lens.org), Peru (63,196 in lens.org) and Uruguay (23,115 documents in lens.org) are at a very similar level of state investment, but their instruments seem diverse. They are endeavoring in different ways to generate a path towards the consolidation of their systems. While Uruguay invests most in research and innovation instruments, Peru diversifies and Costa Rica would appear to fully focus on the funding of projects. Of the three countries, Peru has the greatest diversification and shows a potential transition towards consolidation, which would mean a more effective investment focusing on diversification to generate a social and scientific critical mass in the generation of results.

Lastly, Panama (9,816 documents in lens.org) and Paraguay (4,405 documents in lens.org) are countries that are generating a greater number of instruments in research training according to their proportion of investment. This generates expectations of an increase in size of the national research and innovation systems in the coming years, with faster growth in Panama than in Paraguay.

According to Mazzucato (2018), and contravening to a large extent the principles of liberalization of investment in research proposed in the 1980s and 90s by linear R&D investment systems, which gave greater normative importance to private investment (for example, Freeman, 1995; Sagasti, 1981), the states with greater capacity for funding are capable of generating a major impact on production and generating enough trickle-down to be able to boost the market (Mazzucato, 2013) as a mission-oriented investment (Mazzucato and Penna, 2020.) In other words, governmental agencies in the consolidated countries in Latin America have made significant investments and—Mazzucato was correct in this regard—but it is yet to be proven that such investment has an impact both in social and economic terms; this gap is most likely generated by the lack of evaluation instruments oriented in this direction.

Public policy instruments for funding Research and Innovation in state agencies of Brazil and Mexico, excluding Federal agencies

The case of Brazil and Mexico is special because of the creation of state research agencies that also guide the system's expectations. This analysis has excluded the agencies CNPq and FINEP (of the Ministry) in Brazil and CONACYT in Mexico, focusing on the importance of provincial state agencies for the promotion of STI. Of the 2,734 calls found in Brazil, 2,191 occurred in the states, accounting for almost 80%. It was not possible to extract the proportion of calls of the national agencies in Mexico due to a lack of data. In total there were 2,534 calls between the states of Brazil and Mexico, which represents a reasonable total of 51% of the findings obtained through web scraping regarding the total number of calls from Latin America as a whole. Table 6 shows the distribution by agency and state of the calls found between 2004 and 2021.

Table 6. Distribution and number of calls by state in the Federal Republics of Brazil and Mexico.

Country/Agency/State	n
Brazil	**2191**
Fapesp (São Paulo)	453
Faperj (Rio de Janeiro)	312
Fapema (Maranhão)	264
Fapes (Espírito Santo)	212
Fapergs (Rio Grande do Sul)	172
Fapeg (Goiás)	155
Fapesc (Santa Catarina)	145
Funcap (Ceará)	109
Fundect (Mato Grosso do Sul)	101
Fapemig (Minas Gerais)	77
Fapeal (Alagoas)	69
Fapemat (Mato Grosso)	34
Fapepi (Piauí)	27
Fapesq (Paraíba)	19
Fapdf (Distrito Federal)	16
FACEPE (Pernambuco)	9
Faespa (Paraná)	9
Fapeap(Amapa)	5
Fapt (Tocantins)	3
Mexico	**343**
Coetcytjal (Jalisco)	182
Concytep (Puebla)	103
Icti (Michoacan)	45
Icti (Chiapas)	5
Coqcyt (Querétaro)	4
Concyteq (Quintana Roo)	3
Coscyt (Baja California)	1
General total	**2534**

Source: Vélez Cuartas, G and Torres Arroyave, D (2021).

On a more exact map of the types of call-funded activities, we can see that research and innovation are predominant in most of the states in Brazil, and the state of São Paulo almost equals in number CNPq calls, with the difference that it allocates its grants exclusively to research and innovation projects. In contrast, in Mexico, only the agencies of Jalisco and Puebla, which are relevant economies for the country (occupying 4th and 11th place respectively in national GDP contributions according to INEGI data in 2020[2]), have a large fraction of calls for research and innovation projects (See Figure 5.)

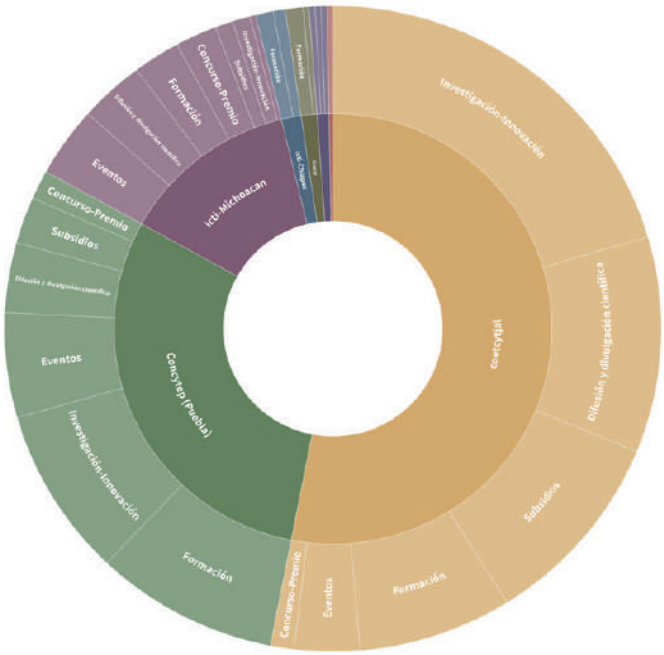
2 https://www.inegi.org.mx/app/tabulados/default.aspx?pr=17&vr=6&in=2&tp=20&wr=1&cno=2

Figure 5. Distribution of research funding instruments by activity type and state agency in Mexico and Brazil.

BRASIL

MÉXICO

*CONACYT está excluido por falta de acceso a la información.



Source: Vélez Cuartas, G and Torres Arroyave, D (2021).

