

## **Mechanisms for Financing Science, Technology, and Innovation Initiatives**

Del-Castillo-Ruiz-Caro, David Eduardo<sup>1</sup>, Huayta-Franco, Yolanda Josefina<sup>2</sup>, Espirilla-Sicos, Waldir Milan<sup>3</sup>, Villalobos-Risco, Oscar Moises<sup>4</sup>, Carlín-Marres, Luis Alberto<sup>5</sup>

### **Abstract**

*This original study was carried out with a descriptive design on those mechanisms used by various countries for the financing of various initiatives in science, technology, and innovation, documented from the year 2017 to 2022, for which two search engines were used: Scopus and SciELO, using the descriptors: "science and technology", "subnational governments", "innovation", "financing", "mechanisms", as well as the use of Booleans such as "AND", "OR" both in English and Spanish, for which 20 scientific articles were obtained, of which 13 were from Scopus and 7 from SciELO, all of them qualitative. It was concluded that although there are several mechanisms to finance initiatives in science, technology, and innovation that can be replicated in other territories, the first step is to articulate the discourse of leaders with development plans and these, in turn, with public budgets, allowing greater management responsibilities to be ceded to subnational governments, the private sector, among others, thus demanding new strategies and a legal framework to ensure greater predictability in joint activities aimed at seeking knowledge and resources clearly and securely for both.*

**Keywords:** *Science and technology, subnational governments, innovation, financing, mechanisms, funding.*

### **INTRODUCTION**

This research article seeks to carry out a systematic review of the existing mechanisms for financing science, technology, and innovation initiatives in various countries, in view of the permanent need to incorporate more knowledge with scientific evidence in the spaces where decisions are made. For this purpose, a review has been made of scientific articles published in open-access indexed journals in the last five years.

Investment in science and technology is vital for a country to sustain its growth. However, several countries in the region are lagging. Although laws have been passed, national science and technology policies have been enacted and various documents on the importance of investment in this field have been published, progress is still limited. In recent years, several central governments have delegated a greater number of functions to subnational governments, which has translated into larger budgets that require efficient mechanisms for their success.

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<sup>1</sup> Universidad Cesar Vallejo, Lima, Perú, <https://orcid.org/0000-0002-2413-7488>; e-mail: ddelca73@ucvvirtual.edu.pe

<sup>2</sup> Universidad Cesar Vallejo, Lima, Perú, <https://orcid.org/0000-0003-0194-8891>; e-mail: yjhuaytaf@ucvvirtual.edu.pe

<sup>3</sup> Universidad Cesar Vallejo, Lima, Perú, <https://orcid.org/0000-0003-3835-785X>; e-mail: wespirilla@ucvvirtual.edu.pe

<sup>4</sup> Universidad Cesar Vallejo, Lima, Perú, <https://orcid.org/0000-0001-9042-4461>; e-mail: ovillalobos@ucvvirtual.edu.pe

<sup>5</sup> Universidad César Vallejo, Lima, Perú, <https://orcid.org/0000-0002-2878-4455>; e-mail: p7001264543@ucvvirtual.edu.pe

One of the main mechanisms for financing science, technology, and innovation initiatives is through government funding for research and development. Governments around the world allocate significant funds to scientific research and technological advances. This funding is often directed to specific areas of research, such as healthcare, renewable energy, and artificial intelligence. Government funding can also support the development of infrastructure and facilities needed to conduct research. In addition to direct funding, governments may also offer tax incentives and subsidies to encourage private-sector investment in research and development.

Private sector investment in innovation is another crucial mechanism for financing science, technology, and innovation initiatives. Companies in a variety of industries invest heavily in research and development to remain competitive and gain a strategic advantage. Private sector investment can generate important advances in technology and can also drive economic growth. Venture capital firms also play a crucial role in funding early-stage start-ups, providing the financing needed to bring innovative ideas to fruition. Private sector investment in innovation is often driven by the potential for financial returns, but can also generate social and environmental benefits.

International science and technology funding partnerships provide another important mechanism for funding science, technology, and innovation initiatives. Collaborative efforts among countries can generate significant advances in research and development, as well as provide access to resources and expertise that may not be available domestically. International partnerships can also facilitate the sharing of knowledge and best practices, leading to more efficient and effective use of resources. Organizations such as the United Nations and the World Health Organization play a key role in promoting international partnerships for science and technology funding and coordinating efforts between countries.

