DOING RESEARCH IN VENEZUELA

Science, Technology and Innovation Capabilities to Overcome the Crisis in Venezuela

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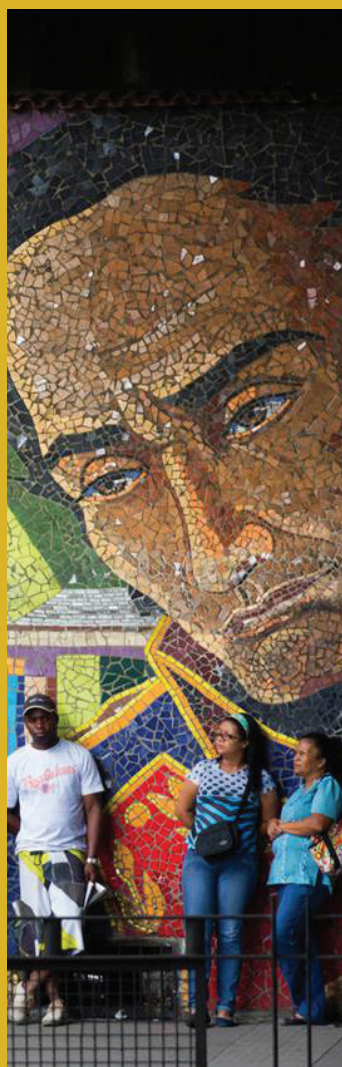

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Table of Contents

INTRODUCTION 6

THE SEVERE STRUCTURAL CRISIS 8

Food insecurity and deteriorating health conditions 8

Collapse of education at all levels 9

Loss of economic-productive capacities 10

Collapse of public services 14

DEINSTITUTIONALIZATION OF THE NATIONAL SYSTEM OF SCIENCE, TECHNOLOGY, AND INNOVATION (SNCTI) 16

STATUS OF NATIONAL CAPACITIES FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT 23

Overview 23

Loss of research capacities in health and food safety 28

Loss of engineering and technology capabilities 31

REINSTITUTIONALIZATION AND NEW GOVERNANCE FOR SCIENCE AND TECHNOLOGY 39

Differentiated institutional responses 40

Rethinking the institutional framework of science and technology 41

BIBLIOGRAPHIC REFERENCES 43

GLOSSARY 47

Index of Tables and Graphs

Tables

Table 1. Techno-productive situation of industrial activities in the hands of the Government 16

Table 2. Ordinary resources in Science, Technology, and Innovation in relation to GDP 2004–2015 22

Table 3. Percentage of investment in IES projects 2001–2014 24

Table 4. Venezuelan universities (1998–2019) 27

Table 5. Allocated budget and budget deficit in independent universities 2018–2020 29

Table 6. Percentage of investment in R&D of higher education institutes in relation to the 2004-2015 allocated annual budget 31

Table 7. Migration of professionals and engineers in six countries (Venezuelan residents in 2018) 38

Table 8. Entities associated with the Ministry of People's Power for Science and Technology 2017–2019 41

Graphs

Graph 1. Percentage of manufacturing GDP with respect to non-oil activity (ANP) and variation of ANP and manufacturing GDP (2007-2016) 14

Graph 2. Basic Metal Production (MTMA) 15

Graph 3. LOCTI (Organic Law of Science, Technology, and Innovation) collection (millions of US$) 23

Graph 4. Nominated researchers vs. accredited researchers in ONCTI programs 1990–2015 25

Graph 5. Variation in LOCTI collection (percentage) 26

Graph 6. Production of scientific articles in Venezuela 1998–2019 31

Graph 7. Active USB Academic Staff by Division 2013–2019 36

Graph 8. Centers for Research and Technological Development (CIDT) founded in Venezuela between 1960 and 2019 39

INTRODUCTION

For a little more than five years, Venezuela has been going through a serious structural crisis, which is mainly, though not exclusively, the result of politics, which manifests itself in all areas (economic, educational, social, health, etcetera) and which maintains the population in extremely precarious living conditions, as has been seen in various studies.

The Puntofijo Pact

The political crisis, characterized by the impossibility of forming a functional political system that is capable of arbitrating the conflicts resulting from the relations between the State, market and, society, began in the late 1980s, when the political system that had been in force since 1958 was quickly delegitimized due to the growth of poverty and inequality. The founding political pact of Venezuelan democracy, the so-called Puntofijo Pact, which has been described as a "populist system of agreement between elites", was based on strengthening and expanding accessions on restricted participation through political parties, with the management of oil income as the backdrop. The political pact's vulnerability began with the 1983 debt crisis, which particularly affected the oil-producing countries, including Venezuela.

Hugo Chávez's Presidency

Venezuela had four decades of political stability, thanks to the aforementioned agreement, which began to weaken in the early 1990s. This occurred amid the delegitimization of and mistakes made by the ruling elites, giving rise to massive popular protests and failed coups, which culminated in the election of Hugo Chávez Frías, a former military man, in late 1998.

The current political phase began in the first decade of the 21st century. Despite the fact that this had once enabled the system's forced stabilization and national economic growth, mainly thanks to the rise in oil prices, under current circumstances the system is dangerously challenged by its own dysfunctionality and inability to achieve a minimum consensus to resolve the prolonged political conflict that has been progressively taking shape.

However, in the 2006-2012 period, taking refuge in the enormous and at the same time unstable oil income (which dropped significantly with the 2008 crisis), the Government initiated a risky political experiment in "2lst century socialism", which with strong reminiscences of real socialism of the 20th century sought to emphasize the leading role of the State in the economy, to the detriment of an already weak national private sector. The foreseeable failure of indiscriminate nationalization was exacerbated by the external shock of 2013–2020.

Post-Chávez Chavismo

After the death of Hugo Chávez and the narrow election of Nicolás Maduro as President of the Republic in March 2013, the political-structural conflict with a weak and directionless government was rekindled. On the one hand there was the need to manage an economy on the verge of a catastrophe, and on the other hand, a strengthened and more cohesive opposition at the electoral level. The opposition won a clear electoral victory in the 2015 elections to the National Assembly, which was annulled for all practical purposes by the Supreme Court of Justice, through measures that have been severely questioned as to their legality. It was, without a doubt, a severe blow to the rule of law, which reinforced the Government's authoritarian tendencies.

Maduro was reelected for a new term (2019-2025). Various national observation bodies

recorded numerous violations of established norms, which rendered Maduro's win illegitimate. This led opposition sectors and close to 50 countries refusing to recognize his appointment. Juan Guaidó, president of the National Assembly, was then named as the legitimate president of Venezuela, which led to a dualization of power. One of the impacts of this was the international community's approval of economic sanctions against the Maduro government. As a result, the political conflict has intensified despite various negotiation initiatives.

Today, this permanent game of chess is far from being an ideological confrontation and is, above all, a power struggle that has had catastrophic consequences in Venezuelan society. The price paid by society from 2013 to 2020 is equivalent to almost 70% of the country's GDP, and has led to a humanitarian crisis, aggravated by the country's health fragility in the face of the COVID-19 pandemic. This is a situation from which it is difficult to escape without a political agreement that allows the economy to be rescued, which, in the current global situation, would mean rethinking the country's productive vocation and beginning to face the challenges of the 21st century. This urgent process of redesigning the country's main development policies includes those related to science, technology, and innovation (STI).

The purpose of this report

In the midst of the current political crisis, parliamentary elections have been called, in accordance with provisions in the National Constitution, for the end of this year. Up until now, the electoral process has been uneven in many respects, especially amidst the serious obstacles imposed by the pandemic. This has led to an uncertain scenario with respect to the very way in which voting will take place and the political consequences that will arise from the elections.

It is not a question of ignoring the obstacles that arise from the political conflict at hand, but rather of identifying the opportunities that are beginning to be seen in social and productive instances, even in the current situation. These are essential to help overcome the humanitarian crisis. From the perspective of strengthening STI activities there are two particular opportunities of great importance in the areas of health and food safety, and in engineering. It is also looking towards the challenges and opportunities of the 21st century, which are the result of the radical techno-scientific transformations that constitute the foundation of the so-called Fourth Industrial Revolution. In other words, it's about loosening the shackles of the 20th century and synchronizing ourselves with the rest of the world.

THE SEVERE STRUCTURAL CRISIS

The economic, political and social crisis has caused the emigration of more than five million Venezuelans, mainly to five countries: Colombia (34%), Peru (16%), Chile (9%), Ecuador (7%), and Brazil (5%).[1] The Venezuelan migration phenomenon has brought about important changes in recent years. The most recent wave of migrations began in 2017, characterized by a forced emigration of citizens seeking better working conditions (82.8%), made up of a mainly young population (41% between 15 and 29 years of age).[2] The latter translates into an acceleration of the aging of the remaining population in Venezuela. In the last five years (2015-2020) we have lost almost three decades of Venezuela's demographic bonus. Currently, the number of people under 15 and over 65 exceeds the number of the economically active citizens, which means great challenges from the economic and social policy point of view for the coming decades.

Food insecurity and deteriorating health conditions

In Venezuela, the average daily income is 0.72 US$, so 79.3% of the population lives in extreme poverty because they do not have enough resources to cover the basic basket of goods. Thirty-three percent of households are severely food insecure, and the number of moderately food insecure households is increasing. In 2018, 31% of households were in this situation, a figure that increased to 36% in 2019 and 41% in 2020 during the COVID-19 pandemic. This means that at least 74% of Venezuelan households suffer from concerns about the food supply, which affects diet quality, mainly due to a decrease in protein intake. An alarming fact is that 30% of children under five years of age have chronic malnutrition or suffer from stunting, which puts us on par with some Central American or African countries[3].

The collapse of the health system has generated an increase in morbidity. The infant mortality rate is 26 per thousand children, which is a regression to 1985–1990 levels. Life expectancy for the population born in the period 2015-2020 has dropped by 3.7 years.[4] Since 2016, there has been a shortage of essential medicines and a lack of medical equipment for chronic and terminal patients (HIV, kidney patients, bleeding disorders, cancer), putting some 3 million people at risk. However, the lack of transparent information on the health system makes it difficult to monitor this problem, to the point that most relevant information over the last five years has come from various NGOs.[5]

In addition to the aforementioned there is the problem of the reappearance of preventable cattle diseases that had been controlled for decades, highlighting important flaws in epidemiological surveillance and the Expanded Program on Immunizations (EPI), which reports a generalized drop in all immunizations nationwide. The recent diphtheria (2016) and measles (2017) epidemics have not yet been brought under control due to late and insufficient immunization coverage.[6]

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[1] R4V 2020.

[2] ENCOVI 2019–2020.

[3] ENCOVI 2019–2020.

[4] ENCOVI 2019–2020.

[5] Amnesty International 2017.

[6] The extremely low coverage rates in municipalities inhabited mainly by indigenous ethnic groups stand out. This phenomenon can be seen in the states of Delta Amacuro and Amazonas, in which coverage barely reaches 5.2% (Oletta and Rísquez 2019).

From 2000 and 2017, Venezuela went from having 2% of the continent's malaria cases to more than half, which is why it is now part of the group of countries with the highest malaria burden in the world with 0.22% of all global cases. The population at risk of contracting the disease increased alarmingly, reaching 61.37% in 2017. Mortality increased 17 times between 2010 and 2017.[7] A potential risk of reappearance of poliomyelitis and other infectious diseases is also reported. This represents a risk to public health, not only in Venezuela, but also in countries receiving migrants.[8]

Coronavirus in Venezuela

One example of the critical issues facing the Venezuelan health system has been the management of the coronavirus epidemic. The management of the crisis has been characterized by opacity in the data, the stigmatization of patients and migrants, and mistreatment related to confinement. A report from the Academy of Physical, Mathematical, and Natural Sciences (ACFIMAN) published in May[9] alerted the authorities that the number of infections was being underreported by at least 63%, and also highlighted the need to expand diagnostic capacity by carrying out more PCR-RT tests and to decentralize diagnosis by incorporating other laboratories in the country. The study estimated that the peak of the epidemic would be between June and September, with an infection rate of between 1,000 and 4,000 cases per day. As a result of this report, ACFIMAN received public threats from government officials, and there are also recorded cases of the persecution of doctors, journalists, and members of NGOs who disseminate unofficial information about the epidemic, the situation in hospitals and failures in the national supply of water, electricity, and gasoline. Four months after the confinement in Venezuela began, only three laboratories had been authorized to analyze PCR-RT tests.

Collapse of education at all levels

The education sector is not free of the crisis. According to the 2016 national budget[10], investment in education suffered cuts of 84% compared to resources allocated to the sector in 2015.[11] There is a decrease in enrollment, educator dropout, and deterioration of infrastructure, which ultimately threatens educational quality and coverage. Some estimates point to a drop in sectoral demand due to forced emigration and the economic crisis, so the number of people of school age (three to 24 years) in the system has been reduced by 1.7 million.[12] In 2019, educational centers operating with less than 40% of their required teaching staff were reported. This situation is also seen with administrative personnel, affecting the operation of schools and high schools.[13] Educational coverage fell at all levels, but mainly in higher education (population between 18 and 24 years old). In 2016 tertiary education coverage was 48% and by 2019 it had fallen to 25%.[14]

Budgets with increasingly higher deficits granted by the national government have had a negative impact on the quality of education, the provision of services and benefits to students, teachers and workers in the sector, as well as the on the maintenance of infrastructure.

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[7] Oletta 2018.

[8] Oletta and Rísquez 2019.

[9] ACFIMAN 2020.

[10] Starting in 2017, the national government stopped presenting the national budget to the National Assembly for approval, which is stipulated in the Constitution.

[11] Transparency Venezuela 2016.

[12] ENCOVI 2019–2020.

[13] Provide 2019.