*** CONACYT is excluded due to lack of access to information**

It is interesting to see that although the agencies with the highest number of calls belong to states that have a large proportion of GDP per capita of their respective countries, those with the greatest GDP do not necessarily have the most prolific agencies in research funding instruments. In Brazil, FAPESP plays a very important role in the internationalization of science and the generation of scientific resources for the country. A large part of its calls are made with international partners at an inter-institutional level. Rio de Janeiro has a longstanding tradition in research with its multiple centers and productive universities, but the agency that ranks next in number of calls is that of Maranhão, a state that is in 20th place in GDP per capita contributions in Brazil (Brazilian Institute of Geography and States IBGE, 2020.[3]). It is the same in Mexico, where the Jalisco agency appears as one of the strongest ahead of other states such as the State of Mexico, Mexico City and Monterrey, which have different dynamics and depend more on central resources than those generated by the states themselves. In any case, the state dynamic of the federal countries appears to be of great relevance when defining the orientation of investment in research and innovation activities in the countries.

Furthermore, some forms of state profiling reflect sociotechnical profiles and expectations generated in the science and innovation systems in these geographic areas. For example, a detailed review of calls taking only three examples reveals that in Brazil, the performance of the agency FAPESP, which has generated a state dynamic that connects local capacities, with the international potential of research, generating a very high expectation of internationalization. Of the 453 calls between 2006 and 2021 available on the internet, over half of these are made jointly with national, European and Latin American agencies. Their model of joint calls with universities in the region is also very interesting. It promoted both South-South and North-South cooperation with the local funds available for research. The local agency in Guadalajara, Jalisco, is in the middle of a sociotechnical niche where the software industry is a major development hub. A large number of the calls are aimed at the development of innovations, especially in the area of software (Ordoñez, 2017), boosting the science-industry relation and generating major trickle-down for economic growth in the region. Software is not the only economic sector of relevance for Jalisco; there is also agroindustry, manufacturing and trade, but the orientation of regional innovation systems defined by the government in competition with economic sectors has been in software.[4] Lastly, the case of Michoacán in Mexico, which especially orientates its calls at training and the creation of incentives to attract different parts of the public to scientific training, has continuous annual support programs for indigenous women to undertake postgraduate courses. This type of vocation does not necessarily affect the local GDP but inevitably generates cultural transformations that establish a profile of the different facets of a knowledge-based society.

It is necessary to broaden this study to observe much more precise dynamics and profiles far more limited to the expectations that are being generated according to the types of funding instruments offered by the different agencies at national and state level. In any case, this study could not verify the information in the analog files of all the Latin American agencies, but the information gathered certainly makes it possible to analyze expectations generated by governmental structures to profile the powers and current standing in the direction of research in different territorial contexts. A more precise analysis of these profiles requires an assessment of content with automated and semi-automated techniques. There follows a contribution from the subject restricted to the SDGs and the profiling of the region according to the areas derived from these multilateral proposals.

3 https://www.ibge.gov.br/explica/pib.php

4 https://iieg.gob.mx/contenido/Economia/BoletinEconomico0219.pdf

SDGs in public policy instruments in 10 countries in Latin America

Of the 2,632 policy instruments for exclusively funding research and innovation projects and programs identified in all the agencies observed, 1,419, or 53%, are related to any one of the concepts offered by the SDGs (see table 7.) It is important to stress that this relationship is semantic, that is, the identification of the concepts proposed by the SDGs in the calls, which does not imply a direct intention to work with the SDGs, but at least a match. It is also important to consider that certain designed instruments coincide with more than one SDG. In an absolute count of targets attributed to the instruments, we found 3,762 objectives or elements included in these instruments that direct their funding at one of the SDGs. Figure 6 presents a ranking with the calls that target the greatest number of SDGs and the countries of origin.

Table 7. Distribution of SDG-oriented calls for research and innovation in agencies of 11 Latin American countries (excluding only the calls of the CONACYT in Mexico), 2004-2021.

Country	Instruments oriented at SDGs (n)	Research and innovation instruments (n)	Proportion of total instruments
Argentina	52	74	70%
Brazil	770	1705	45%
Chile	197	361	54%
Colombia	151	180	84%
Costa Rica	3	8	37%
Mexico	77	103	75%
Panama	49	60	82%
Paraguay	23	30	77%
Peru	55	78	71%
Uruguay	32	33	97%
General total	**1419**	**2632**	**54%**

Source: Vélez Cuartas, G and Torres Arroyave, D. (2021)

Figure 6. Instruments with highest number of concurrent SDGs by country of origin.[5]

Convergent SDG (n)	Freq	Freq%	Countries
1	486	34	-
2	380	26	-
3	213	15	-
4	124	86	-
5	81	56	-
6	56	39	-
7	22	15	-
8	21	15	-
9	15	10	-
10	10	0,6964	-
11	5	0,3482	PA,PA,PA,CO,MX
12	5	0,3482	CO,CO,CO,PA,PA
14	1	0,0696	CO