For specialists (OECD, 2019), it is estimated that Latin American governments will not be able to meet the objectives of the 2030 Agenda, since the investment made by the State, in fields such as health, education, and economic reactivation, in a context of pandemic, while promoting investment in research and development, as well as the implementation of policies aimed at promoting the competitiveness of their sectors, are insufficient. In this sense, although the extraction of resources or raw materials represents important financial resources for the countries that own them, it does not guarantee sustained economic growth. It should be noted that countries with a higher level of investment in research and development (R&D) can experience sustained economic growth, to a greater extent if they are aimed at training qualified human capital as well as financing projects with a greater impact on society.

In the 1960s, the less developed countries, with the support of several international organizations, sought to promote scientific research in their countries through technology transfer policies from the more developed nations, many of which involved the installation of transnational companies and with it, their technology (Archundia, 2020).

Nowadays, the aim is to bring science and technology closer to society, empowering local scientists and generating policies that motivate their participation, motivating more people to get involved from an early age (Archundia, 2020).

Thus, for example, China's scientific community focused its efforts on ensuring self-sufficiency in food production through the green and white revolutions, which led to progress in the development of scientific and technical capabilities in agriculture. Today, the country has created important human capital at the technological level in fields such as biotechnology, pharmaceuticals, and space research, among others. Thus, in the 1990s, investment in research and development represented 0.8% of GDP; in recent years this percentage has been reduced to 0.7%, a percentage much higher than that of many developing countries (Krishna, 2021).

This contrasts with those years when the least developed countries were characterized as countries that expelled talent. Currently, each country is promoting the creation of research groups and networks associated with new businesses, which focus their efforts on improving productivity in certain economic sectors, which are facing the "tax yoke" that complicates progress in science and technology, with education as a solution for this purpose (Raesfeld et al., 2018).

In addition, to encourage innovation, governments implement a series of science and technology policies, including subsidies and tax incentives, where public procurement has a positive synergistic effect on innovation policies. The idea that the effect of science and technology policies promotes innovation by increasing the inflow of innovation resources is highlighted. The great challenge faced by the governments of less developed countries is to articulate the discourse in favor of science and technology in development plans, as well as in public budgets towards investments that produce higher returns (Almeida et al., 2020). This is complemented by the birth of the term research and experimental development (R&D), which comprises three specific activities: basic research, applied research, and experimental development.

The link between the triad of science, technology and innovation with higher education and adequate funding could support the development of many countries, avoiding copying successful models of first-world countries, which, in several cases, do not consider the social problems of each reality, so the State must promote that research is articulated to the priorities of national development plans (Almeida et al., 2020).

Mechanisms for financing science, technology and innovation initiatives are critical to the advancement of society. Government funding for research and development, private sector investment in innovation, and international partnerships for science and technology funding are important avenues for financing these initiatives. By utilizing these mechanisms, innovation and progress in a variety of fields can be fostered, leading to a better quality of life for all. It is essential that we continue to invest in science, technology and innovation to ensure a better future for generations to come.

## **MATERIALS AND METHODS**

This is an original research with a qualitative, descriptive approach (De Gialdino, 2006). This research begins with the review and exploration of the scientific literature from 2017 to 2022, using two search engines: Scopus and SciELO, using keywords such as financing mechanisms, science and technology, subnational governments, innovation, financing, mechanisms, sustainability, in addition to the use of Booleans such as AND, OR both English and Spanish. A first search yielded 784 articles: 695 from Scopus and 89 from SciELO.

After a debugging process eliminating duplicates, articles not related to the research topic, non-scientific articles, publications, books, and theses, among others, of the 784 articles found, 530 were eliminated (68%), 161 for not being scientific articles (65%), 73 for not corresponding (78%). In the end, 20 scientific articles were selected, of which 13 came from Scopus and 7 from SciELO, all of them qualitative, including a case study, which were grouped in the Mendeley Web manager, and chosen according to the keywords. The systematic review process took the third and fourth week of December, the analysis of the data obtained took the first and second week of January, and the complete review of the article and its contributions took the third and fourth week of January. The review and reading were synchronized with the Mendeley Desktop manager, completing information and creating folders for each of the topics, which allowed linking it with the APA style of the seventh edition.