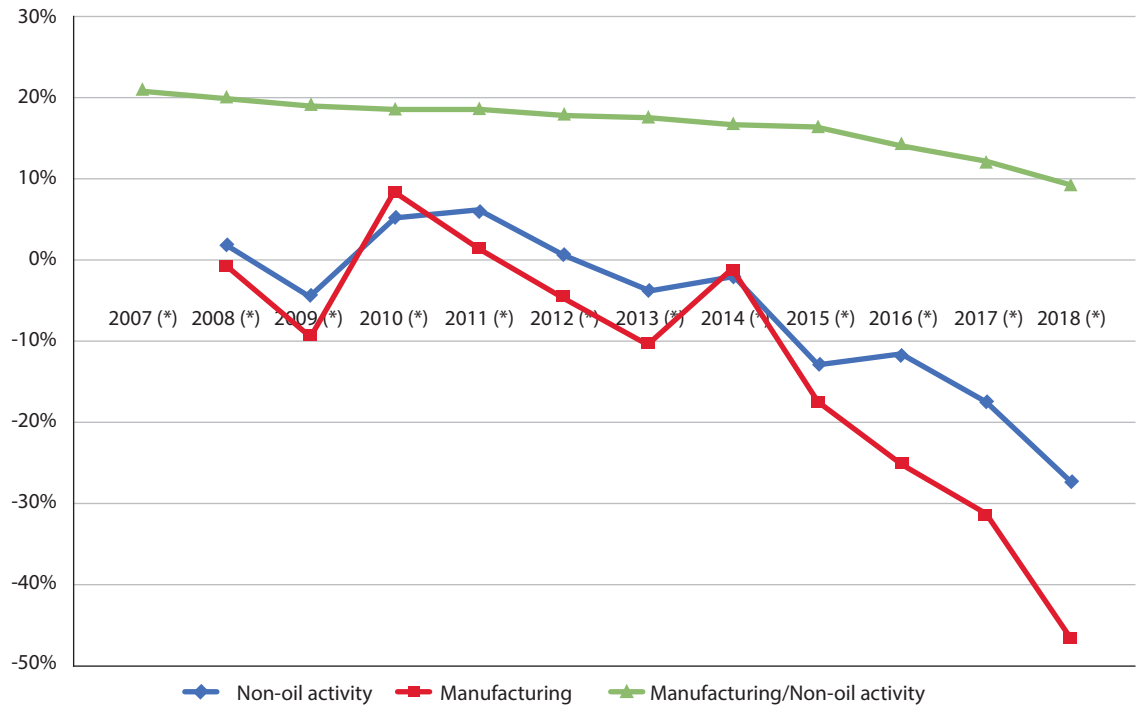
[14] ENCOVI 2019–2020.

Loss of economic-productive capacities

The country is experiencing its seventh year of economic decline. At the end of 2019, GDP had contracted 62% compared to that of 2013.[15] Oil production in June 2020 was 500,000 B/D - one sixth of what was extracted in 2012 - falling back to 1940s levels. Simultaneously, refining dropped from 991,000 B/D in 2011[16] to 89,000 B/D in February 2020, a decrease of more than 90%. This means that today there is not even the capacity to cover the internal demand for fuels, nor to supply raw materials to the petrochemical industry.

The real economy (the total production of goods and services) is collapsed. The drop in manufacturing GDP is even more pronounced than that of total GDP (over 75%), also showing a significant decline in its contribution to non-oil GDP, from 20% in 2008 to just under 10% in 2018 (Graph 1). This has notable repercussions on well-being, as it impacts key variables such as employment and the provision of goods, even the most essential ones, to the population. This has been one of the factors that has most triggered the humanitarian crisis.

Graph 1: Percentage of manufacturing GDP with respect to non-oil activity (ANP) and variation of ANP and manufacturing GDP (2007-2016) Manufactura = Manufacturing ANP = Non-oil activity



Source: BCV, 2020

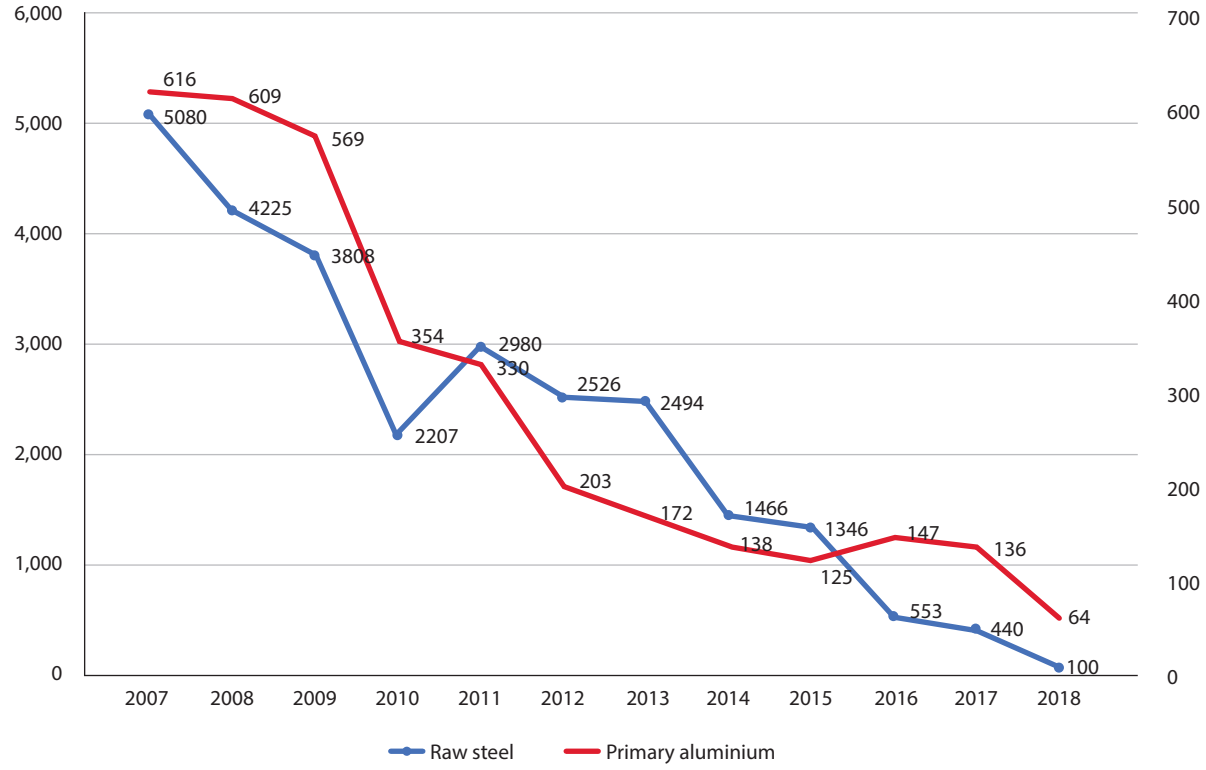
Basic industries

Apart from the oil industry, productive activities in the hands of the State are almost completely bankrupt. The state has practically had a monopoly on basic industries since 2007, the year that steel and cement companies were nationalized. From that point on, these companies' production

[15] ECLAC 2019.

[16] MppPetróleo (2014).

Graph 2: Production of basic metals (MMTA)



Source: WMP, multiple years

began to decrease steadily. The same thing happened to companies in the petrochemical and aluminum sectors, which, for the most part, were already in the hands of the State.

The extent of the collapse of these industries can be seen in the variation in the production of crude steel and primary aluminum. The production of 5,080,000 and 616,000 tons respectively in 2007 dropped steadily to settle at 100,000 and 64,000 tons in 2018, a reduction of 98% and 90% respectively (Graph 2).

Technically, these industries have stopped, generating the dismantling of industrial chains (semi-finished and finished products), and the paralysis of the transformation sectors. The same thing has happened in the petrochemical industry. The shutdown of olefin production compromises the production of thermoplastics, and the failure in the supply of some basic products from refineries, the production of solvents, and intermediate products for the chemical sector. A similar phenomenon can be seen in the construction sector: the decrease in the production of cement and aluminum, iron, and steel has led to an alarming drop in the industry.

Destructuring of the private manufacturing industry

The decline of the private sector started in the first decade of the century. The 2007–2008 Economic Census[17] recorded 27,344 manufacturing companies, of which 98.8% were private; 16,144 belonged to the industry. By the end of 2019, only 2,145 manufacturing companies were operating. The causes, apart from the aforementioned

[17] INE 2010.

problems, are regulatory restrictions, the loss of specialized labor, failures in basic services (electricity, water, telephone, and Internet), and the significant decrease in demand, due to a drop in Venezuelans' purchasing power.[18] This hinders operations, which have been falling steadily. At the end of 2019, capacity utilization in the surviving companies was barely 18%. It is predicted that if the current economic situation continues, more than 50% will bring their operations to a stop.[19]

Technical-productive conditions

In this context, a loss of technical-productive capacities has been experienced, with serious consequences for production, the environment, and workers. Chains in different industries, especially those controlled by the State, have supply problems. These range from extraction and primary processing of natural resources to difficulties in acquiring spare parts and parts. Added to this is the poor quality of industrial and public services, and a deficit in electricity supply. This affects production in all links in the chain, resulting in a net decrease in the production of finished goods (Table 1).

In the first quarter of 2020, just before the COVID-19 crisis, only 2% of companies planned to invest in machinery, while 27% planned to do so in operational areas. This lack of investment will have a negative impact on infrastructure and technological capacity conditions. Related to this, technological obsolescence constitutes a serious problem (Table 1).

Industry representatives highlight the drop in investment in fixed capital in recent years, which increases the gap in question.

Table 1: Techno-productive situation of industrial activities in the hands of the Government

Group industrial	Raw materials, inputs and industrial services	Production	Equipment condition and technological capacity	Environmental situation	Employment situation
Metals basic	Supply break in the industrial chains due to decreased extraction and production of intermediaries. Difficulties in acquiring pieces and parts. Deficit in energy supply. Poor industrial services.	Drop in extractive production. Stoppage of the production of aluminum, iron and steel. Stoppage of manufacturing of finished products	Obsolescence of extraction machinery and mining transport equipment Obsolescence of production and control machinery. Maintenance issues. Loss of technological capabilities (use and operation, engineering and design).	Increased environmental impact in extractive processes Obsolescence of control equipment discharges (solid, liquid, and sodas). Loss of management capabilities. regulatory breaches. Increased environmental impact and increased risk in industrial operations.	Deterioration of work conditions (health and labor safety). Crashing fall in income and worker qualifications.

[18] FEDECAMARAS 2019.

[19] CONINDUSTRIA 2017.

Petro-chemicals	Breakdown of supply chains. Ethane and propane deficiency. Stoppage of the production of olefins. Deficit in the production of bases for lubricants and solvents. Deficit in energy supply. Difficulties in acquiring pieces and parts.	Thermoplastics production drop.Paralysis of plastic conversion sector. Stoppage of the production of intermediate chemicals, greases, lubricants, and solvents	Obsolescence of production and control machinery. Loss of technological capabilities (use and operation, engineering and design, and destructuring of R+D groups. Maintenance issues.	Deterioration of emission control equipment. Loss of capabilities management. Loss of ISO 14000 certification. Non-compliance with the regulations. Increased environmental impact and in health of the surrounding communities.
Pulp and paper	Forest damage due to faults in prevention systems and fire control. Decrease in pulp production. Deficit in energy supply. Difficulties in acquiring pieces and parts.	Semi-paralysis of pulp plants. Semi-paralysis of paper production. Semi-paralysis of converting companies.	Obsolescence of production and control machinery In different stages (pulp-paper). Loss of technological capabilities (use and operation, engineering and design) Maintenance issues.	
Cement	Difficulty acquiring industrial Supplies. Problems in the transport of raw material to the plant. Poor supply of spare parts and parts. Deficit in energy supply. Difficulties in acquiring pieces and parts. Poor industrial services.	Severe fall in production: 60% (2018). Noticeable decrease in productivity. Some plants paralyzed.	Obsolescence of extraction and mineral transport machinery. Technological obsolescence of the operating and control equipment. Loss of technological capabilities (use and operation, engineering and design). Maintenance issues.	

Source: Own preparation

In addition to the aforementioned are the factors that affect the technical conditions of the equipment. As income decreases, allocations for other activities decrease, amongst these, maintenance, which tends to be more corrective than preventive.

Equipment deterioration affects production efficiency and increases the potential for environmental impact and risk. If the loss of management capabilities due to the decrease in qualified personnel is added to this, the industry faces a critical environmental situation, since it cannot even comply with regulations.

Finally, the employment situation has become alarmingly precarious. Apart from the brutal fall in workers' incomes, all State industries show a deterioration in working conditions and a loss in qualified labor force (Table 1).

Collapse of public services

The Venezuelan Observatory of Social Conflict (OVCS) reported 5,375 protests associated with the collapse of public services in 2019, surpassing those that were held to demand the right to political participation. This has contributed significantly to the deterioration of Venezuelans' quality of life, which has emerged as another factor that aggravates the humanitarian crisis. The following is a brief overview of the state of essential basic services.

Water and environmental sanitation

Seventy percent of the population does not have a constant water supply. Only 23% have continuous access to water, and 11% of the population do not have this utility at all.[20]

Electricity

At the end of the twentieth century, Venezuela had significant generation capacity (hydroelectric and thermoelectric) and a transmission and distribution network that comfortably covered demand. In this century, although considerable resources, estimated at 17,000 million US$, were allocated for the system's expansion and maintenance, this money was mostly wasted by corruption and the nominal generation capacity hardly increased.[21] In recent years, intensive rationing has been implemented in various regions of the country, notably damaging the quality of life.

ICT

According to figures from CONATEL, there was a significant increase in access to ICT between 2000 and 2010. From 2010 onwards, with the exception of Internet service, growth slowed down as a result of the difficult economic situation. Only four out of every ten households in Venezuela have Internet access, mostly through the state-run telephone and internet service provider CANTV.[22]

Added to the low Internet penetration is the drastic drop in service quality. According to opinion studies by the OVSP, 53% of those consulted who have the service claim to experience daily interruptions in the connection.[23] Regarding mobile phone services, specifically the penetration of smartphones, 60.4% of those surveyed have a device of this type. There has been a verified increase in the consumption of mobile data and a decrease in the use of calls. The deficient electricity service affects the operation of the mobile telephone transmission network.