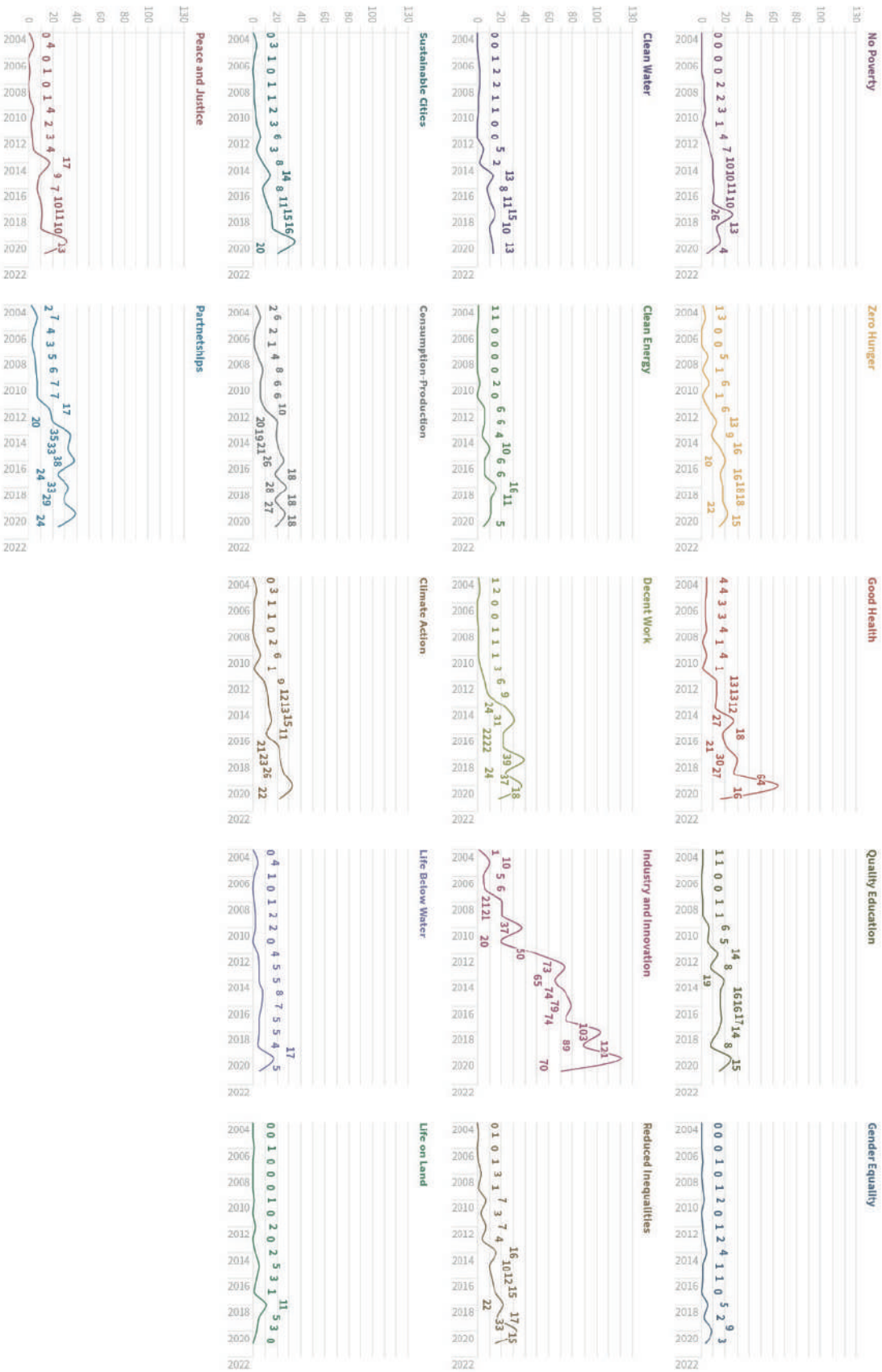
Source: Vélez Cuartas, G and Torres Arroyave, D (2021)

Half of the research and innovation policy instruments in the region are aimed at missions related to SDGs. Of course, not all science is applied and needs the development of communities from basic science projects and from other perspectives that may or may not feed the purpose of missions proposed by the government. In any case, from the perspective of Mazzucato and Penna (2020), a large volume is not enough, as orientation is required from these calls by objectives proposed by specialist institutes or agencies. From the perspective proposed by this study, there is high expectation generated in the research community regarding the orientations given by the agencies on what should orient the construction of research problems and these trends have been growing over time, which means greater attention from governments to science and innovation, asking for concrete results that have a trickle-down effect on different contemporary issues that are more visible to the international community.

The behavior of the instruments observed over time shows a positive effect of the inclusion of the SDGs in the design of these policies. Figure 7 shows the references to targets of SDGs in different calls of the region.

5 The 14 SDGs referred to for the case of Colombia are: No poverty, Zero Hunger, Good Health and Well-Being, Quality Education, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, Industry, Innovation and Infrastructure, Reduced Inequalities, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action, Life Below Water, Peace, Justice and Strong Institutions, in the call: "Construction of peace, resilience and mental health: binational research call to promote support and understanding for current challenges in Colombia during the pandemic."

Figure 7: Time series of SDGs present in different calls in 11 Latin American countries



Source: Vélez Cuartas, G and Torres Arroyave, D (2021).

There are two relevant aspects to analyze: the orientation of research towards specific goals and the growing interest in mission-oriented calls. On the first aspect, the two most outstanding goals are in keeping with the Latin American promotion of research policies oriented at health programs that seek solutions to specific vectors (Suárez Tamayo et al., 2018). In the last two years especially there has been increased interest in research oriented at resolving problems related to the COVID-19 pandemic, but also in some national research traditions related to endemic diseases. The orientation of calls especially to goal 9 on sustainable industrial development and innovation has an important tradition in the creation of national innovation systems in Latin America, based on the strengthening of the science-business relationship (from Sagasti, 1981; to Dutrénit et al., 2019.) The time series related to the other goals are more modest, but a common line can be identified in the goals related to socioeconomic and political problems, such as poverty, zero hunger, quality education and decent work, among others. Three goals clearly receive less attention in the region: life below water, life on land and gender equality.

Regarding the growing interest in SDGs, there are prior experiences and concerns in the region. Significant growth was clearly observed after the publication of the guidelines document from the UN. In general terms, this growth cannot be accounted for by an increase in the percentage of R&D investment compared to the GDP of each country or region, as can be seen in table 8. In fact, while interest in mission-oriented research grows, the regional R&D budget is tending to decrease.

