SCIENCE MELTDOWN IN VENEZUELA

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SUMMARY

The most relevant indicators of a scientific system, i.e., human resources, infrastructure, finances and output are analyzed in order to review the current dynamics of the Venezuelan scientific community. During the first half of the 20th century, Venezuela had no major organized institutional scientific activity. From 1954 thru 1983, a considerable number of research and development institutions were built within the public sector, the major provider of funds. While the current scientific workforce in Venezuela is 0.61 active researchers per 10000 inhabitants, a demographic analysis reveals that it is aging at a fast pace; more scientists abandoning the profession than new ones joining in. The number of publications per researcher has declined rapidly after peaking in 1993, reaching its lowest value ever last year. While some systemic parameters, such as infrastructure or number of researchers or publications in indexed periodicals show pyrrhic increments (4-7%), official figures for number of researchers or investment claim increments by several folds in recent years. Either the scientific system is not efficient or funding is not reaching the laboratories. In any case, as long as the rate of growth of crucial parameters such as number of scientists and research output stays near the country's vegetative growth, existing gaps in S&T between Venezuela and other nations will not be reduced. Overall, it appears that science in Venezuela is in peril. This ought to be a matter of concern, since the present generation of researchers and academics in Venezuela could have been amongst the most significant accomplishments of its democracy.

On October 12, 1978, David Dickson reviewed for *Nature* the state of science in Venezuela. He highlighted that research budget for universities and research and development (R&D) centers were reduced 7%. Science was considered vulnerable, marginal and isolated from the country's needs. Scientists were claiming for new economic resources to the sector and hopes were centered on a law under study that taxed industrial income (Dickson, 1978). In May 29, 2009, Barbara Casassus, in appraising for *Science* the unrest of the Venezuelan academic establishment, listed a number of perceived government failures or threats to the scientific community. They were almost equal to those perceived 31 years earlier; a 6% reduction in universities and R&D centers budgets, scientists were ordered to engage in research on "relevant" social problems, and there was a general complaint that funds obtained from a Law enacted in 2006 taxing industries and supporting R&D activities were not reaching the labs (Casassus, 2009).

Although at first sight it would appear from those two reports that in the last three decades nothing much has occurred to science in Venezuela, that is not the case. Indeed, while during the first half of the twentieth century, scientific research in Venezuela was mostly a matter of individuals who spent their free time satisfying their intellectual curiosity, during the second half the activity became professionalized and institutionalized. The few researchers active in the teaching laboratories at the two public universities existing in the country in 1950 were almost exclusively drawn from classical professions. However, they began to be substituted by graduates from the newly created science faculties who found career jobs with the creation of a large number of laboratories and research centers across the country. Publications in the biomedical and basic sciences domains have been the areas of knowledge favored by Venezuelans while, in terms of intellectual creation, social sciences and humanities are the less productive, even though those are the fields of knowledge embraced by most professionals (Requena, 2005).

The R&D system constructed in Venezuela during the last fifty years of the 20th century exhibits a predominance of the public sector. In the last thirty years, the State has privileged the hydrocarbon related technological

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service at the expense of academic research in universities, while maintaining agribusiness related technical services at the same level of expenditure.

While the generation, starting practically from zero, of a modern R&D community in Venezuela, together with higher education, could well be one of the most significant accomplishments of its democracy, this remarkable social achievement seems nowadays to be in peril. The object of this study is to analyze the temporal course of some of the parameters traditionally used to describe the performance of science in a society. Specifically, the historic series of human resources, infrastructure, economic assets, and publication output of the Venezuelan scientific system will be analyzed. The aim is to provide facts for a meaningful discussion of a sociological issue.

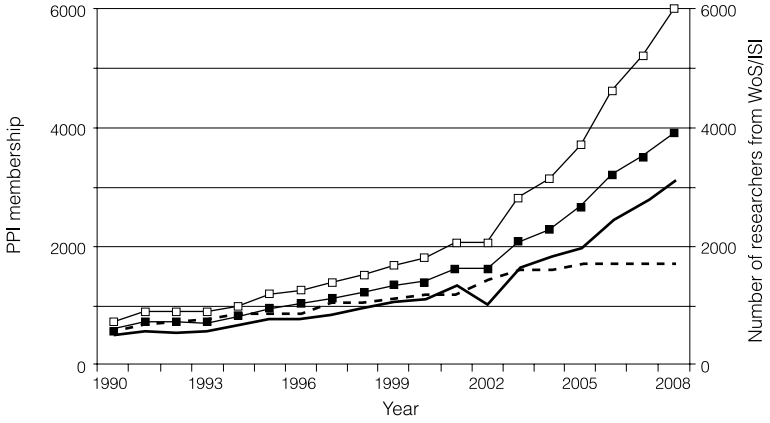

Figure 1. Historic series for the number of Venezuelan researchers accordingly to diverse methods of determination. Sources: Annual reports of CONICIT, FONACIT, PPI and WoS/ISI/Biblios dataset.

Methods and Data

The input used in this study comes from two databases built by the author and handled by a software called BIBLIOS, developed in Microsoft FOX v9 and its Visual Basic, running on Windows operated microcomputers. BIBLIOS is proprietary software (*Fundación Universidad Metropolitana*) that uses simple SQL statements enabling complex cross analysis of bibliometric and personal data.