[20] OVSP 2020.

[21] During the electrical emergency of 2009–2010, 13,000 MW of thermoelectric generation capacity were acquired without any control. Of these, only 3,000 MW (23%) were available in 2015.

[22] OVSP 2020.

[23] OVSP 2020.

The aforementioned has caused the country to have significantly regressed in ICT. In an interconnectivity index, Venezuela ranked 108th out of 139 countries, and 13th in Latin America and the Caribbean, behind countries such as Colombia, Ecuador, and Peru.[24]

This panorama reflects the greatest economic collapse to have occurred in a country without war in at least 45 years, and allows us to understand, to a large extent, the human tragedy that it has created. The common denominator in this critical situation in industry and services is the extraordinary loss of human talent which, in the case of engineering skills, vital for industrial and service operations, corresponds to the loss of 200,000 professionals who have left the country. As will be seen in the following sections, training, research, and professional practice are seriously compromised, and require extraordinary efforts if they are to recover.

[24] World Economic Forum 2016, in Ávalos and Mercado 2019.

DEINSTITUTIONALIZATION OF THE NATIONAL SYSTEM OF SCIENCE, TECHNOLOGY, AND INNOVATION (SNCTI)

Since the creation of the National Council for Scientific and Technological Research (CONICIT) in 1967, an institutional framework for science and technology (S&T) was designed in Venezuela. Despite having been discreet and lacking necessary recognition from a significant number of political and economic elites, CONICIT promoted the consolidation of important research capacities. In the eighties, scientific productivity in some disciplines equaled that seen in relatively more developed countries of the region, such as Brazil, Mexico, and Argentina. This was not the case with technological development, in which the formation of knowledge production capacities in universities and R&D centers was scarce. Nor did it occur in industry, while, although there were important exceptions, there were few technological innovation efforts.

Drastic changes have taken place during the two troubled decades of this century. The intention was to direct S&T subject to the Government's political orientation of the Government, which would thereby affect the sector's operation and governance.[25] More recently, these activities have not been safe from the terrible effects of the economic crisis.

At the beginning of Hugo Chávez's government there were efforts to strengthen S&T. Science and technology are granted a constitutional rank in the 1999 Constitution and, based on this, there were attempts to consolidate a new institutionality. From that year to 2002, the Ministry of Science and Technology was created, and a Law of Science and Technology and Innovation was formulated. Emphasis was placed on promoting the development of information and communication technologies (ICT) and the democratization of the Internet through a program —INFOCENTROS— whose objective was to allow the population free access to new forms of knowledge and information management.

In 2004 the National Plan for Science, Technology and Innovation 2005–2030 (PNCTI) was formulated, which highlighted the desire for inclusion and the attempt to plan in the long term. In 2005, the Organic Law of Science, Technology, and Innovation (LOCTI), was approved, establishing unprecedented aspects regarding participation and financing. An attempt was made to expand the S&T ecosystem by incorporating the private sector as both promoter and executor of these activities. A novel element was the establishment of the obligation for large companies to invest in and/or contribute to S&T, which significantly increased resources and had, until 2009, a mobilizing effect on the industry around innovation. To promote inclusion, programs for the dissemination and popularization of science were designed, as were socio-productive networks that incorporated various actors, integrating scientific and technological knowledge with traditional, ancestral, and popular knowledge.[26] These efforts failed due to the lack of institutional capacities that would ensure their sustainability.

[25] Laya and Vessuri 2019.

[26] Mercado and others 2014.

Taking advantage of the increase in State income from the upturn in oil income, an attempt was made to develop technological capabilities. Trying to overcome supply-side views, institutions were created in the areas of ICT, aerospace, and chemistry, and existing institutions were strengthened. But in contrast, a rift began to form with autonomous universities, which were critical of some Government actions. However, during 2006 and 2007 some of these universities benefited from LOCTI, attracting significant resources from the private sector, which allowed them to strengthen research capacities. It should be noted that, even though, thanks to LOCTI, there were efforts to increase university-productive sector links, a culture of intramural research continued to prevail in these institutions, with little development of technological activities. It should be noted that a high percentage of what were declared as S&T activities by the companies in question did not actually correspond to these activities, and a good part of the proceeds were not used for projects. Hence, the impact of the law, although positive, was not proportionate to the amounts reported.

In 2008, LOCTI and PNCTI guidelines were questioned, in a reflection of the political turnaround that began in 2007. Many promoters of the law and plan, including some who had made careers in CONICIT and later in the Ministry, left the Government, causing a clear institutional breakdown and marking the beginning of a sustained deterioration. In 2010, the LOCTI was reformed without further consultation. This imposed a biased political orientation in violation of the constitution by establishing that policies were oriented towards coordinating and integrating CTI actors to contribute to the strengthening of popular power. In terms of CTI dynamics, the most significant change was to convert the obligation of companies to invest in themselves and/or contribute, into a tax that FONACIT would administer at its discretion. The elimination of the previous system put an end to technological efforts that were beginning to be implemented, which included, in some cases, participation from universities and R&D centers.

There was a centralization of politics, increasing a markedly sectarian top-down management style. An attempt was made to align institutions with the socialist project in order to promote useful research and innovation.[27] Paradoxically, this meant a regression to supply models, with the aggravation of having a vague and above all erroneous conception of what "science for the people" is[28] rather than a *scientific* vision.

One factor that contributed to this distortion was the Science Mission that was announced by the Executive Power in 2006. The mission's purpose was "that society take possession of knowledge and begin to generate it […] to increase wealth, strengthen self-management, and make social welfare accessible to all". It was part of the strategy to create a parallel institutionality to accelerate the Executive Branch's political actions and plans without interference from other areas of the State. Apart from bloating the bureaucracy, most of the programs that were proposed overlapped with those promoted by the Ministry. In fact, much of the discretionary and wasteful use of resources was through this mechanism, which, in turn, was one of the main promoters of the system's politicization.

[27] http://www.mcti.gob.ve/Ciencia/Programa_Proyectos_Estratégicos

[28] Ávalos and Mercado 2019.

Support for R&D focused on the Ministry's institutes, experimental universities, and new Bolivarian universities, in which the politicization of the technical and scientific functions prevailed, severely affecting the capacities that in some cases were beginning to develop. The autonomous universities were pushed into the background, with increasingly reduced access to financing, and the private sector was no longer considered an SNCTI actor.

In 2014, a new modification of the LOCTI was approved, which reinforced companies' control of resources, and articles were eliminated that established the possibility of public and private actors opting for funding from the aforementioned. Resources allocated to science and technology would increasingly depend on this tax, rising from 4% in 2009 to 45.5% in 2015.[29]

From that year onwards, institutional deterioration accelerated, recording, together with high turnover of officials in senior positions in the most important government agencies, a significant decapitalization of professional and technical staff in the Ministry and its agencies. The consequences of this were a substantial decline in the Ministry's management capacities, which translated into the disappearance or paralysis of important programs; limitations on the collection, processing, and generation of information; and loss of monitoring and control capacities, with the exception of LOCTI control, around which an important bureaucratic structure was consolidated.

Availability and use of financial resources

In the second half of the first decade of the twentieth century, the conjunction of the increase in oil revenues and the obligation that companies had to contribute resources to science and technology increased the resources allocated to S&T, increasing, according to data from the ONCTI, from 0.38% of GDP in 2004 to 0.66% in 2008.

The modification of the LOCTI produced an increase in the Ministry's financial resources, but not in investment in S&T. In 2009, the year in which oil prices collapsed due to the global crisis, 16 million US$ in contributions were collected. Contributions recovered in 2010 when they reached 48 million. It must be remembered that until that year companies could invest in or contribute to STI activities. In the following two years, with the tax having already been established, revenue experienced a substantial increase and reached 360 million US$ in 2012, coinciding with high volumes of oil exports and record Venezuelan basket prices of 103 US$ per barrel, which significantly increased income (Graph 3).

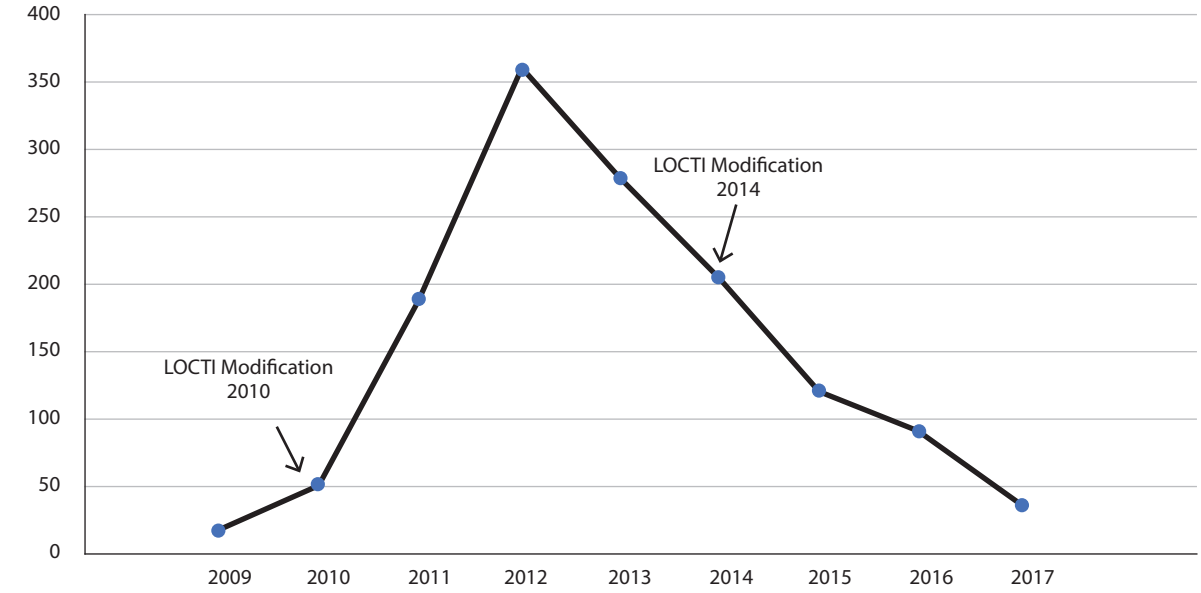
Table 2: Ordinary resources in science, technology and innovation in relation to GDP. 2004–2015

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
%	0.38%	0.52%	0.74%	0.68%	0.66%	0.64%	0.45%	0.34%	0.53%	0.66%	0.76%	0.40%

Source: ONCTI, 2017

[29] ONCTI 2017.

Graph 3: LOCTI tax collection (millions US$)



Source: Our calculations based on MCTI Statements from 2011 and 2012; ONCTI's 2017 Statement; and several years of statements from BCV

From 2013 onwards, LOCTI tax collection began to show a continuous decrease. In 2017, revenue barely reached 34 million US$, less than 10% of the 2012 tax income, which placed it at a lower level than in 2010, when it was not a mandatory contribution. The sharp drop in economic activity in the previous two years worsened this situation and further reduced research resources.

The high inflow of LOCTI resources between 2011 and 2013 could have enabled the SNCTI to strengthen R&D capacities. It should be remembered that the law establishes that the resources from this contribution are set aside to "finance science, technology, innovation activities and their applications". However, in 2012, the peak year, the resources allocated to projects barely exceeded a third of what was collected (20.5% to research, development, and innovation projects, and 17.3% to industrial development, energy and oil, and telecommunications projects) (MCTI, 2013). This behavior appears to have continued. In 2015, the S&T Commission of the National Assembly highlighted that, according to the MCTI's report and account, 14 billion bolivars entered LOCTI, of which 6 billion were invested, that is, 43%. The fate of the remaining 8 billion is not specified.[30]

In addition to the decreasing availability of resources for R&D projects, was the discretionality in the allocation of these.[31] In fact, in 2016 the last public call for Research, Innovation, and Knowledge Socialization Projects was announced. However, no information on their results was obtained. In addition, as has been indicated, the granting of resources for projects (in general) was preferentially directed to the institutes attached to the Ministry and the experimental universities. From the information contained in the reports, it was possible to establish that the budgetary

[30] Asamblea Nacional, 2017.

[31] It is known that a significant part of these resources was diverted to cover other expenses, such as payroll payments, and infrastructure and equipment for programs in other areas.

Table 3: Percentage of investment in projects in IES. 2011-2014

Institution type	2011	2012	2013	2014
Experimental	28.4%	51.0%	39.4%	47.0%
Autonomous	67.9%	41.1%	57.1%	24.4%
Polytechnics	2.9%	3.6%	1.9%	11.2%
Colleges and university institutes	0.9%	4.3%	1.7%	17.4%
Total	**100%**	**100%**	**100%**	**100%**

Source: ONCTI, 2017

allocations for this item awarded to bodies attached to the Ministry were greater than those given to autonomous national universities and the Simón Bolívar University, which historically have been responsible for the bulk of the country's research.

The intention existed from 2005 to 2010 to reduce this concentration, promoting capacities in experimental universities and other organizations. But after 2011, a net decrease in support for autonomous universities was evidenced. In fact, their share of research resources allocated to HEIs fell by almost a third, from 68% in 2011 to 24% in 2014 (Table 3).

Thus, even though in the first years there was an intention to strengthen R&D capacities, sectarianism began to suffocate the institutions that had historically borne the weight of the country's research. And although efforts were made to develop these capacities in other institutions, they did not escape sectarian practices and politicization, as management bodies themselves failed to do. This resulted in the literal destruction of many promotion and execution capacities. The economic crisis further aggravated the situation.