Crowdfunding and other alternative financing mechanisms have emerged as innovative ways to finance initiatives in science, technology, and innovation. Crowdfunding involves

raising small amounts of money from a large number of people to fund a project or initiative. This approach has become increasingly popular in recent years, particularly for startups and small businesses. Other alternative financing mechanisms include peer-to-peer lending, income-based financing, and community development financial institutions. These financing mechanisms offer alternative options for innovators and entrepreneurs who may not have access to traditional forms of financing.

**RESULTS**

A search in Scopus and SciELO identified 784 articles, of which 20 are being selected, all of which have been published in indexed journals.

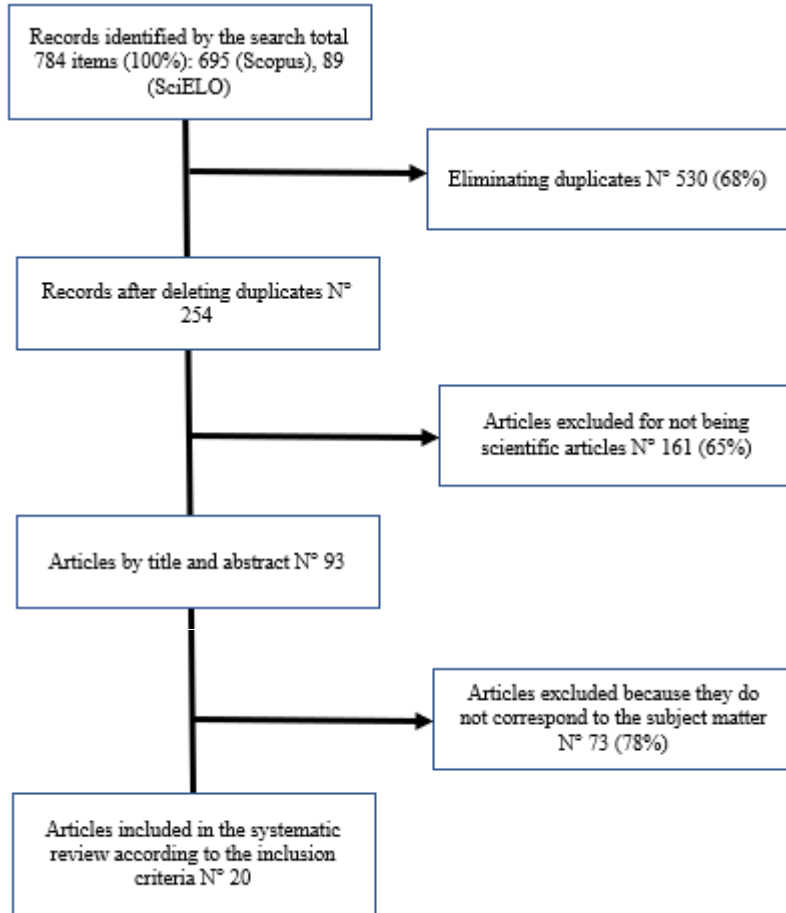


Figure 1. Flow chart of the original investigation

Note: Adapted from PRISMA Methodology.

Table 1. Articles defining original research

N°	Authors					Type of study and sample	Characteristics of the studies
		Science and Technology	Subnational Governments	Financing	Strategies		
1	(Alpizar, 2019) Cuba	X	X	X	X	Qualitative	Analyzes the experience of the Financial Fund for Science and Innovation (FONCI) and its importance in financing innovation in Cuba in recent years.
2	(Almeida, et al., 2020)	X	X	X	X	Qualitative	Presents the case of an agency specialized in science, technology, and