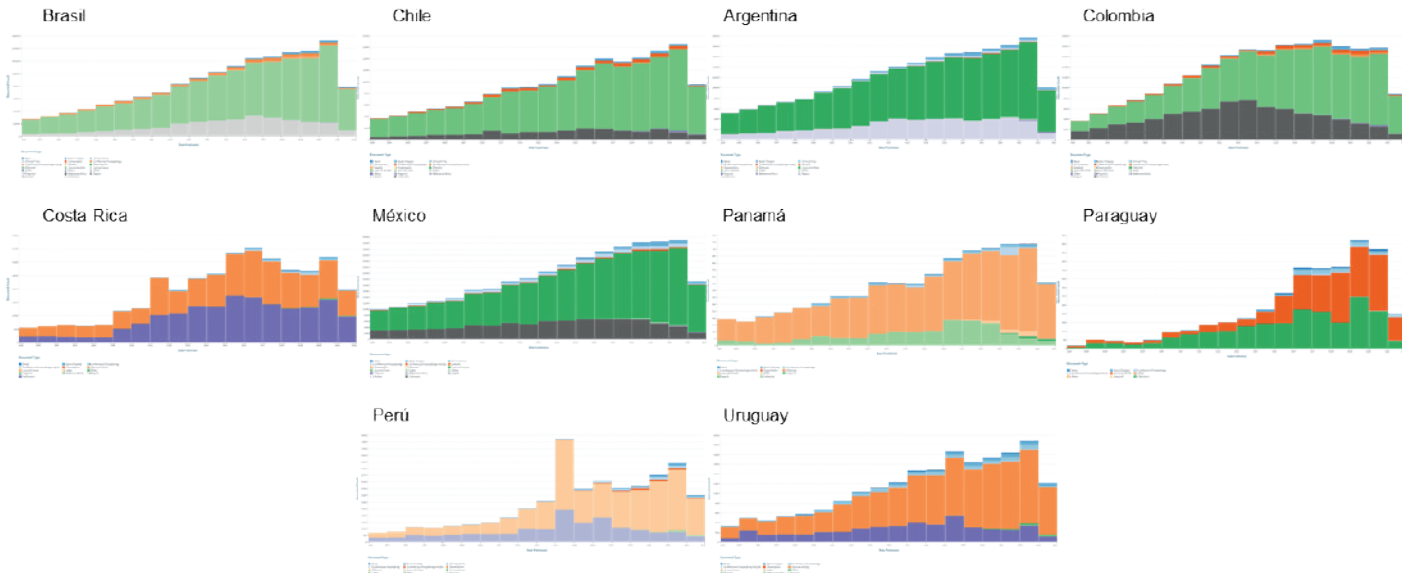
Table 8. R&D Investment compared to GDP of 11 countries in the region and the average for Latin America and The Caribbean.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Argentina	0.56%	0.57%	0.63%	0.62%	0.59%	0.62%	0.56%	0.56%	0.50%	0.46%
Brazil	1.16%	1.14%	1.13%	1.20%	1.27%	1.34%	1.26%	1.09%	1.16%	--
Chile	0.33%	0.35%	0.36%	0.39%	0.38%	0.38%	0.37%	0.36%	0.35%	0.34%
Colombia	0.23%	0.22%	0.24%	0.27%	0.31%	0.32%	0.28%	0.24%	0.25%	0.23%
Costa Rica	0.48%	0.48%	0.57%	0.56%	0.58%	0.45%	0.46%	0.45%	0.39%	--
Mexico	0.49%	0.47%	0.42%	0.43%	0.44%	0.43%	0.39%	0.33%	0.31%	0.28%
Panama	0.15%	0.17%	0.08%	0.06%	0.14%	0.12%	0.14%	0.15%	--	--
Paraguay	--	0.04%	0.07%	0.07%	0.08%	0.10%	0.12%	0.15%	0.15%	0.14%
Peru	--	0.08%	0.06%	0.08%	0.11%	0.12%	0.12%	0.12%	0.13%	0.16%
Uruguay	0.34%	0.35%	0.33%	0.32%	0.34%	0.36%	0.41%	0.49%	0.42%	0.53%
Latin American and the Caribbean	**0.65%**	**0.63%**	**0.62%**	**0.65%**	**0.68%**	**0.69%**	**0.64%**	**0.58%**	**0.58%**	**0.56%**

Source: Ricyt http://app.ricyt.org/ui/v3/comparative.html?indicator=GASTOxPBI&start_year=2010&end_year=2019

When attempting to find an answer in the changes in the generation of various funding instruments for research and innovation, aside from the classic perspectives centering only on the development of a knowledge-based market, it is important to note some aspects. Despite the decrease in resources in recent years, scientific production in terms of articles produced is increasing. This goes against classical theories that account for growth in scientific output (See for example, De Solla Price, 1963.) Investment according to the proportion of national GDP is decreasing and output is increasing. Figure 8 shows the growth of scientific production in different forms for the countries in this study from the information available at lens.org.

Figure 8. Growth of scientific document output in 11 Latin American countries (2004-2022)



Source: Lens.org consulted on 28 September, 2021.

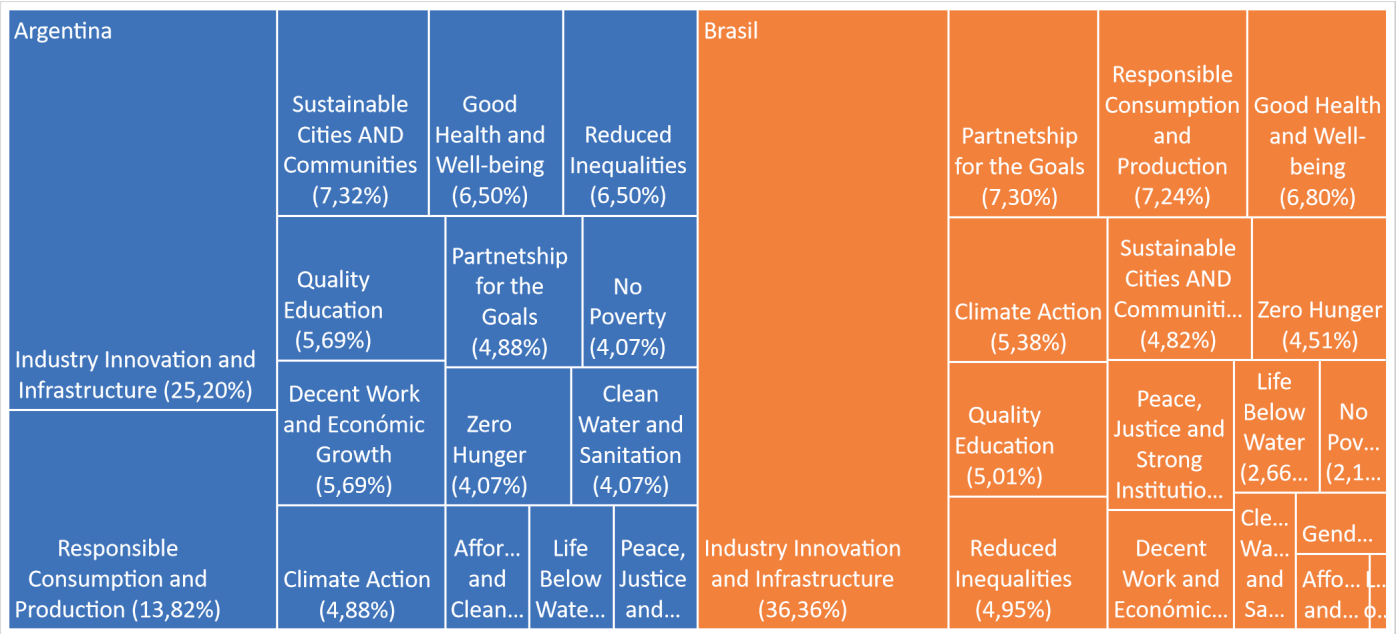
The same thing occurs with the diversification of the agendas of government policies. There is no increase in funding of research, but new agendas are starting pay attention to more diverse problems, not just market growth and, and a knowledge-based economy is starting to emerge. This requires that governments understand the role of science in several social spheres. The exclusivity of science as an agent of change in the market and as the only interpretation of its role is changing, but investment is changing as well. No doubt the international pressure exerted by the agreements reached on the SDGs has had a significant impact.