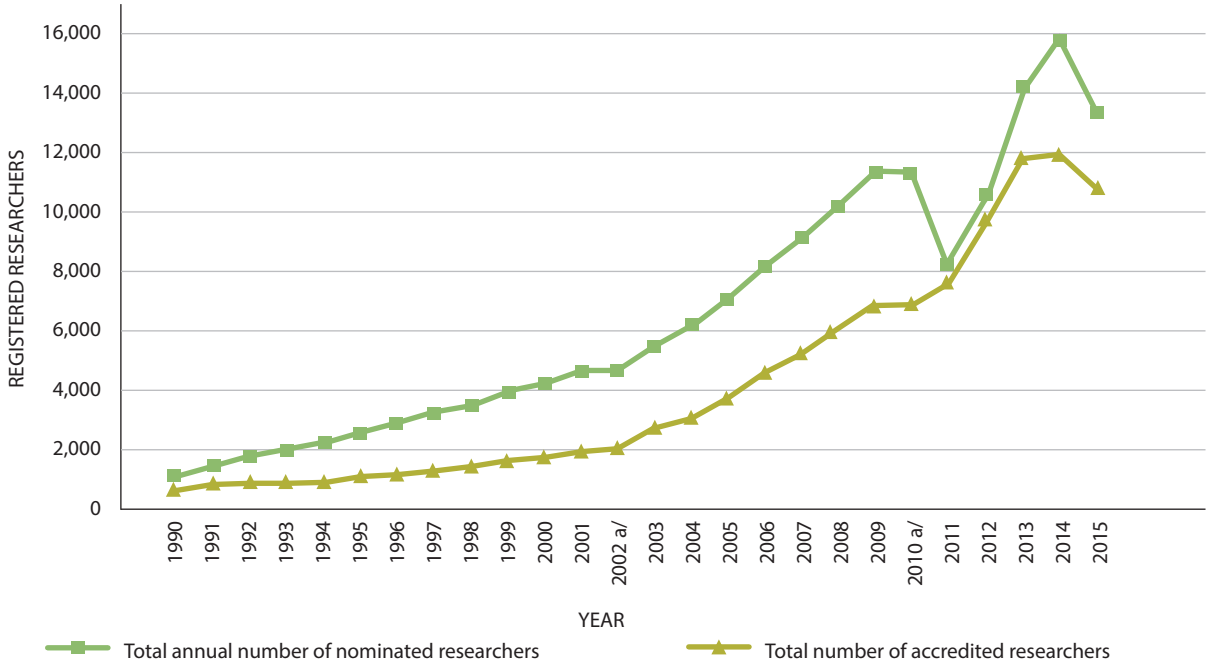
Another clear example of decreased support for research can be seen in the evolution of support programs for researchers. Since the implementation of the first Researcher Promotion Program (PPI, as per its acronym in Spanish) in 1989 to 2001, the number of accredited individuals progressively increased, reaching 2,094 (year-on-year growth of 10%) (Graph 4). Between 2001 and 2007, the rate of accreditation increased (22% year-on-year), a consequence, on the one hand, of the increase in investment and, on the other, of changes in the entry criteria used to assess the training of new researchers[32]. This trend continued until 2010. In 2011, the PPI was replaced by the Program to Stimulate Innovation and Research (PEII, as per its acronym in Spanish), with two categories (innovator and researcher).

The entry criteria were broadened for the former category and included topics such as work and community participation. As a result, the valuation of formal knowledge production and dissemination activities decreased, and the number of accredited individuals increased considerably to close to 11,000 in 2015 (Graph 4). The last call was made in 2015, and the last allocations were made in 2016. The program was paralyzed, and no official explanation was ever provided. It should be noted that these programs helped prevent the brain drain at critical times in the 1990s.

Information management

Another problem that shows the weakening of management is the availability and

Graph 4: Nominated researchers vs. Accredited researchers in ONCTI programs. 1990-2015



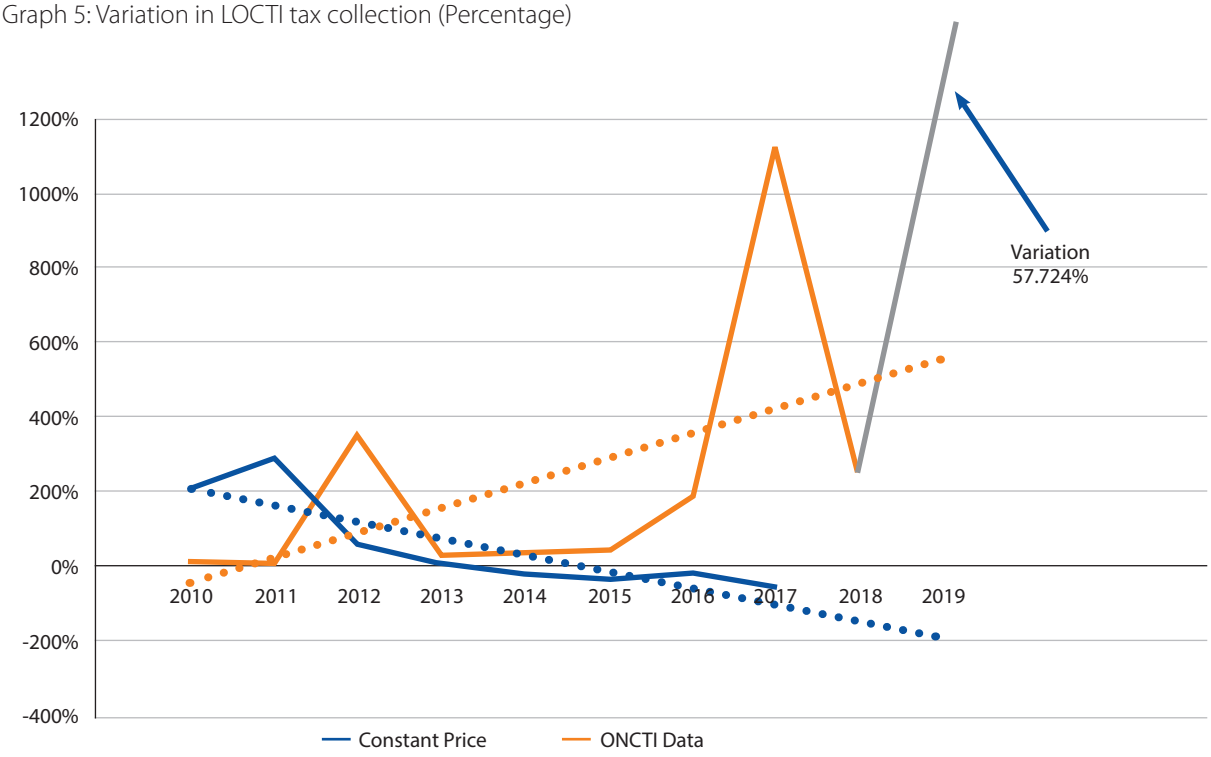
Source: ONCTI, 2017

quality of information on S&T, which makes it difficult to develop instruments for its recovery. This is partially the result of the Government's deliberate attitude to not provide this information. In fact, the Ministry's Annual Report and Account, which must be submitted to the National Assembly, was made for the last time in 2016. It is also surprising that much of the information on the Ministry's policies and programs and the historical statistical series on projects and resource allocation are no longer available on the relevant web pages.

On the other hand, the loss of technical capabilities is reflected in the quality and reliability of the little information available. The latest data on S&T cast many doubts. Serious problems are to be found, as seen, in the series on research personnel, which, despite the fall in financial indicators from 2012, show a positive trend and continued to increase steadily until 2015. The same is observed in the management of economic indicators. A clear example is the report on the percentage variation of LOCTI tax collection, which is available on the ONCTI website. This information is presented without indicating whether the values are given at current or constant prices. Consequently, disproportionate increases in revenue, which reached 57,724% in 2019 compared to the previous year are observed. In contrast, the data are presented adjusted —as much as is possible— to the value of the US$ (Graph 5).

Significant distortion in information production, politicization charged with sectarianism and exclusion, and the impoverishment of policy formulation and monitoring and control capacities, show the urgent need to rebuild S&T institutional framework. This will be essential to promote the creation of an S&T ecosystem capable of responding to the country's enormous demands.

Graph 5: Variation in LOCTI tax collection (Percentage)



Source: Own preparation

As a preliminary conclusion, it can be said that some institutional milestones at the beginning of the century were a sign of change in State support of S&T. One highlight was the enactment of LOCTI and PNCTI in 2005, which opened up opportunities to increase resources for these activities and expand the science and technology ecosystem. But these initiatives did not last long, since everything began to change rapidly in 2008 with the decision to implement a socialist model that tried to place the country and these activities under ironclad State control which in the end led to their dismantling.

STATUS OF NATIONAL CAPACITIES FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT

Overview

Over the last two decades, the Venezuelan higher education system has undergone important changes as a result of government policies directed at this sector. Between 1999 and 2001, the Chávez government's policy for the sector was formulated with the broad participation of specialists, with the goal of strengthening the role of the State as the governing body of education and increasing coverage and quality.[33] Public enrollment increased by 10%, higher than that registered in the entire preceding decade (1990-1999), which had corresponding levels of 8%.[34]

Economically there were improvements, because after many years, a real recovery was observed in the salaries of higher education teachers.

But as of 2002, the government abruptly abandoned the policies that had been partially implemented until then, at which point political tensions began to arise with the autonomous universities, as a result of the intention of exercising greater political control over them. It should be noted that, to date, these constitute the only institutional environment where the government has not been able to do so.

With the creation of the Sucre Mission in 2003, a parallel structure began to be formed, which was intensified in 2009 with the Alma Mater Mission that was created in order to instill "a new institutional fabric of Venezuelan higher education."[35] Between 2003 and 2019, the number of public universities increased by 310% with 42 university institutions created by decree

Table 4: Venezuelan universities (1998–2019)

	Public universities					Total Universities Public	Universities Private	Total
Period	Autonomous[1]	Experimental	Nationals[2]	Territorial	Specialized[3]			
1998	7	9	1	-	-	17	17	34
1999–2002	7	12	2	-	-	21	23	44
2003–2019	7	14	6	22	13	62	29	91

[1] *The USB and UCLA are included, since despite being experimental, they were recognized as having the right to internally choose their authorities. Recently this has begun to change with the appointment of authorities by the Government.*
[2] *It includes two university institutes created in 2008 and 2009.*
[3] *Seven of them have the character of experimental universities.*

Source: Own preparation based on Stephany (2019); Morles and others (2003).

[33] Castellano 2010, in Parra Sandoval 2015.
[34] Morles and others 2003.
[35] Official Gazette No. 39,148, March 27, 2009.

Source: Own preparation based on Stephany (2019); Morles and others (2003).

(Table 4), including the transformation of previously existing technological institutes and university colleges into regional polytechnic universities. This new institutional framework is subordinate to the National Executive, lacks autonomy, and with the establishment of the National Training Plans (PNF),[36] do not have any academic freedom either.[37]

According to figures from MPPES (2008), between 1998 and 2007, enrollment experienced a strong increase concentrated in the parallel system, going from 668,109 to 2,135,146 students. Although there were quantitative inclusion achievements, these declined drastically and by 2015, 91.23% of enrollment was concentrated in 17 autonomous public universities and the USB, with only 9.77% in Bolivarian universities.[38] With regards to the quality of education and the qualifications of these institutions' graduates, significant well-founded doubts have arisen. Economic conditions, and the lack of a precise academic career for teaching staff lie at the roots of the problem.

This process is accompanied by the creation of parallel government-controlled university representative bodies that have occupied different spaces. Thus, in the decisions made in the CNU as the governing body of the university education system, the numerical majority of the members of the Association of Bolivarian Rectors (ARBOL) designated by the MPPES, is able to impose itself before the Venezuelan Association of University Rectors (AVERU), which is made up of authorities from the autonomous universities. Additionally, there has been a growing concentration of decisions on higher education by the national government, taking powers away from traditional universities and thereby undermining their autonomy.[39]

As part of the control measures exercised by the government through the OPSU, budget suffocation is applied. The university budget has been in deficit since 2006 (Table 5), and is used almost exclusively to cover payroll, meaning that universities have had to cut operating and maintenance costs. Between 2010 and 2014, the university budget was reduced six times in absolute values.[40] The phenomenon of hyperinflation unleashed in 2015 deepened the collapse of the university.

The budget deficit has had a negative impact on the provision of services and benefits to students, teachers, and university workers. Student scholarships are insufficient (less than two dollars a month) and their politicization has been reported.[41] The application of a regressive salary policy and the unilateral imposition of an insufficient salary table not adjusted to the inflationary index, ignoring union representation and collective agreements, has brought the real salary of university workers to subsistence levels which do not even cover basic food needs. A university professor on the highest scale (Exclusive Dedication Professor) who would have earned a salary equivalent to 2,456.12 US$ in December 2001, went on to receive the equivalent of 12.42 US$ in December 2018. This reduced salary barely covers 17.63% of the products in the food basket, which represents a wage loss of -99.49% in 17 years.[42]

[36] The PNFs are prepared, modified, or eliminated by the ministry responsible for university matters while universities are limited to administering them. National Plans for Advanced Training (PNFA) were also created. These are parallel postgraduate courses created with the same characteristics as the PNF.

[37] EPIKEIA 2019.

[38] Rodríguez Raga 2019, in Stephany 2019.

[39] Parra Sandoval and Núñez-Torres 2016.

[40] Stephany 2019.

[41] EPIKEIA 2020.

[42] Stephany 2019.

Table 5: Allocated budget and budget deficit at autonomous universities. 2018–2020

University	2018		2019		2020	
	Assignment	Deficit	Assignment	Deficit	Assignment	Deficit
LUZ	1%	99%	0.14%	99.8%	2.25%	97.70%
UDO	10%	90%	11%	89%	-	-
UC	11%	89%	-	-	-	-
UCV	20%	80%	32%	68%	9.80%	90.20%
ULA	30%	70%	-	-	2.54%	97.70%

Source: CEDICE (2019) and Aula Abierta (2020), prepared with sources from public universities

Loss of Research Capabilities

The number of researchers in the country is key when inventorying national techno-scientific capabilities. Historically, this number has been low, to the point that it has never even reached the minimum necessary set by UNESCO (1 researcher per 1,000 inhabitants). According to the ONCTI, in 2016 there were 10,382 researchers.[43] Taking into account the UNESCO criteria, the country should have about 30,000 scientists (there would therefore be a deficit of around 20,000 researchers). However, studies indicate that the official figure is bulky, because the criterion that defines what a researcher is was modified, making it broader and far from the standards. If, then, only researchers as they have traditionally been defined are counted, the number drops to 6,831.