N°	Authors					Type of study and sample	Characteristics of the studies
		Science and Technology	Subnational Governments	Financing	Strategies		
	Brasil						innovation to finance research and development activities in Brazil.
3	(Archundia, 2020) México			X	X	Qualitative	Analyzes investment in science and technology in Mexico from 1980 to 2019.
4	(Ayala, et al., 2021) España	X	X		X	Qualitative	Analyzes the role of subnational governments in the design of science and technology strategies and policies.
5	(Bagattoli, et al., 2021) Brasil	X		X	X	Qualitative	They analyze the reforms carried out by several Latin American countries in science, technology, and innovation, to create a culture of innovation and entrepreneurship, and analyze the similarity of political discourses.
6	(Catalá, et al., 2021) España	X		X		Qualitative	Analyzes the experience of public-private partnerships and their importance in the innovation system.
7	(Cevallos, et al., 2021) Chile	X	X	X	X	Qualitative	Analyzes the performance of the National Science, Technology, and Innovation Policy Councils (STI)
8	(De Almeida, et al., 2017) Cuba	X		X	X	Qualitative	Stresses the importance of investment in science, technology, and innovation and the need for funding by developing countries
9	(De la Cruz, et al., 2021) Venezuela	X		X	X	Qualitative	Analyzes the National and Regional Innovation Systems and the role of the State. in the implementation of science and technology
10	(Gómez & Díaz, 2021) Colombia	X	X	X	X	Qualitative	Analyzing the implementation of agreements to articulate investments in science, technology, and innovation in Colombia
11	(Gonnova, et al., 2021) Rusia	X	X	X	X	Qualitative	The Interstate Exchange of Scientific and Technical Information (STI) in Russia is analyzed.
12	(Gulín-González, 2021) Cuba	X		X	X	Qualitative	Analyzes the contribution of the Cuban Science, Technology, and Innovation System (CSTIS) in the training of professionals in new fields, such as bioinformatics, the existing technology infrastructure, and its contribution to the economy.
13	(Leta, et al., 2021)	X			X	Qualitative	Analyzes the evolution of investment in science, technology, and innovation in Latin America since the 1960s.
14	(Mullin, et al., 2021) USA	X		X		Qualitative	Analyzes the use of revolving funds as instruments to promote state investment.
15	(Pang, et al., 2021) China	X		X	X	Qualitative	Analyzes government subsidies, tax incentives, and their influence on innovation and technological development
16	(Raesfeld, et	X	X	X	X	Qualitative	Analyzes the implementation of

N°	Authors					Type of study and sample	Characteristics of the studies
		Science and Technology	Subnational Governments	Financing	Strategies		
	al., 2018) México						science and technology through the Regional Innovation System and its relationship between society and business.
17	(Reis, et al., 2021) Brasil	X	X	X	X	Qualitative	Presents a proposal to make the country's research and innovation activities less bureaucratic in general.
18	(Rodríguez, et al., 2020) Cuba	X		X	X	Qualitative	Analyzes the linkage between research projects, society and small and medium-sized enterprises, and systematizes the contribution of various spaces for dialogue.
19	(Rodríguez & Núñez, 2021) Cuba	X		X	X	Qualitative	It identifies five main achievements and five critical challenges for future STI policies, related to governance
20	(Sardiñas, 2021) Cuba	X		X	X	Qualitative	Proposes a Science, Technology and Innovation strategy as a tool to enhance its management level.

Note: Own elaboration

## DISCUSSION

At the global level, there are different mechanisms for financing science, technology, and innovation initiatives, here we attempt, from a systematic review, to identify those mechanisms that have achieved a certain level of effectiveness and the attainment of objectives. The great challenge in developing countries has been to consolidate the institutions in charge of promoting science, technology, and innovation, this differentiation can be found in (Leta, et al., 2021) where it is explained that in some countries, such as Brazil and Argentina, they have opted to establish a Ministry of Science and Technology. In the case of Peru, Mexico, Ecuador, and Chile, they have opted to set up National Councils, in Colombia there are Administrative Departments, and in Panama, National Secretariats were created. At the regional level, there is a precedent for the initiative of some strategies such as COSUCTI or the South American Council for Science, Technology and Innovation, whose objective was to strengthen scientific and technological integration, promote the transfer and use of social technologies for the benefit of the neediest, among others.

Internally, subnational or regional governments in some countries have been effective in designing science and technology strategies and policies, thanks to greater proximity to the needs of the population; however, this improvement in the provision of services to citizens is challenged by problems of coordination and budget allocation for funding, which could result in a dispersion of the intervention (Ayala et al., 2021). There are coincidences among Latin American countries when analyzing the structures and national plans related to science, technology, and innovation, highlighting what they consider to be "best practices", i.e. the implementation of imitative policies, which stands out as a typical characteristic of these countries (Bagattolli et al., 2021).