Furthermore, science appears to respond to a funding dynamic in which different actors are involved and not just oriented by government investment. The growth in output despite the decrease in investment reflects that in reality there is no linear interdependence between GDP and development of scientific production, but judging by the new orientations of the availability of funding for research, there is clearly a new emerging driver of output results. Ramírez et al. (2019) and Romero et al. (2019) note this in the case of Mexico and Colombia, respectively, in their reports on the relation between growth of scientific output and convergence of SDGs towards forms of innovation for transformation, in the case of Mexico, and growing interest in agricultural research, in the case of Colombia.

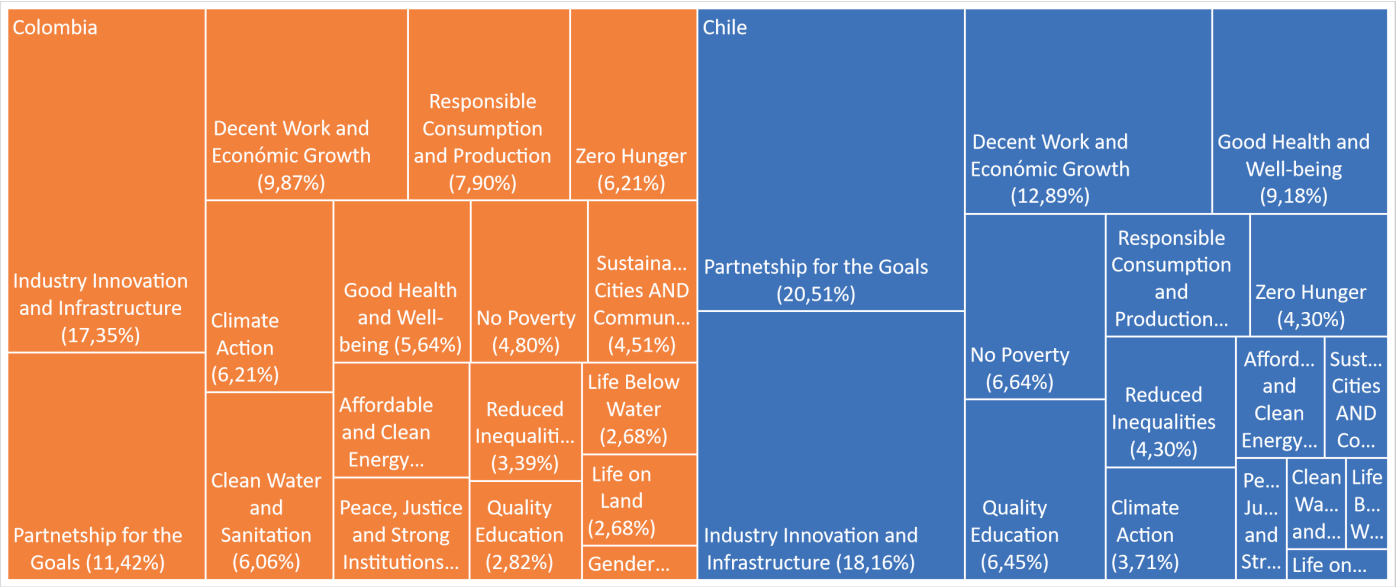
If we consider the proportion of research by groups of countries according to the heuristic proposed—consolidated, in the process of consolidation, emerging and in the process of formation—we can observe the national relevance of certain goals. Figure 9 shows the distribution by country of the allocation ratio of policy instruments dedicated to funding research and innovation geared towards the SDGs.

Figure 9. Distributions by countries of the allocation ratio of their policy instruments dedicated to funding research and innovation, geared towards the SDGs.