Currently this figure should be significantly lower due to the massive resignation of teachers, and their going abroad. It is estimated that 2,084 researchers have emigrated in the last 18 years, the majority of whom did so after 2014.[44] The real loss of human capital is difficult to estimate because in addition to resignations, early retirements and unpaid leave must be considered. This decapitalization constitutes the largest and most serious dismantling of research and training capacities in higher education in the recent history of Latin America, only comparable to the exodus of researchers that occurred in Argentina in the late 1960s as a result of the military coup.

It is important to highlight not only the quantitative impact, but also the impact in terms of the distribution of capacities across scientific disciplines in recent years. According to RICYT data based on information provided by the government, in 2008 the natural sciences grouped the largest number of researchers (32.5%), followed by the humanities (24.2%) and engineering and technology (12.3%). This proportion changed in 2016, with social sciences and humanities accounting for almost half of the researchers (28.8% and 20.3% respectively), while the other 50% was distributed in smaller portions among natural and exact sciences (24.3%), engineering and technology (9.9%), medical sciences (7.6%), and agricultural sciences (9.2%).

Although these data provided by official bodies present serious problems of statistical reliability, the increase observed in the social sciences could be explained - from a qualitative perspective - as the result of the aforementioned policy, of broadening the

[43] ONCTI 2017.

[44] Ten and others 2020.

criteria of what scientific research means, and, consequently, of who are considered researchers-teachers; as well as by the deployment of a parallel system of institutions, which, from academia, support the political proposal of socialism of the 21st century at a discursive level. Not surprisingly, most of the undergraduate and graduate degrees in the parallel university system are linked to the areas of social science and humanities. In this sense, unlike other authoritarian contexts, in which political power suppresses dissent and criticism that has commonly been associated with social and humanistic thought, in Venezuela the government has managed to instrumentalize an important part of the intellectual production of the social sciences and humanities as a valid and "neutral" framework of interpretation of the Venezuelan political process.[45]

This quantitative predominance of the social sciences and humanities, over the rest of the scientific disciplines, is contradictory since it is the autonomous universities (UCV, ULA, LUZ, among others), which have historically supported the bulk of social and humanistic research in the country. In the face of the weakening of the research and teaching capacities of these institutions, the parallel system seems to have gained space and captured resources. An example of this is the Miranda International Center (CIM, as per its acronym in Spanish), created in 2006 as a result of meetings of left-wing intellectuals (both national and international), called Encounters of Solidarity with the Bolivarian Revolution. Many of these institutions operate as foundations and are attached to agencies other than the ministries of science and technology or higher education.

It is also important to note that some private universities have increased their research capacities. Such is the case of the UCAB research groups on poverty and humanitarian crisis. A fundamental factor has been the administrative flexibility that has allowed them to access international financing, either independently or through NGOs.

Consequently, it should not be assumed that the country has sufficient scientific capacities in the social sciences and humanities. It has been observed that, in accordance with the crisis and the possibility of obtaining resources, the capacities and research agendas of both areas are generally diminished. This means that in addition to strengthening them, a large part of their work agenda must be transformed to adapt to the techno-scientific transformations that shape the 21st century, which entail, among other things, a reorientation related to joint work with other scientific and technical disciplines.

Deterioration of higher education institutions and its impact on research

In the last five years, the circumstances in higher education institutions, but also in research centers attached to the State, has notably worsened. The chronic and growing budget deficit has had severe consequences: a decrease in research professors, the disappearance of scholarship programs, the closure of postgraduate programs, the deterioration and obsolescence of facilities and equipment, a decline in the situation of students, and long negative consequences that lead to the loss of research capacities and the possibility of offering quality academic training.

[45] This strategy goes far beyond the national sphere. In general, the doctrine of 21st century socialism had until very recently, the support of a large part of the international academy, mainly in networks such as CLACSO and LASA, as well as in more political spaces such as the World Social Forum and the Sao Paulo Forum, as part of the so-called "turn to the left" that took place in Latin America at the beginning of this century.

Table 6: Percentage of investment in R&D of higher education institutes in relation to allocated annual budget 2004–2015

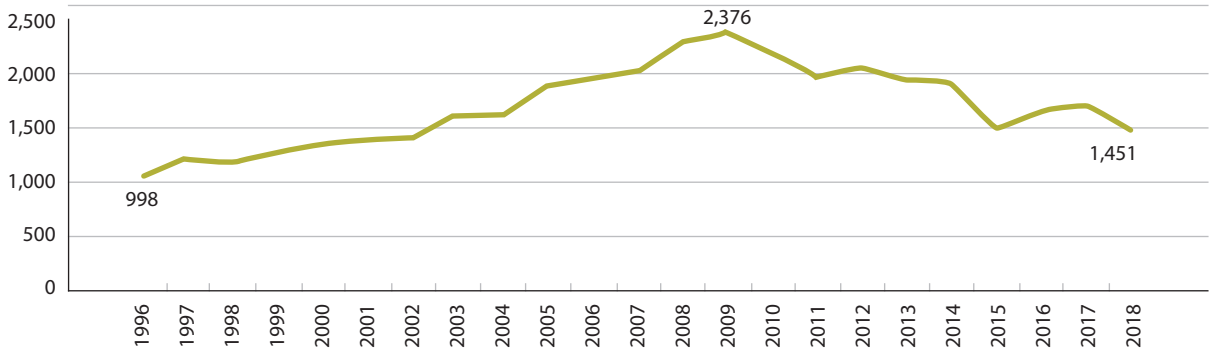
University education institutions	Year											
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
University Institutes and Colleges	0.38	0.59	0.57	0.27	0.56	0.25	0.07	0.67	2.69	0.15	0.01	0.02
Autonomous Universities	6.12	6.58	9.87	5.02	4.5	5.62	2.42	2.69	3.34	3.3	1.15	0.95
Experimental Universities	6.66	6.05	4.91	2.72	2.06	2.9	1.18	2.06	1.6	1.23	0.44	0.29

Source: ONCTI, 2016

The infrastructure for teaching and research has suffered an unprecedented deterioration that, together with service failures and crime, make it very difficult to carry out these activities. The current investment in STI is practically nil (Table 6). Of the ordinary budget assigned by the Executive Branch to autonomous universities, the percentage allocated to research is barely 2%.[46] From 2004 to 2017, US$ was invested in materials and supplies for teaching and research (books, laboratory equipment and reagents, computer equipment and software, etc.), with a marked divestment throughout the aforementioned period. In 2017, the allocated budget for this item was 52,383 US$, corresponding to only 1.65% of what was granted in 2004 when 3,176,400 US$ were allocated. Budgetary allocations for the acquisition of computer packages and programs and telecommunications are those with the lowest budget, followed by resources designated for books and magazines. Only 3 US$ was allocated in the 2017 budget for the latter.[47]

After ten years of budget reduction in research, the consequences are reflected in the decrease in Venezuelan production of articles in indexed and refereed magazines. Sustained growth in scientific production started in1996 and then began to decrease as of 2010 (Graph 6).

Graph 6: Venezuelan production of scientific articles 1998-2019



Source: Ramírez, 2020

[47] EPIKEIA 2019.

Venezuela's percentage contribution to the total production of scientific articles in Latin America and the Caribbean went from 4.7% in 1998 to just 0.8% in 2018.[48] Venezuela progress in science went back to 1950s levels. The decline is also reflected in the RICYT. In 2008, the country reached its highest peak after publishing 1,730 articles in the Science Citation Index. Colombia surpassed it with 823 publications more. Colombia's productivity continued to grow, reaching 5,692 documents in 2016, while Venezuela's productivity began to decline, dropping to 1,033 articles that same year.[49]

Loss of research capacities in health and food safety

The loss of research capacities in health and food safety has profound implications for the future, as these are fundamental not only to reverse the humanitarian crisis that the country is going through, but also to generate the conditions necessary to enable its economic and social recovery. Some of the triggering causes for this are the mass resignations and retirements, as well as the migration of professors/researchers from both areas during the recent years.[50] This situation is aggravated by the aging observed among the research community since the 1980s and which has intensified since 2000.

According to Diez et al. (2020), Venezuela has lost 16% of its research force as a result of migration, mainly in recent years.[51] In the case of medical sciences, the loss is as high as 19%, while in agricultural sciences it is 10%.[52] Some partial data on the situation reveal that in 2015 the UCV Faculty of Medicine had about 900 professors, a figure that has dropped to about 600 in 2020[53]. In 2018 this faculty reported the loss of around 25% of its professors, without accounting for retirees and or those on leave[54]. In 2020 it is estimated that the decapitalization of the teaching staff is already around 35% (between 20–30% for the basic area, 30% in the clinical area, and between 40–50% in public health). Only 5% of the teachers are full professors and 9% are associate professors[55].

In food safety, the number of active teachers and/or researchers has been reduced to 47% due to retirements, resignations, abandonment of positions, and lack of interest in pursuing a research career, a reality that is also seen among technical and service personnel. Additionally, the remaining staff have reduced their dedication to the university, concentrating on teaching to the detriment of research and extension activities. In doing so they can practice professionally outside the institution and supplement their salary[56].

Another phenomenon that is repeated throughout the research system is the increase in requests for sabbaticals (paid and unpaid), and research periods, etc., which are constantly extended[57]. These mechanisms, which were ideally created to promote mobility and national or international academic exchange, now serve as a bridge for emigration researchers. Due to these gray

[48] Ramírez 2020.

[49] Inojosa 2019.

[50] In addition to the economic crisis, political polarization and the criminalization of protests have also provoked the loss of capacities. The university union has also been persecuted as a result of the multiple protests for labor claims. The Venezuelan state has exercised direct violence against union members, attacking their assets and the headquarters of some of their associations, and have also repeatedly violated university campuses to suppress both union and student protests (Stephany 2019).

[51] Diez and others 2020.

[52] Requena and Caputo 2016.

[53] Key informant interview, 07/31/2020.

[54] Stephany 2019.

[55] Key informant interview, 07/31/2020.

[56] Clavijo 2020.

[57] Stephany, 2019.

areas, it is very difficult to estimate the real degree of permanence or desertion of the personnel available for research in both areas.

The renewal of research staff is also seriously compromised. Student enrollment at the UCV Faculty of Medicine went from 6,304 students in 2012 to 2,400 in 2018[58], putting the possibility of having a replacement generation that could enable the recovery of the national health system and particularly research capacities at risk. In the case of the agri-food sector, undergraduate enrollment has dropped to a third (34%) compared to a few years ago. A similar situation is observed in postgraduate studies, where enrollment is 40% of that which was recorded ten years ago, due in part to the difficulty in carrying out the research component that is necessary to complete the training process[59].

The precarious conditions in conducting health and food safety research

The strangling of the university budget, as well as that of autonomous research institutes, has eroded research resources. In 2018, the UCV School of Medicine's budget was only about 8.11 US$ according to the official rate. This school is one of the largest at UCV and with the highest student enrollment at the university and in the country[60].

As of 2015, both universities and research institutes stopped receiving foreign currency to import supplies and equipment for research. This situation severely limits, if not eliminates, the possibility for professors/researchers to offer internships for teaching purposes at both undergraduate and graduate levels; attend scientific events; access updated literature; carry out field work or experimental research, which requires constant replacement of instruments and supplies; or to maintain, repair, or replace laboratory equipment.

According to estimates on research at the UCV School of Medicine, in 2019 these resources were reduced by 70%. Added to the budgetary difficulties is the risk of political persecution that teachers who investigate sensitive topics, related to the collapse of the health system, the reappearance of emerging diseases, or the recent active epidemics in Venezuela, including that of COVID-19 are exposed to. The worsening of the crisis generated by the pandemic also compromises the continuity of postgraduate courses, given that residents cannot complete the number of interventions required to complete their studies, given that they work in deplorable conditions due to the lack of supplies and equipment and exposing themselves to a high risk of contagion[61].

Recent studies report that in careers such as medicine, bioanalysis, veterinary medicine, and engineering, largely theoretical training is being given, since practical exercises have been reduced or limited to demonstrations. Of the seven existing bioanalysis schools, three are technically closed due to lack of reagents (ULA, LUZ, and UC). The Anatomopathology Institute at the UCV (the main reference source for the classification of some neoplasms) has been technically closed for more than two years due to lack of materials for tests, which meant that the immunohistochemistry service lost its ability to determine tumor markers[62].

The situation of the state company Quimbiotec evidences the crisis in the field of RDI. In 2011, Quimbiotec satisfied 95% of the national demand for blood products.

[58] Provea 2018.
[59] Clavijo 2020.
[60] Provea 2018.
[61] Key informant interview, 07/31/2020.
[62] Stephany 2019.

As a result of inefficient management, it was paralyzed in 2015, compromising the continuity of operations. Since then, technological diversification projects involving the construction of plants for recombinant pharmaceutical products, ophidic and scorpion antivenoms, and vaccines against influenza A have also been paralyzed.[63]

For its part, in the UCLA's Agro-industrial Engineering course it has not been possible to restore the equipment inventory for about five years, and laboratory materials have not been replaced for at least 13 years.[64] This situation extends to the entire agri-food training and research system. Plants where technological contributions are developed for the processing of vegetable and animal products, particularly milk, lack equipment and supplies. Fieldwork, essential for agricultural research, has been practically paralyzed for years due to a lack of vehicles and supplies needed to carry out tests, as well as the lack of resources to cover associated expenses.[65]

Regarding research institutes in the agricultural area, the State Research Center Foundation for Agro-industrial Experimental Production (CIEPE), which is attached to the MPPCT, stands out. Its pilot plant is paralyzed, which has decreased its operational capacity to the point that is able to provide only some laboratory analysis services for water, microbiology, and physicochemical characteristics of products.[66]

In the IVIC, an institution that in 2015 reported 110 investigations in the health area and nine in the agri-food sector[67], the situation is no different. Data from 2018[68] show that 75% of laboratories are paralyzed and 24% of researchers have emigrated. Of the 28 postgraduate courses offered at IVIC, only 13 opened in 2018. However, only two students entered, a figure that is far from the 83 who entered in 2014. The Marcel Roche Library, declared by UNESCO in 1996 as the Regional Reference Center for Latin America and the Caribbean, has not updated its subscriptions to international scientific journals since 2015.