The participation of the private sector, as well as other areas of government, should also be studied, which requires a new legal framework to ensure greater predictability and the promotion of joint activities that seek knowledge and resources clearly and safely for both (Reis et al., 2021). One of the mechanisms that has achieved greater acceptance is cross-

financing, based on an experience born in Brazil, which consists of allocating a percentage of the taxes collected from companies working in certain energy and hydrocarbon sectors, among others, to finance research in the same sectors. This allowed a high degree of independence from public funds and better planning for each sector of the economy.

In addition, there are high-tech incentives in subnational governments, as well as the development of development funds that can help in this regard (Rodríguez & Núñez, 2021). The need to promote local strategies in science, technology and innovation that, in turn, seek to address local problems, as a condition for achieving social and scientific development in their localities, is highlighted. The authors highlight the need to empower local scientists in their role as active subjects and producers of new knowledge.

In De la Cruz et al. (2021), the National Innovation Systems and Regional Innovation Systems are presented as an efficient mechanism to promote scientific and technological innovation, which consists of a network of multiple agents and institutions from both the public and private sectors, whose objective is to import, modify and disseminate new technologies and innovations, based on three actors: governments, productive structure and science and technology infrastructure. These are also known as the Scientific-Technological Triangle or the Triple Helix Model, where the State participates as the designer and executor of policies on productive issues, the science and technology infrastructure as the supplier of technology and the productive sector as the demander of this technology.

At the level of the mechanisms that several countries have to finance these activities, there is the experience of the Financial Fund for Science and Innovation (FONCI) in Cuba, which, although it has some problems in its allocation, has managed to increase business financing for innovation in the country, promoting the development of some production forces. However, it is not enough to have a fund that lends money and then recovers it, it is important to highlight the achievements obtained and correct mistakes, for this, a permanent feedback system is needed, which could be translated into research on the effectiveness of these resources in the short, medium and long term (Alpízar, 2019).

It is worth highlighting the experience of the Science, Technology and Innovation Agency, presented in (Almeida et al., 2020), which, with the support of a Technology Board and a Scientific Council, has managed to finance and promote research and development activities, in addition to proposing mechanisms for better work with universities, companies and institutes in charge of research requiring this technology. Among its conclusions, it highlights the need to take into account market demands, since some scientific projects presented problems when they reached the commercialization phase. It should be taken into account that many non-innovative projects can access credits from commercial banks and not necessarily depend on financing from agencies or foundations.

Efforts to consider knowledge as a common good, which can circulate freely, without restrictions to generate more knowledge, are highlighted, citing some efforts such as Plan S, which intends that all research funded by Science Europe publish its results under an open access scheme. The case of Mexico is cited, where more than 60 percent of the research that has received funding from the State is published in journals with restricted access, which makes knowledge a private good, and can ultimately undermine the progress of science, technology and innovation in a country.

(Pang et al., 2020) explores the effects of other mechanisms for financing science, technology and innovation initiatives such as government subsidies, tax incentives, as well as mechanisms for appropriate public procurement for the promotion of innovation based on the theory of synergy, very good for the promotion of innovation in different



fields, in addition, provides evidence arguments for a deep understanding of the effect of science and technology from innovation policies.

In the case of Chile and Spain, there is the experience of the National Policy Councils for Science, Technology and Innovation (STI) whose objective is to help governments direct efforts in science, technology and innovation. These spaces have gradually gained political and academic attention to coordinate a better strategic approach. However, when analyzing each case, it is clear that the greater the capacity of these spaces, the more difficult it is to fulfill their mandate and therefore the demands, there is also an important cultural development of learning in each organization that allows visualizing a favorable future (Cevallos et al., 2021).

In Colombia, there are agreements aimed at promoting science, technology and innovation actions from the State entities, in some cases, direct contracting is allowed in the selection processes, and requirements are streamlined with the companies providing these services. Colombian regulations establish four types of agreements: agreements aimed at financing science, technology and innovation activities, cooperation agreements, project management agreements and contracts, the first three of which have a special legal regime. There are also the agreements of the Francisco José de Caldas Fund, whose resources are managed according to the fund's guidelines (Gómez & Díaz, 2021).