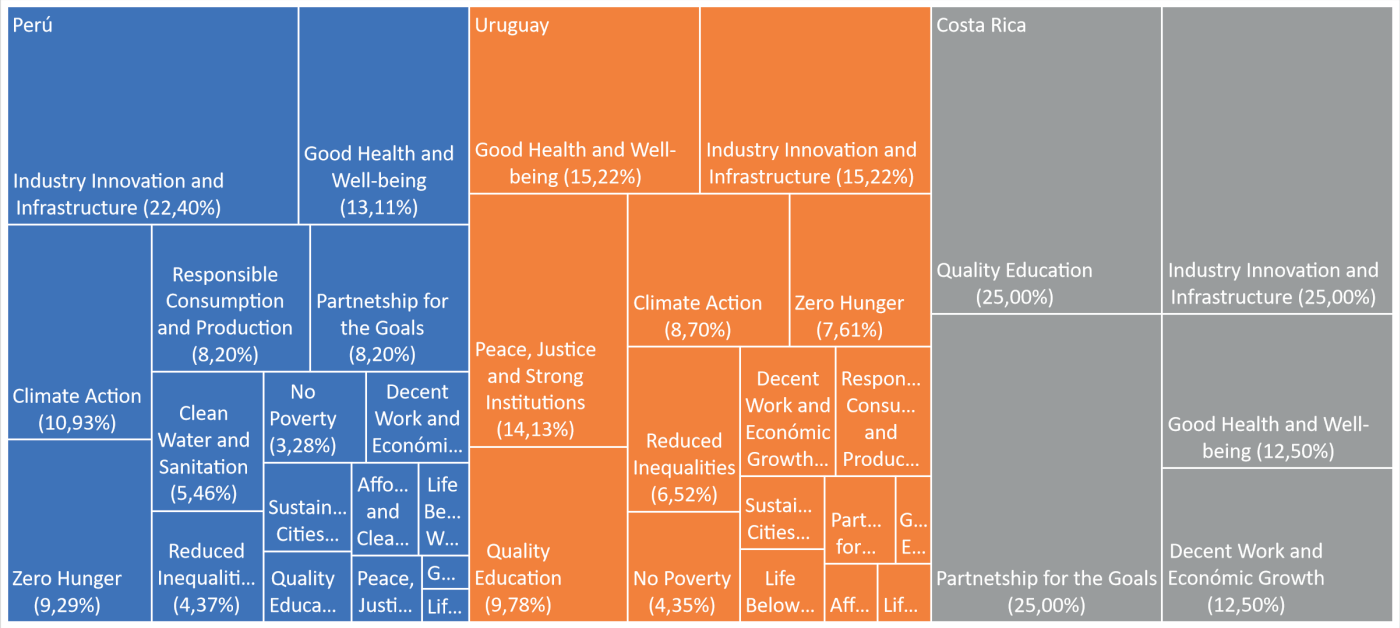
Consolidated (A)



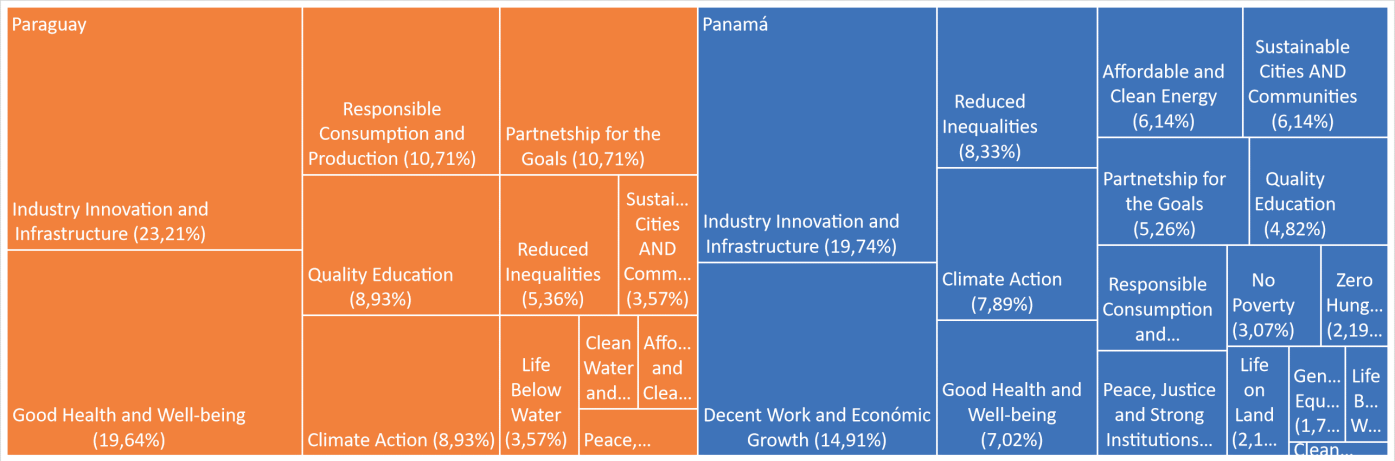
In the process of consolidation (B)



Emerging (C)



In the process of formation (D)



Source: Vélez Cuartas, G and Torres Arroyave, D. (2021)

With the exception of Costa Rica (probably due to the scarce information gathered from this country), all the countries invest mostly in goal 9 (Industry, Innovation and Infrastructure). Brazil has almost one third of its resources allocated to missions close to the SDGs and Argentina has one fourth. The other countries invest between a fifth and a sixth of the resources allocated to this type of call. The other goals vary from group to group and from country to country.