It is important to mention that part of the training, research, and extension activities that the universities still carry out are completed thanks to donations from graduates in the case of health, and financial support from agricultural producers, individually or through organizations created by unions with private contributions linked to the agri-food sector[69].

Regarding the parallel health education system in health, the creation of the University of Health Sciences (UCS); the Paulo Freire Latin American University Institute of Agroecology (IALA); the Argimiro Gabaldón Rural University of Venezuela (UCVAG) and the Comprehensive Community Medicine degree at UBV stand out. Countless questions have arisen about the latter, mainly concerning the fact that the UBV does not have a medical school, so the degree was created in an improvised fashion, with a curriculum designed that ignored the CNU and was entrusted to the Cuban Medical Mission.[70] Continued pressure from the Executive Branch to incorporate graduates into the Venezuelan health system has also generated significant criticism, from their inclusion in the Barrio Adentro program to

[63] SIC Magazine 2016.

[64] Stephany 2019.

[65] Clavijo 2020.

[66] Clavijo 2020.

[67] IVIC 2016.

[68] ASOINIVIC survey given to heads of IVIC laboratories and research and service units.

[69] Clavijo 2020.

[70] Ramírez, 2020.

the recent attempt to allow community doctors to perform clinical work.

Loss of engineering and technology capabilities

By the middle of the decade, the loss of research capabilities was estimated at 16%.[71] In the specific case of the Central University of Venezuela (UCV), it is estimated that about a third of its teaching base has been lost this decade. Of the 5,800 active teachers that the UCV had at the beginning, only 4,300 were left at the end of 2017[72], a situation that has worsened in recent years.[73] The dismantling of research and teaching capacities is visible in this institution's Faculty of Engineering (FI, as per its acronym in Spanish). Information provided by the Research Coordination area highlights that its nine schools and four research centers have registered a significant reduction in personnel. A third of the teachers, the majority at an intermediate point in their academic careers, resigned, and a slightly smaller percentage retired, so the decapitalization of the teaching-research staff exceeds 55%. As a consequence, faculty research and teaching have been supported by a small group of teachers who, for the most part, already have enough time accumulated to request their retirement. The question arises: if the situation does not change, what will happen when these staff members leave? The situation is worsened by the fact that the few calls for applications to cover positions are left deserted mainly due to the meager salary offered, something that occurs not only at the UCV, but at all national universities.[74] Apart from the loss of talent, the conditions for research at the FI are precarious. Added to the aforementioned problems is the absence of any type of funding. No new projects have been started in the last four years. Activity has been reduced to the completion of some projects, very few, that were started before 2013.[75]

Another of the universities that has been significantly affected is the Simón Bolívar University (USB), a higher education institution with a strong emphasis on scientific and technological research. USB's academic offer is mainly oriented, although not exclusively so, to careers in the engineering field.

In the 2013–2019 period, the institution's active academic staff was reduced by 20%. This decrease in active academic staff was mainly due to the departure of members of the so-called *ordinary* staff, who, in addition to teaching, carry out research and extension activities. The number of ordinary staff members decreased by 27% between 2013 and 2017.

Graph 7 shows the behavior of active academic staff by division, noting that the greatest decrease in staff was seen in the physical sciences and mathematics (36.3%), and social sciences and humanities (31%).

In addition to being the largest of the four divisions of the university, the physical sciences and mathematics division, concentrates capacities in engineering and technology in twelve departments that serve the core disciplines of knowledge in science and engineering careers.[76] Laboratory and research activity operations have

[71] Diez and others 2020.

[72] https://segundoenntación.com/venezuela-universidades-se-quedan-sin-profesores-falta-presupuesto-2017-11-27

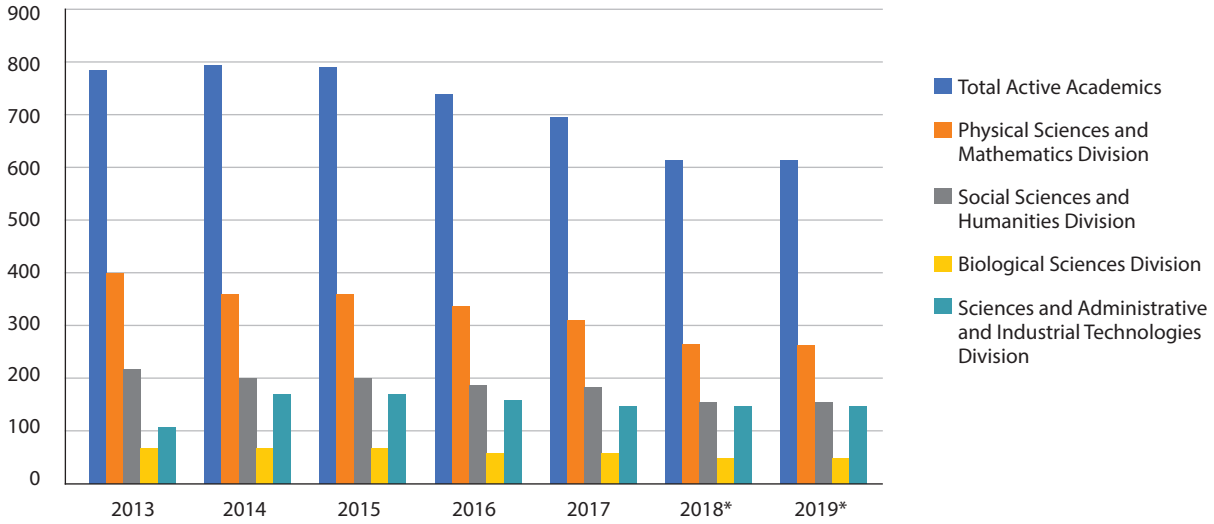
[73] http://efectococuyo.com/la-humanidad/rectora-de-la-ucv-estoy-firmando-un-promedio-de-10-renuncias-diarias/

[74] Ávalos and Mercado 2019.

[75] Ávalos and Mercado 2019.

[76] The pure and applied mathematics; physics; chemistry; mechanics; thermodynamics and transfer phenomena; electronics and circuits; energy transportation; processes and systems; material science; computing and information technology; earth sciences; science and statistics departments.

Graph 7: Active academic staff at USB by division: 2013–2019*



Notes: a) Active academic staff is the sum of ordinary academic staff plus contracted academic staff; b) information by activity was not available for the years 2018 and 2019.

Sources: USB (2018a); Statistical Bulletin 2013–2017; USB (2018b); USB (2019).

been seriously affected by the numerous resignations and retirements at all personnel levels and the difficulty in obtaining funding. However, as stated by a USB professor: "Despite the fact that they are outdated, with the existing instruments and the remaining material, especially reagents, from previous projects, some research is still being done", to which he added: "It is impressive how some groups in the institution persist and efforts are made to maintain the quality of both research and teaching".[77]

Alternatives are being explored to maintain activity and quality in the field of teaching. The program Volver a la Simón, a stimulating experience, has been promoted by the Friends of USB Association. This enables alumni of the institution to collaboratively join the institution as teachers, helping to fill some vacancies in key subjects for different courses. This initiative deserves special attention, because it could be the seed of an interesting linking process between the academic and the productive sectors, which could be used to fulfil training requirements for industry professionals.[78]

Another public university facing similar financing problems, a brutal drop in workers' real wages, and deterioration of the physical campus is the University of Los Andes (ULA). However, according to ULA's rector, Mario Bonucci, the resignation of research professors at the Universidad de los Andes (ULA) has been comparatively lower than that seen at other national universities, sitting at around 10% of the professor's payroll in 2018. Most of these professors are professionals at an intermediate point in their academic careers with postgraduate degrees. The most alarming thing in this case is student dropout, which stands at 40%. "We reached a point where we had 44,000 undergraduate students and now we barely have 30,000. This has happened in just two years." To compound the situation, 80% of students assigned to the university by the National University Entry System

[77] Ávalos and Mercado 2019.

[78] Ávalos and Mercado 2019.

(OPSU, as per its acronym in Spanish) do not enroll, mainly due to the serious economic difficulties they face.[79]

From 2010 to 2016, there was a total of approximately 100 resignations, with the faculty of engineering being the most affected (32% of the total), followed by architecture and design (18%), and dentistry (13%). However, leave may be covering up the magnitude of the problem, since, as it was seen, this is requested mainly with the objective of going to carry out research and teaching in foreign universities; but experience has shown that a good percentage of requested leave periods turn into resignations.[80] With the worsening of the economic crisis since 2018, it is possible that this situation has been aggravated.[81]

Research activities have also suffered a significant decline and those underway are projects that had already started prior to this situation arising. But in some cases, given the breakdown of teams, results are being verified with teams from foreign universities. This is done via contributions from professors who were from the ULA and who have now left, or professors who were postgraduate students at the institution. In the latter case, important cooperation initiatives have been established with some Colombian universities.

Educators, consequently, point their fingers at the crisis. Nevertheless, in trying to overcome deficiencies and lags, important actions are carried out. These include the internationalization of postgraduate courses due to the recognition of their academic quality. This has enabled postgraduate courses to be opened in other countries in the region, with teacher and student mobility, and with a mix of face-to-face and distance classes offered. This could be a tool to be used to put an end to the loss of professors and to maintain academic exchange. It could even help attract former teachers, at least via virtual participation. This requires modernizing platforms for distance and blended learning.[82]

Loss of engineering and technology capabilities in industry and services

Industrial employment, which has traditionally been of high quality, has been declining at an alarming rate. CONINDUSTRIA's Qualitative Survey on the Industrial Situation for the first quarter of 2020 points out that 62% of companies showed a reduction in employment levels for that quarter when compared to the same period of 2019. In the aforementioned survey, 36% of companies indicated that they had lost between 10% and 40% of their qualified personnel, although a lower loss of talent was observed compared to that seen in previous surveys.[83] The service sector also shows an extraordinary loss of qualified personnel. By way of example, in October 2018, in the electricity sector, just over 40% of the 50,000 workers of the National Electric Corporation (CORPOELEC), most of them professional engineers and technicians, left the company and the majority of them went abroad.

Although there is no official information, it is estimated that some 200,000 engineers have left the country in the last 20 years. They make up a significant percentage of the diaspora, particularly in Latin American countries and in Spain (Table 7).

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[79] http://efectococuyo.com/la-humanidad/en-dos-anos-la-ula-ha-perdido-14-mil-estudiantes-advierte-el-rector-bonucci/

[80] http://prensa.ula.ve/2016/04/01/cifras-de-deserci%C3%B3n-estudiantil-profesoral-y-de-personal-ato-se-han-incrementado-en-la

[81] The Antonio José de Sucre National Experimental Polytechnic University's Barquisimeto campus, especially the engineering faculty has been facing a similar situation.

[82] Ávalos and Mercado 2019.

[83] CONINDUSTRIA 2020.

Table 7: Migration of professionals and engineers in six countries (Venezuelan residents in 2018)

Country	Total of Venezuelan residents	Professionals	% of total residents	Engineers	% of total professionals
Argentina	117,519	42,337	36.00%	16,234	38.30%
Colombia	1,032,016	500,197	48.50%	90,036	18.00%
Chile	288,233	123,940	43.00%	12,395	10.00%
Peru	607,503	200,032	32.90%	42,814	21.40%
Spain	274,357	140,773	51.30%	-	-
United States	418,366	54,291	13.00%	-	-
Total 6 countries	**2,737,994**	**1,061,570**	**38.80%**	**161,479**	**-**

Source: Mercado and Ávalos 2019

Precariousness in carrying out research and technological development (RTD) activities

As indicated, the precipitous fall in the HEI budgets makes it impossible to finance any RTD activity. In addition to this, the public S&T promoter and finance organizations have not held calls since 2013. Consequently, the few projects that are currently being executed correspond to the completion of those that were already underway from previous years, and a few ones carried out with materials and research supplies left over from previous projects. This has also had an impact on a decrease in the provision of services, particularly in the productive sphere, which, due to the abysmal fall in its activity, has almost totally halted its historical demand towards universities, which was focused on analysis services and some technical assistance.