Another mechanism to highlight are the interstate exchanges for the development of research and technical and scientific knowledge, motivated by the Russian Academy of Sciences (Gonnova, 2021), as well as the efforts of the Cuban Science, Technology and Innovation System (CSTIS) so that both young people and adolescents develop a passion for science from an early age (Gulín-González, 2022), which translates into numerous contributions to the provision of services. Public-private partnerships deserve special mention, which have been gaining prominence in recent years as a working mechanism between the public and private sectors, but they deserve legal regulations that allow for predicting future scenarios in advance (Catalá-Pérez et al, 2021), where external factors can directly influence the success of these partnerships.

The Regional System of Science, Technology and Innovation also stands out as a space where mechanisms are developed that facilitate the work between universities and companies, financing to a large extent basic research and generating synergies between the academic and productive sectors (Raesfeld et al., 2018). Along the same line (Rodríguez & Núñez, 2021) highlights the work with small and medium-sized enterprises, which require meeting spaces with research spaces in order to become more competitive.

In addition, the importance of Communication as a valid and effective means to deliver information to an already defined public is pointed out, this is reflected in the Brazilian National Science and Technology Policy, highlighting the capacity for discussion and debate of scientific topics with specialized and non-specialized audiences, within the framework of a reciprocal learning towards the search for solutions in different fields.

It also highlights the need to create a legal framework, as well as the necessary spaces for subnational governments to better meet the information and service needs of citizens, especially those in the rural information sector, who require new intervention strategies. To this end, consideration should be given to the systemic and collective character that should exist in research, and that results in cooperation between the academic system and the productive sector, which should function in a systemic and articulated manner, otherwise it could be generating obstacles to the development of the sector (Raesfeld et al., 2018).

Similarly, Almeida et al. (2020) detail the need to encourage innovation, broadening the selection criteria, encouraging the presentation of innovative projects with more generic criteria, and allowing isolated actors to access funding. In Public Administration there is



evidence of "imitation behavior" where some sub-national governments observe what other sub-national governments are doing and, based on this, decide to imitate or improve on what is being implemented, deciding their basic levels of benefits. Thus, the conventional wisdom of political decisions regarding social benefit levels is confirmed, even in spaces where there is no central government participation in the design, regulation or financing of a system (Ayala, et al., 2021). Governments articulate efforts to promote science, technology and innovation in their territories through innovative policies, which require adequate strategic planning to promote the transition of the productive structure with greater added value (Sardiñas, 2021).

## CONCLUSIONS

The review carried out affirms that several mechanisms for financing science, technology and innovation initiatives in our countries can be replicated in other territories. However, all efforts must begin by articulating the discourse of leaders with development plans and these, in turn, with public budgets.

There are coincidences among Latin American countries when analyzing the structures and national plans related to science, technology and innovation, however, the mechanisms for their promotion vary among them, in there are Competitive Funds, Financing Funds or Agencies, Public-Private Partnerships, Agreements, Subsidies, among others.

Funding mechanisms for science, technology and innovation are critical to the development and progress of societies. While government funding provides stability, private sector investment brings innovation, and international aid and grants offer support, each has its advantages and disadvantages. To ensure effective funding mechanisms, collaboration between government, the private sector and international organizations is recommended, along with diversification of funding sources and a focus on impact and long-term sustainable development. By implementing these recommendations, we can ensure that science, technology and innovation continue to thrive and benefit society.

New mechanisms should be explored for central governments to cede management responsibility to subnational governments, specialized offices, the private sector, among others, to enable the promotion of science, technology and innovation policies, which requires new strategies and a legal framework that ensures greater predictability in joint activities that seek knowledge and resources clearly and securely for both.

Finally, to ensure the sustainability and long-term impact of STI initiatives, it is essential to focus on sustainable development. This includes not only the development of new technologies and innovations but also the integration of these developments into existing systems and infrastructures. Effective funding mechanisms should prioritize initiatives that have the potential to generate lasting change and contribute to sustainable economic and social development. By focusing on sustainable development, STI initiatives can create a positive feedback loop, in which the benefits of innovation and progress spill over to society as a whole, creating a virtuous circle of growth and development.

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