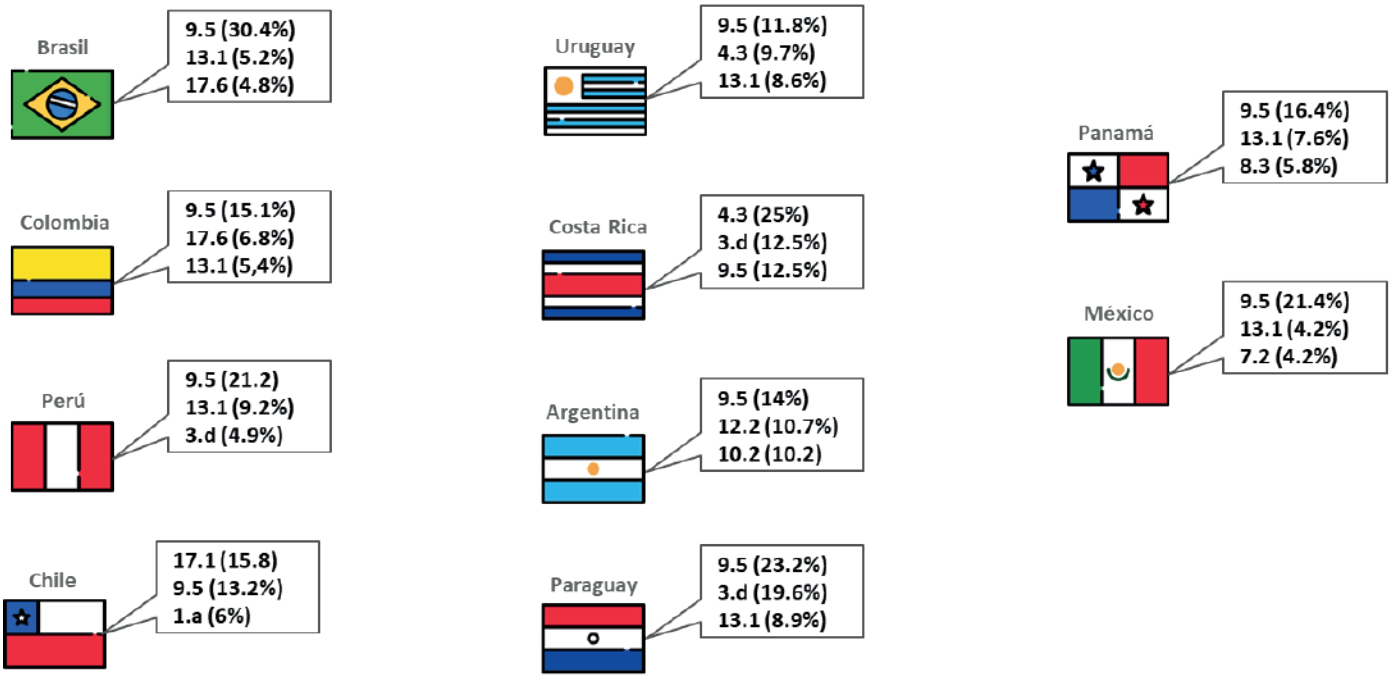
In group A, Argentina does a great deal of work in calls on responsible consumption, as does Brazil. Other items of importance are sustainable cities, health and well-being, and reduced inequalities in the case of Argentina. For Brazil the other goals are of less importance, but there are items associated with action for climate change, quality education, health and well-being and partnerships for the generation of models of governance to achieve transformations. Brazil has calls for all the goals while in Argentina there is no record of calls on gender equality or life on land.

In group B, top priority is given to sustainable industry and innovation; in second place, there is concern for the generation of governance models. For Chile in particular calls are oriented towards problems such as decent work and economic growth, health and well-being, and poverty. For Colombia, they are geared towards responsible consumption, clean water and sanitation, climate action, health and well-being, zero hunger, among others. For Colombia there are calls focusing on all the goals, but as in almost every country, gender equality is the area of less interest in the calls.

In group C, both Peru and Uruguay show interest in all the SDGs except for water and basic sanitation in Uruguay. From Costa Rica only 8 calls were recovered, which showed interest in at least these 4 issues: industrial innovation and infrastructure, decent work, governance for the achievement of transformations and health and well-being. In Uruguay, health and well-being, peace, justice and strong institutions and quality education are of great interest. In Peru, priority is given to zero hunger, health and well-being, responsible consumption and action for climate change.

In group D, Panama shows information on all the SDGs, unlike Paraguay, which excludes five. For Panama there is particular relevance in the areas of decent work and economic growth, health and well-being, climate action and reduction of inequalities; for Paraguay, in health and well-being, responsible consumption and action for climate change. Figure 10 shows more specifically the three most frequent goals included in the calls of the countries studied compared to the total of calls focusing on the SDGs for the purposes of the evaluation of the above areas and specification of the trajectories and relevance given by international agencies to concepts contained in the SDGs and expressed in their calls.

Figure 10. Three most frequent goals in the calls oriented at SDGS in the countries studied.[6]



Source: Vélez Cuartas, G and Torres Arroyave, D (2021).
*Conacyt is excluded from Mexico.

This study is not sufficient to answer whether these subjects gathered by the governmental agencies aim really for a connection with the internal development agendas or whether they are arranged to fit the demands of national or international interest groups. The mission-oriented instruments do not necessarily

6 Consult the goals at the following link: https://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible/

address urgent social and economic problems. Mazzucato's examples (2013) on this type of policy show the attempts made by leading global countries to show their supremacy, which has major trickle-down in the economy, such as the Manhattan Project and the development of NASA space programs mentioned by the author. In this sense, the research and innovation policies adopted by different government agencies do not necessarily generate well-being for the whole population, but they do create synergies in different sectors: science, health, industry, social organizations, etc. It is unlikely to find an ideal model that will generate a broad, consensus-based solution. The SDGs operate as horizons, but institutional arrangements respond to trajectories and agreements generated between different groups, whether elite ones or collective movements or public policy networks. What is evident in the data is the multiplying effect of agreements based on the SDGs, certainly after 2015. There is a concern to respond to challenges through national research and innovation policies, but this follows national itineraries and different political and social environments that surround these designs.

5. CONCLUSIONS

According to Arocena and Sutz (2020), it is important to make a transition from the traditional models of National Innovation Systems in Latin America to a conception oriented towards sustainable models that make it possible to generate greater balance. Their particular proposal is to move towards a concept that they call heuristics of innovation. These heuristics would have a situated, contextualized character to harness the capacities generated in the environment. On a similar path, but more removed from the normative models of national innovation systems currently moving towards transformative principles (Schot and Steinmuller, 2018), observation should take place from more empiricist point of view and not so much from a normative one, and the direction of the analysis of policy instruments oriented at research and innovation in Latin America would have to focus more on the existing capacities.

In this context and based on the principles set forth in this report, this movement should occur in various directions:

1) The first should be to exhaustively review the profiles that have historically been constructed from the existing research funding agencies in the different countries. Those profiles denote certain development capacities and concerns present in national agendas. The profiles generated by the funding agencies make it possible to describe these profiles, but depending on their funding capacity incidence for R&D in the different countries, it would be necessary to broaden the models of observation and investment in territories that share their obligations with different public and private sectors.

2) Secondly, the construction of these profiles must necessarily be tied to the exploration of capacities to generate continuity in certain agendas. Such continuity presents real possibilities for each agency to boost relevant aspects of the development of scientific communities and their possibilities of impact on society in their different areas. Schot and Ràfols in 2020 on the panel of Transformative Metrics[7] mentioned the importance of generating maps instead of rankings, and such maps necessarily create profiles that can be a better input in decision-making. They proposed that the path to generate major transformations based on the possibilities of innovation must necessarily involve the generation of metric instruments that would make it possible to observe more precisely the dynamics of the regions of study.