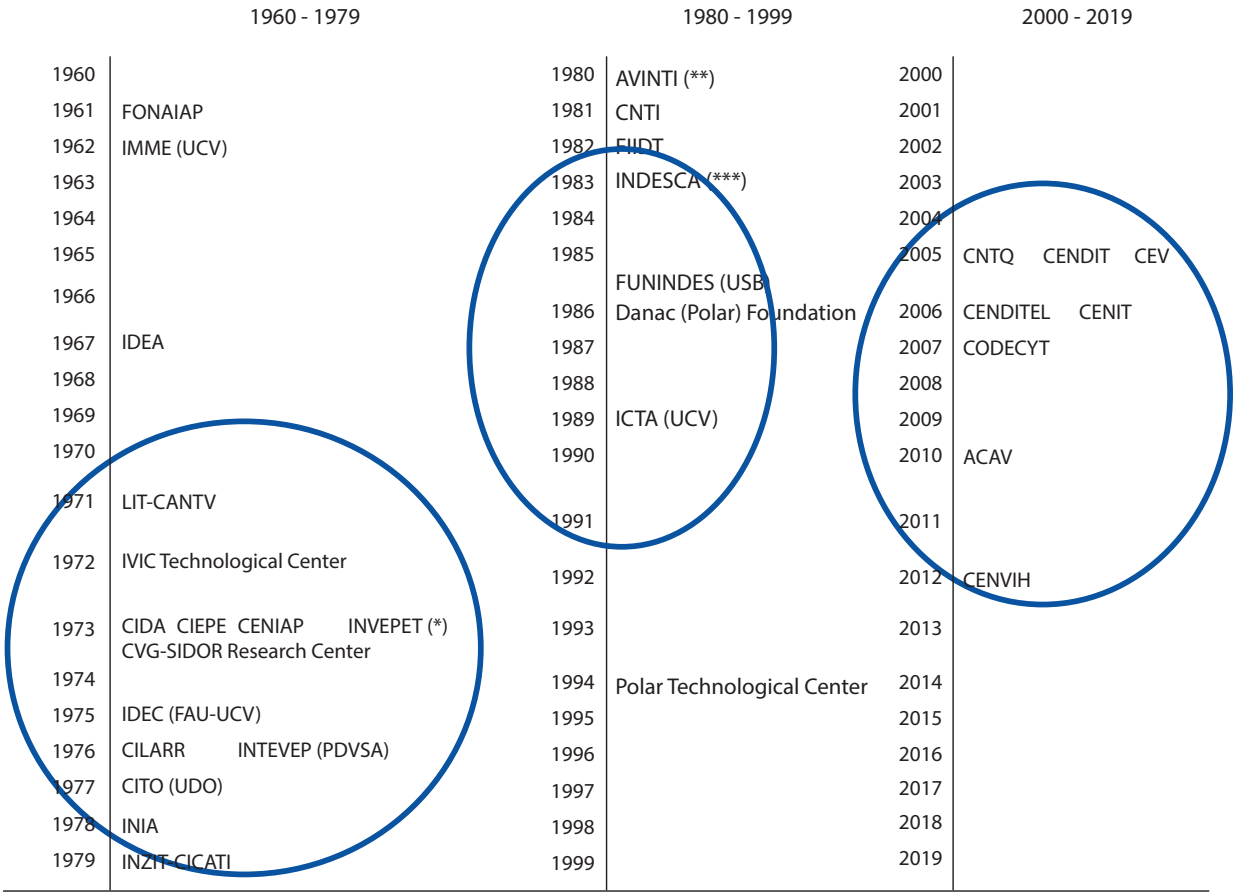
The ONCTI acknowledges this collapse in its 2016 Report and Account. In 2012, they financed 974 projects; in 2015 only 62. Much of the equipment is outdated or damaged. As an example, at the USB, the director of the Division of Physical Sciences and Mathematics pointed out that although there has been an attempt to keep the laboratories operational, they work with many deficiencies. Some pieces of equipment are over 30 years old, and others are out of service. According to the director of the Laboratories Unit in 2019, the budget for more than 180 laboratories was barely enough for the repair of the unit's truck.[84] In May, the AlumnUSB corporation donated several pieces of equipment and supplies for academic and administrative activities.

However, in the face of this negative situation, the resilience still shown by a significant number of teachers and researchers stands out as a positive element. In reviews carried out, the survival of research groups strong in terms of their knowledge generation capacity and quality and their willingness to participate in institutional recovery programs is observed. The situation is leading these groups to explore alternative ways of organizing teaching and research, highlighting the internationalization of postgraduate courses, and the effort to develop research projects collaboratively with foreign groups. This is done either with professors who have emigrated or with former foreign students who studied postgraduate degrees in Venezuela.[85]

[84] Inojosa 2019.

[85] Mercado and others 1998.

Graph 8: Technological Research and Development Centers founded in Venezuela between 1960 and 2019



Notes:

(*) The Instituto Venezolano del Petróleo ("Venezuelan Petroleum Institute") became the Instituto de Tecnología Venezolana para el Petróleo ("Venezuelan Technological Institute of Petroleum") (INVETEP) in 1973

(**) Asociación Venezolana de Institutos de Investigación Tecnológica Industrial ("Venezuelan Association of Industrial Technological Research Institutes") (AVINTI), whose founding members were: ACNTV, CIEPE, INVESTI, Centro de Investigaciones Tecnológicas de Oriente ("Oriente Technological Research Center"), and the IVIC Technological Center

Source: Own preparation based on Esqueda, et al., 2020, and other papers

Additionally, there is a great commitment from graduates to their alma mater and there are currently several initiatives led by graduates to support their universities. In addition to the graduate associations with an international reach that have been created, a scientific diplomacy initiative with Venezuelan researchers abroad stands out. This effort, led by graduates of the USB and the UCV, is aimed at mapping and identifying people who are still involved in research, in order to summon them to work towards reconstructing Venezuela from wherever they may be.[86]

Technological research and development centers

As indicated, in recent years the situation of HEIs (autonomous, experimental, and private) has worsened notably, as has that of other actors who make up the innovative fabric, such as technological research and development centers, which are mostly attached to State entities. Graph 8 presents a map of the technological research and

[86] Inojosa 2019.

development centers (CIDT) created in the country in the last six decades (1960–2019).

In the 1970s and 1980s, important steps were taken to build technological capabilities in the country, with the creation of centers and institutes linked to universities and research centers (CT-IVIC, IDEC, CITO, FUNINDES), specialized centers assigned to specific industries (INTEVEP, LIT-CANTV, CI-SIDOR), open market centers[87] (CIEPE, FIIDT, CILARR, INZIT), and a mixed capital center (INDESCA), whose activity focused on plastics technology. It should be noted that in the country RTD activities have been the object, almost exclusively, of the public sector, with two private initiatives standing out: The Danac Foundation for Agricultural Research (1986) and, later (1994), the Polar Technological Center, were both created by the Corporación Empresas Polar and continue operating today.

Among the CIDTs that appear in Graph 8, the Foundation Institute of Engineering for Technological Research and Development (FIIDT, as per its acronym in Spanish), known as the "Instituto de Ingeniería"; the Venezuelan Institute of Technology for Petroleum (INTEVEP); and the IVIC Technological Center stand out for their engineering and technology capacities.

The purpose of the FIIDT is to carry out research activities, technological development, technical advice, and services in the fields of engineering and related disciplines, connected to different national and international industries. In 1983, there were about 50 people on the FII payroll. It grew in numbers of centers and employees, reaching 258 people in 2007.[88] Although it was not possible to obtain precise information on the current situation of the Engineering Institute, it is estimated that two-thirds of the research and development staff has been lost. Figures published by ONCTI show 67 "researchers and innovators" for the period 2017-2019.[89]

In 2002, INTEVEP received up to 55% of all resources invested in science and technology in Venezuela.[90] Throughout its history it achieved 314 patents in various operational areas, although very few of them were implemented in production. At the beginning of 2003, in the midst of the national political crisis that was centered on oil industry, PDVSA authorities fired half of the personnel (scientific, technological assistance and administrative) that worked in the institution.[91] Ninety-seven percent of them were professionals and technicians, 76% were between 30 and 45 years of age, and 49% had between 11 to 20 years of experience in the industry.[92] It was not possible to find information about the institute's current personnel, but it is undeniable that the massive dismissal of researchers has affected the national capacity to produce knowledge in this area.

The IVIC Technological Center manages the portfolio of technical services offered by different research centers and support units and is aimed at both public entities and companies as well as the private sector and organized communities. These services are mainly related to the areas of health, environmental impact of

[87] Esqueda and others 1992.
[88] Callarotti 2008.
[89] ONCTI: http://www.oncti.gob.ve/INDICADORES.html
[90] Requena 2005.
[91] Requena 2005.
[92] Requena 2011.

Table 8: Entities attached to the Ministry of People's Power for Science and Technology 2017-2019

Acronym	Entity attached to the MPPCTI (2017-2019)	No. of researchers and innovators (2017–2019)	Foundation date
CIDA	Francisco J. Duarte Astronomy Research Center	40	1973
CIEPE	State Research Center for Experimental Agro-industrial Production	18	1973
CNTQ	National Center for Chemical Technology	10	2005
CODECYT	Corporation for Scientific and Technological Development, S.A.	14	2007
FIIDT	Engineering Institute Foundation for Technological Research and Development	67	1982
IDEA	Institute for Advanced Studies Foundation	45	1967
INZIT	Zuliano Foundation Institute for Technological Research	32	1979
IVIC	Venezuelan Institute of Scientific Research	237	1959
ONCTI	National Observatory of Science, Technology, and Innovation	4	2001
CEV/ABAE	Venezuelan Space Center Foundation (Bolivarian Agency for Space Activities)	18	2005
CENDIT	National Center for Development and Research in Telecommunications Foundation	15	2005
CENDITEL	National Center for Development and Research in Free Technologies Foundation	2	2006
CNTI	National Center for Information Technology	10	1981
CENVIH	National Center for Research and Certification in Housing, Habitat, and Urban Development	7	2012
ACAV	Venezuelan Academy of Agricultural Sciences	3	2010

Source: Own preparation based on official sources; number of researchers and innovators at entities attached to: http://www.oncti.gob.ve/INDICADORES.html

production processes, and the needs of the oil, chemical, and pharmaceutical industries.[93] The laboratories and units that provide the services are financed mainly with the regular IVIC budget.[94] As a result, budget cuts have seriously affected the institution's service delivery capacity.

In 2005, the CEV/ABAE, CENDIT, CNTQ, CENDITEL, CENIT, CODECYT, ACAV, and CENVIH institutions attached to the MPPCTI were created. The creation of several of these centers in the areas of telecommunications and information technologies responded to institutional policies of universal access to information and democratization of

[93] Among the most demanded services are paternity tests, dosimetry, gamma ray irradiation, lab animal housing, dosimetric calibration, diagnosis of celiac disease, plasma carnitine levels, DNA sequencing, rapid diagnostic tests (RDTs), proton services, PCR for the determination of hepatitis, cystic fibrosis, automated sequencing, and X-ray diffraction.

[94] IVIC 2015.

access to telecommunications, with ICT as enablers of the new scientific-technological model.[95] However, the results have been well below those expected, not only due to the difficult economic situation, but also because their work continues to be defined without considering users' needs, and "their growth is limited because the knowledge that is generated, which can be classified as applied research, is frequently at an early development stage that makes its use and/or appropriation difficult."[96]

Marked politicization and low salaries have caused a significant proportion of personnel to leave public institutions. The current number of high-level personnel dedicated to research and development, both in implementation and promotion, is so insignificant that it becomes practically impossible to carry out or promote major technological development activity.[97] Table 8 shows the number of "researchers and innovators" in the entities attached to the MPPCTI in the 2017-2019 period, according to the ONCTI.

[95] MPPCTI Reports 2011, 2012.

[96] Mercado 2011.

[97] Ávalos and Mercado 2019.

REINSTITUTIONALIZATION AND NEW GOVERNANCE FOR SCIENCE AND TECHNOLOGY

The economic-productive situation and the humanitarian crisis show a breakdown of the country's institutional framework, with its fundamental origins in a government that conceived its actions based on confrontation and political discrimination. In addition to this is the aggravation of trying to replace a technostructure that had good levels of professionalization for personnel with low qualifications, but which was unconditional from the political point of view. A high percentage of government senior management has come from the military sphere, with little knowledge of the areas they have been assigned to, which has had dire consequences for management. The most compelling proof of this is the accelerated deterioration of PDVSA that started in 2017, when its leadership was placed in the hands of members of the armed forces.

There are also efforts made by institutions and social groups, aimed at surviving and maintaining spaces for professional and democratic exercises. In S&T, some of these experiences have led to forms of organization and functioning that do not have support, even marginal, from the State. This is certainly unusual in a country where initiatives historically arose from or under government protection.

Examples can be found in universities, specifically autonomous and private ones. It has been seen that the former have been subjected to severe budgetary and political harassment. They have managed to survive and are practically the only public institutions in the country not taken over by Chavismo. Despite such adverse conditions, and recognizing a significant loss of capabilities, they continue to offer training plans at all levels and carry out some research. Although these universities' rankings have fallen significantly, three of them remain within the top 100 in Latin America. For their part, there are some private companies that are carrying out increasing numbers of research projects. One of them also falls into this group.[98]

Important experiences can also be found in the private productive sphere. The survivors have shown remarkable resistance and resilience, displaying, additionally, a more conscious attitude in relation to the integral role that companies must play in society. In the informal sphere, initiatives by micro-producers stand out, especially in the agricultural sector, which, although difficult to quantify, have contributed to mitigating the food deficit.

Finally, the activity of new civil society organizations stands out, in particular NGOs and foundations, which are playing a prominent role in coping with the humanitarian crisis, also participating in education-training activities and even in research, mainly on issues related to the crisis.

This response capacity possessed by various actors is key in taking on the recovery of the S&T ecosystem, which involves the reconstruction of institutions and the creation of inclusive governance based on cooperation.

[98] Ranking QS. Public: Universidad Simón Bolívar (38); Universidad Central de Venezuela (43); Universidad de Los Andes (82). Private: Universidad Católica Andrés Bello (84). https://es-urgente.com/usb-ucv-ula-y-ucab-entre-las-mejores-de-america-latina/

Differentiated institutional responses

As seen in the various experiences analyzed, responses to the economic crisis and the institutional disaster have been aimed at, above all, survival. But there are cases of more proactive responses that open up new opportunities and fortify institutional spaces. On the other hand, new forms of financial support are emerging, elements that together invite us to rethink the S&T ecosystem.

Universities and research centers

Two strategies can be distinguished in the face of the crisis. The first is one mainly of resistance, observed more than anything in the autonomous organizations, where an effort has been made to continue operations even with budgets that fail to cover maintenance of the physical campus. But some groups that have access to international financing and establish informal cooperation with centers abroad are also identified. This allows them to function beyond subsistence. These responses are the product of personal efforts, because the rigidity of the university structures only allows these alternatives. The matter becomes more serious upon confirming that there are no institutional proposals that seek to change this situation.

Consequently, most research efforts are paralyzed. Faced with inertia in a large part of the experimental and field activities, work is done by taking advantage of information that was created earlier, or data accessed through different channels. A second, more proactive strategy is implemented by two private universities that have developed institutional mechanisms to interact with and obtain financing through international cooperation, especially for work on issues related to the humanitarian crisis. They even work with civil society organizations to develop projects, which is remarkable if one takes into account that research at these institutions has been a relatively recent occurrence.

New actors in civil society

For their part, NGOs and private foundations are key actors in civil society. In 2018, at least 450 actors of this type were identified operating throughout the country, and are mostly focused on social, economic, and cultural rights.[99] Some join university projects, even seeking out connections with related organizations abroad to access technical and financial support for cooperation through them.

The private sector

Private initiatives, through their unions, have been preparing diagnoses of the crisis and proposals to overcome it (for example, participation in workers' training systems[100], and links with universities and R&D centers to increase technological capacities in production chains). Some of them have even committed to contributing to fulfillment of the United Nations' Sustainable Development Goals (2015) emphasizing three key purposes: eradication of extreme poverty, combatting inequality and injustice, and addressing the impact of climate change.[101]

International agencies

Until recently, Venezuela, which functioned according to the canons of the investment economy**,** was not on the radar of development cooperation agencies; even more unthinkable was that it would be the focus of those that are concentrated on humanitarian aid. The accelerated and enormous advance of the crisis has placed the country among the priorities of the latter, which at this moment are active participants

[99] Briceño León and others 2019.

[100] http://www.digaloahidigital.com/sites/default/files/20170717% 20Somos% 20Empresarios% 20Somos% 20Futuro% 20-% 20Documento% 20ICGF.pdf

[101] CONINDUSTRIA 2017.

in issues such as migration, health, and food security. But it is clear that this overcoming must transcend the emergency, so there must be a significant financial and technical contribution from both these organizations and multilateral agencies.

The State

Finally, and this is the great unknown, is the role that the State will play. It is evident that in a scenario of political change, the State would be the fundamental actor, having to face a double challenge: its own institutional recomposition, simultaneously with the effort to guide and design actions to overcome the crisis. But in a scenario without political changes, the subsistence and recomposition of the S&T ecosystem would remain mainly on the shoulders of other national and international social actors.

Rethinking the science and technology institutional framework

The importance of rebuilding and/or creating a new institutional framework is emphasized as a basic condition for the recovery of the S&T ecosystem. Additionally, the creation of a new governance is a process that must have active participation from the aforementioned actors and in which international cooperation must play a key role.

The magnitude of the humanitarian crisis means that almost all cooperation efforts focus on this aspect. Various organizations are currently working in the field, including examples such as the Spanish Agency for International Development Cooperation (AECID), which is focused on the food crisis; and the European Union and the Swiss Agency for Development and Cooperation, which donate medical-hospital supplies to face the COVID-19 pandemic.

Members of some of these agencies recognize that more attention must be paid to recovery, although they admit that the current global situation generated by the pandemic makes it difficult. However, some initiatives were identified in the area of S&T: for example, the France-Venezuela university and scientific cooperation agreement (Red Marcel Roche) signed in 2018, with the participation of five Venezuelan and six French universities, the objective of which is the exchange of teaching and research in postgraduate courses. But due to the crisis, its actions have been very limited. Some embassies open offers for project financing, for example, the assistance program offered annually by the British Embassy. One fact that shows the interest in and importance of these initiatives in emergency conditions is that this year more than 200 preliminary proposals were received. These were mainly from NGOs and research groups and far exceed the numbers seen in previous years.

Thus, on the one hand, international organizations are aware of the urgent need to support Venezuela. On the other hand, there is a series of diverse national institutions that work resiliently, awaiting, in many cases, the opportunities offered by international cooperation. Could this be the beginning of a recomposition of the S&T ecosystem? How can these efforts be optimized?

Recovering institutionality

Based on the investigation carried out, it is believed that it is possible to begin to recover, institutionality even without State participation. University and industry personnel were consulted on: i) what would be the most important actions to undertake for the recovery and strengthening of S&T, ii) the experience of participating in support programs of multilateral organizations (e.g., CAF, IDB, etc.) or access to international financing for projects, iii) the role to be played by international cooperation in the recovery and strengthening of R&D, iv) their willingness

to collaboratively participate in a program to promote and develop these activities.

Regarding the first point, the industry indicated that, due to the economic precariousness, support will be required to recover technical and productive capacities and the State's institutional framework. The researchers argued that the recovery of infrastructure and equipment is urgent, as is financial support. With regards to the second, industry spokespersons indicate that they have received support, but for economic studies and analysis of the value chains of productive groups. Some researchers responded that they have obtained funding, but that this has been the product of personal initiatives.

Both sectors agree that international cooperation, especially financial and technical support, will be essential to recover and strengthen their activities. Additionally, in response to the fourth point, there was consensus in indicating the willingness to join programs that support the development of productive activities, highlighting, even, the need to consolidate collaborative spaces.

New institutional arrangements

Thinking about an alternative S&T institutional framework requires considering at least two scenarios: one of political change, which would open up broad opportunities for intervention and participation; and another without political change. In the latter situation, positive State participation of the State should be avoided, and there would instead be a requirement to have active participation from the remaining actors to preserve institutional spaces and advance in the consolidation of collaborative arrangements that promote a new governance of S&T.

How can these diverse efforts be organized? There are experiences of civil society organizations that work with similar entities abroad, through which they access financing for cooperation. There are research groups that seek to obtain grants from international organizations and create informal mechanisms to cooperate with foreign universities in research. Internally, there are unusual approaches between different actors. Recent explorations show that the industry and universities are perceived as valid and necessary interlocutors, and that the possibilities of solving problems and rebuilding the aforementioned occur through collaborative efforts, something that did not happen 30 years ago.

Characterizing these dynamics is useful to conceive a functional institutional framework to face the challenge of overcoming the humanitarian crisis in the short term, the challenge of the techno-scientific transformations that must sustain the fourth Industrial Revolution and the global socio-environmental challenges.

This leads us to consider a research agenda with broad intervention by different actors, both from academia and from various areas of society.

New institutional arrangements must start from the design of strategies that consider the active participation of S&T in the resolution of the crisis and the achievement of national objectives, maximizing the performance of scarce resources (human talent, infrastructure and material resources for R+TD). Networking in all identified sectors (universities, research centers, productive sector, NGOs, foundations, international organizations, etc.) will be essential, as it would optimize the use of resources to offer solutions to the crisis, based on the synergy between research agendas and national problems. Therefore, this should be a fundamental condition of the strategies that are applied from now on.

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GLOSSARY

ABAE	Bolivarian Agency for Space Activities
ACAV	Academia de Ciencias Agrícolas de Venezuela (Venezuelan Academy of Agricultural Sciences)
ACFIMAN	Academia de Ciencias Físicas, Matemáticas y Naturales (Academy of Physical, Mathematical, and Natural Sciences)
AECID	Spanish Agency for International Development Cooperation
ARBOL	Asociación de Rectores Bolivarianos (Bolivarian Rectors Association)
ASOINIVIC	Asociación de Investigadores del Instituto Venezolano de Investigaciones Científicas (Association of Researchers of the Venezuelan Institute of Scientific Research)
AVERU	Asociación Venezolana de Rectores Universitarios (Venezuelan Association of University Rectors)
AVINTI	Asociación Venezolana de Institutos de Investigación Tecnológica Industrial (Venezuelan Association of Industrial Technological Research Institutes)
CAF	Development Bank of Latin America
CANTV	Compañía Anónima Teléfonos de Venezuela (Anonymous Telephone Company of Venezuela)
CEDICE	Centro de Divulgación del Conocimiento Económico para la Libertad (Center for the Disclosure of Economic Knowledge for Freedom)
CENDIT	National Center for Development and Research in Telecommunications Foundation
CENDITEL	Fundación Centro Nacional de Desarrollo e Investigación en Tecnologías Libres (National Center for Development and Research in Free Technologies Foundation)
CENIAP	Centro Nacional de Investigaciones Agropecuarias (National Center for Agricultural Research)
CENIT	Fundación Centro Nacional de Innovación Tecnológica (National Center for Technological Innovation Foundation)
CENVIH	Centro Nacional de Investigación y Certificación en Vivienda Hábitat y Desarrollo Urbano (National Center for Research and Certification in Housing, Habitat, and Urban Development)
CI CVG-SIDOR	Centro de Investigaciones de la Corporación Venezolana de Guayana y Siderúrgica del Orinoco (Research Center of the Venezuelan Corporation of Guayana and Siderúrgica del Orinoco)

CICASI	Centro de Investigaciones Carboníferas y Siderúrgicas (Carboniferous and Steel Research Center)
CIDA	Fundación Centro de Investigaciones de Astronomía "Francisco J. Duarte" ('Francisco J. Duarte' Astronomy Research Center)
CIDT	Centros de investigación y desarrollo tecnológico (Technological research and development centers)
CIEPE	Centro de Investigaciones del Estado para la Producción Experimental Agroindustrial (State Research Center for Experimental Agroindustrial Production)
CILARR	Centro de Investigaciones Lácteas Rafael Rangel (Rafael Rangel Dairy Research Center)
CITO	Centro de Investigaciones Tecnológicas de Oriente (Oriente Technological Research Center)
CNTQ	Centro Nacional de Tecnología Química (National Center for Chemical Technology)
CNU	Consejo Nacional de Universidades (National Council of Universities)
CODECYT	Corporación para el Desarrollo Científico y Tecnológico, S.A. (Corporation for Scientific and Technological Development, S.A.)
CONATEL	Comisión Nacional de Telecomunicaciones (National Telecommunications Commission)
CONICIT	Consejo Nacional de Investigaciones Científicas y Tecnológicas (National Council for Scientific and Technological Research)
CONINDUSTRY	Confederación Venezolana de Industriales (Venezuelan Confederation of Industrialists)
STI	Science, Technology, and Innovation
CT-IVIC	Centro Tecnológico del Instituto Venezolano de Investigaciones Científicas (Technological Center of the Venezuelan Institute of Scientific Research)
CT-Polar	Centro Tecnológico Polar (Polar Technology Center)
FEDECAMARAS	Federación Venezolana de Cámaras de Comercio y Producción (Venezuelan Federation of Chambers of Commerce and Production)
FIIDT	Engineering Institute Foundation for Technological Research and Development
FONACIT	Fondo Nacional de Ciencia Tecnología e Innovación (National Science, Technology, and Innovation Fund)
FONAIAP	Fondo Nacional de Investigaciones Agropecuarias (National Fund for Agricultural Research)

FUNINDES	Fundación de Investigación y Desarrollo (Research and Development Foundation)
FUNVISIS	Fundación Venezolana de Investigaciones Sismológicas (Venezuelan Foundation for Seismological Research)
IALA	Instituto Universitario Latinoamericano de Agroecología Paulo Freire ('Paulo Freire' Latin American University Institute of Agroecology)
ICTA	Instituto de Ciencia y Tecnología de Alimentos (Institute of Food Science and Technology)
IDB	Inter-American Development Bank
IDEA	Institute for Advanced Studies Foundation
IDEC	Instituto de Desarrollo Experimental de la Construcción (Institute for Experimental Development of Construction)
HEI	Higher Education Institutions
IMME	Instituto de Materiales y Modelos Estructurales (Institute of Materials and Structural Models)
INDESCA	Investigación y Desarrollo C.A. (Research and Development C.A.)
INE	Instituto Nacional de Estadísticas (National Statistics Institute)
INIA	Instituto Nacional de Investigaciones Agropecuarias (National Institute of Agricultural Research)
INTEVEP	Instituto Tecnológico Venezolano del Petróleo (Venezuelan Technological Institute of Petroleum)
INZIT-CICATI	Zuliano Foundation Institute for Technological Research
IVIC	Instituto Venezolano de Investigaciones Científicas (Venezuelan Institute of Scientific Research)
LIT-CANTV	Laboratorio de Investigación en Telecomunicaciones de la C.A. Nacional Teléfonos de Venezuela (Telecommunications Research Laboratory of the Anonymous Telephone Company of Venezuela)
LOCTI	Organic Law of Science, Technology, and Innovation
LUZ	University of Zulia
MCTI	Ministry of Science and Technology
MPPCT	Ministry of People's Power for Science and Technology
MPPCTI	Ministry of People's Power for Science, Technology, and Innovation
MPPES	Ministry of People's Power for Higher Education
MPPEUCTI	Ministry of People's Power for University Education, Science, and Technology

ONCTI	Observatorio Nacional de Ciencia, Tecnología e Innovación (National Observatory of Science, Technology, and Innovation)
OPSU	Oficina de Planificación del Sector Universitario (University Sector Planning Office)
OVCS	Observatorio Venezolano de Conflictividad Social (Venezuelan Observatory of Social Conflict)
OVSP	Observatorio Venezolano de Servicios Públicos (Venezuelan Observatory of Public Services)about:blank
PDVSA	Petróleos de Venezuela (Petroleum of Venezuela)
PEII	Programa de Estímulo a la Innovación e Investigación (Innovation and Research Stimulus Program)
PNCTI	Plan Nacional de Ciencia, Tecnología e Innovación (National Plan for Science, Technology, and Innovation)
PNF	National Training Plans
PNFA	National Plans for Advanced Training
PPI	Researcher Promotion Program
R+D	Research and Development
RICYT	Red Iberoamericana de Indicadores de Ciencia y Tecnología (Ibero-American Network of Science and Technology Indicators)
R+TD	Research and Technological Development
SNCTI	Sistema Nacional de Ciencia, Tecnología e Innovación (National System of Science, Technology, and Innovation)
S&T	Science and Technology
UBV	Bolivarian University of Venezuela
UC	University of Carabobo
UCLA	Universidad Centro Occidental Lisandro Alvarado ('Lisandro Alvarado' Central Western University)
UCS	Universidad de las Ciencias de la Salud (University of Health Sciences)
UCV	Central University of Venezuela
UCVAG	Universidad Campesina de Venezuela Argimiro Gabaldón ('Argimiro Gabaldón' Rural University of Venezuela)
UDO	Universidad de Oriente (University of Oriente)
ULA	University of the Andes
UNESCO	United Nations Educational, Scientific and Cultural Organization
USB	Simon Bolivar University

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