3) Thirdly, the heuristics proposed by Arocena and Sutz (2021) may be broadened and not only attend to issues from capacities developed by particular situated niches. These heuristics can also be put forward for the classification of territories from different variables and through different dynamics that observe different logics of action of multiple agents. In our case, the governmental funding agencies, with their historical background, have created possible funding scenarios that lead to the profiling of their own scientific communities, not in a determinist manner, but certainly as an important conditioning factor of research and innovation activities.

7 https://www.youtube.com/watch?v=bbMw0evYD94&t=4s

From the investigative and evaluative point of view, the need to generate an explanatory theory instead of a normative one is imperative. These heuristic procedures as a methodological, not theoretical, model can come to generate a regional theory and boost situated and contextualized innovation and research. In lectures at Latmétricas in 2021, Beigel (2021), Vessuri and Rodríguez[8] offer a few insights in this direction. However, we need more empirical data and new disruptive questions, outside of the traditional frameworks of the social studies of science, in order to generate other visions. The typologies proposed by Dutrenit et al. (2019) propose heuristics to address capacities from the point of view of accumulation of capital and of sociopolitical conditions. Their conclusions in general are based on what is lacking, while contrasting this with normative points of view. This text does not describe the current scenario as a prolific paradise for the generation of scientific communities with an incessant impact on the environment to generate returns and social and economic surplus; however, profiling indeed enables the identification of potential policy instruments at a regional level. One could even go as far as the generation of categories that make it possible to visualize states of advances in the constitution of frameworks of incentives for the generation of certain subjects or the boosting of certain activities that show the capacities that are being formed in the countries. This does not mean that we must do without normative frameworks, but these normative frameworks must be at the level of the political debate, as tools for the different agents who argue for the creation of agendas.

Furthermore, it is interesting that in detailing the behavior of agencies on a meso level (state, not national) profiles begin to appear. These profiles still need to be studied a great deal, that is, there are the positions of the agencies and the construction of their instruments, but it remains to be seen whether these instruments are aligned with economic intentions, priority agendas of social movements or civil networks or chambers of commerce, international organizations and international cooperation agendas. In some it is possible to find certain synchronies, but there is a lot of noise from external actors: the Organization for Economic Cooperation and Development (OECD), the Inter-American Development Bank (IADB), the Chinese Government, the International Monetary Fund (IMF), the United Nations (UN), the votes that ask for urgent temporary but not structural solutions, etc. This type of exercise makes it possible to explore the ceiling of existing options, and the local possibilities for construction, but there is still a long road to travel in terms of research programs.

It is also interesting to observe the role of the multiple calls generated at the local level, with the creation of their own profiles for the generation of research. This occurs especially in federal countries. But in the central agencies in countries where these activities are centralized in the national government, there is a clearly unequal distribution throughout the territory. Thus, local agencies and other types of non-centralized agencies can play an interesting role in the development of regional and sectoral economies that may have a trickle-down effect into other sectors.

Regarding the agendas in particular, it is very interesting to see the diversification that is occurring in Latin America. For traditional agendas oriented at the generation of policy instruments to boost the competitiveness of each country through the development of R&D, other issues associated with the SDGs begin to appear in the agenda. One of the most positive effects that the SDGs have had is precisely the opening of the scientific agenda for the governments of Latin American countries. This means greater funding for other knowledge fields traditionally neglected in comparison with priority issues in each country. This does not mean that we are reaching optimal levels to consider Latin American countries as knowledge societies, as the inequalities are the same as or worse than in the past, investment in R&D is falling as the indicators show, and will surely decrease even more with the economic crises in the region after the pandemic. But one thing is certain, and that is that the agendas have been changing and that the opportunities lie precisely in that diversification, open to other funding organizations that do not go solely through the state. Latin America is a territory highly constricted by its creditors and by the limits imposed by global trade and industrial development organizations and intellectual property protection (in the case of patents for the development of treatments and vaccines against COVID-19), but in the promotion of a more diverse agenda it can trigger interesting future lines of action.

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8 https://www.youtube.com/watch?v=0NmwSKJWEP4

In line with Walsh et al. (2020), we can certainly say that, like the rest of the planet, Latin America is not walking decisively and collectively towards the confluence and fulfillment of the SDGs, but as principles that generate expectation, these are being interpreted from a regional perspective and with a basis on the different capacities, and that is generating transformations. These transformations may not be those dreamed of by the creators of the SDGs, but there are certainly positive externalities and diversification of the agendas that can be observed. If this is enough to stop a disaster predicted by multiple international agencies, we do not know, but transformations are certainly taking place.

Finally, the SDGs not only represent global problems to solve; they also represent fields of research that have not received as much state funding as other programs geared towards boosting the market and competitiveness, as shown by the higher number of calls oriented at Goal 9 observed in the recent past. The appearance of the SDGs not only warns of pressing global needs, but also of the existence of other issues in the field of research that perhaps are not considered a priority on the agendas of governmental agencies or which were made invisible in general calls without a transformation purpose, as perhaps is the case with calls from the last six years, which are strongly geared towards the transformation of society. We must not forget that they account for at least half of the calls of the different agencies, which reveals the importance of this type of orientation in contrast to the most basic calls open to the spontaneous generation of more particular research programs of groups or researchers.

These winds of change can not only be seen in these instrument design trends, but also in the regional FOLEC forums for the transformation of scientific evaluation and Latmétricas, with over 600 Latin American evaluators and specialists in scientometrics debating on the different models, considering issues such as accountability, the generation of endogenous proposals to improve the accuracy of instruments, the need to have their own information systems with technologies that can be developed endogenously, new metrics, the role of diamond open access fundamentally led by Latin America in the world, among other questions that are part of this transition landscape. A process of heuristic development, the construction of maps and a path towards towards an endogenous theory must certainly be considered to be able to better understand our own dynamics internally and in relation with the world.

Final note:

The data for this research is available at:

- Calls at Ministries and Departments of Science, Technology and Innovation of Latin America Dataset: https://zenodo.org/record/5236557

- Calls for science, technology and research: - Latam- Text: https://zenodo.org/record/5234421

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