The first database comprises bibliographic data recorded in the Web of Science/Institute of Scientific Information (WoS/ISI) where at least one author appears giving as its academic affiliation a research facility within Venezuelan boundaries. The data set comprises publications from 1981 to 2008, extracted using the criteria of 'CU=Venezuela'. The set of data thus obtained is filtered to keep only articles in periodicals journals, editorials, corrections, letters to the editor, reviews and peer reviewed proceedings. Any other entry for the WoS/ISI export parameter DT, such as meetings' abstracts is discarded. The initial set of publication data, from 1981 to 1998, was obtained from the late Professor Manuel Bemporad.

The downloaded records should not be used without further analysis since, on average, 10% of the entries are inaccurate; mostly due to entries mistakenly assigned to institutions that are not in the country. In addition, care should be exercised since some entries are registered by ISI with a considerable delay. Finally, to each publication entry, a six-digit UNESCO code describing the field of knowledge that corresponds to the scientific work is assigned, and the Journal Impact Factor as obtained from ISI Journal of Citation Reports recorded by the BIBLIOS software. The publications database contains 19489 papers (from 1981 to 2008), written by 78592 authors of which 27988 are unique and distinct.

The second database consists of a comprehensive listing of Venezuelan scientists and their foreign collaborators. It was developed from the information contained in the scientists census of CONICIT (*Consejo Nacional de Investigaciones Científicas y Tecnológicas*) in the year 1983, augmented with curricula from members of the PPI (*Sistema de Promoción del Investigador*) Program, validated up to 2008. The authors database has 37595 entries of which 11054 correspond to professionals that have applied to the PPI Program; 2493 authors correspond to the CONICT 1983 Census (1325 of which are not in the PPI register) plus other 9471 Venezuelan authors only partially identified. This database also lists 14200 foreign authors with scarce personal information but accurate academic affiliation.

For most Venezuelan entries, the data set contains information such as date of birth, academic affiliation, university education (first degree and doctoral training), together with a six digit UNESCO code describing the field of research of the corresponding author entry. An ID number and, at least, two names and two surnames uniquely identify most Venezuelan authors.

BIBLIOS is capable to correlate the two databases using the author name and its academic affiliation as common fields. The use of the combined two sets of data, publications and authors, for analysis will be identified hereunder as "WoS/ISI/Biblios dataset."

Results

Human resources

The PPI program. The official reference to human resources dedicated to Science and Technology (S&T) activities in Venezuela is the *Programa de Promoción del Investigador* or PPI. The object of the Program is to promote productivity by means of a bonus other than the salary. PPI came as a late offspring of the national economic crisis of 1983, which revealed an urgency to make the scientific or technological research career more attractive to professionals. Then, voices of alarm were raised when the number of investigators seemed to have stagnated, a brain drain was becoming evident (Garbi, 1991), signs of deterioration within the sector were noticeable (Roche and Freites, 1992), and working/salary conditions were poor (Urbina, 1992).

The program was started in the year 1990 by the authorities of CONICIT, following the example of other Latin-American societies (Interciencia, 1992). In 2002, the bylaws of the Program were changed and the criteria for entry, requirements for the various hierarchical levels (*Candidato*, Levels I to IV, and Emeritus), age limits and permanence rules were loosened. The imperative requirement for membership in the Program, to have one publication for the lowest rank, was kept, but the nature of the publication in terms of indexing (WoS/ISI *vs* others international indexes) was relaxed, more weight being given to papers published in national journals than in foreign mainstream periodicals.

The appointment of the first cohort amounted to 740 scientist certified as PPI researchers. By 1994, PPI membership had jumped to 1056 researchers from the 930 level observed during the 1991-1993 period. This leap has been thought to reflect the perception by investigators (and technologists) of the seriousness (and advantages) of the program (Vessuri and Benaiges, 1998). From 1994 on, the number of program beneficiaries shows a growing tendency, although with noticeable oscillations (for an official review see Marcano and Phelan, 2009).

Figure 1 shows the historic series for the number of scientists in Venezuela as revealed by two different

methods of analysis. Four curves are displayed. The top curve reflects overall membership in the PPI. For 2008, the official figure of active scientists registered in the Program is 6 036 professionals. Next down, the curve refers also to the PPI membership but excludes those professionals dedicated to social sciences, humanities or arts; roughly, they correspond nowadays to one third (36.4%) of its membership. The next curve down also refers to the PPI membership, excluding not only social scientists but also all the membership at *Candidato* level, without regard to the field of expertise (physics and chemistry, mathematics, engineering and biomedical research). Since the change in the PPI bylaws, on average, one quarter (27.7%) of the membership of the PPI program fall in the hierarchy level of *Candidato.*

The three curves related to the PPI membership show an inflexion point around 2002 and 2003. During those years, the change in the rules permitted the entry of a significant number of professionals to the program that in the preceding years were not allowed in due to the stricter requisites in place at the onset of the Program. One of those requisites was age and the other, type of publication. In other words, the increment in membership seen after the year 2003 does not represent new talent acquired by the system but, more properly, the recycling of existing human resources. Prior to 2002 the average age for a member of the lowest category (*Candidato*) was 32 years, and by year 2004 it jumped to 40, while for *Nivel 1* category it went from 37 to 42 years. In terms of membership, 38% of *Candidato*s accepted after the change in bylaws in 2002, had applied before and were rejected. For the *Nivel 1* the percentage of recycling was ~67%.

The fourth curve, the lowest of all (dashed line) represents the historic series for the number of researchers as derived from a demographic analysis of those who publish from Venezuela in journals indexed in the WoS/ISI/Biblios dataset; 1 720 researchers are accounted for in year 2008.

Demography of the community. It is possible to segment the role of Venezuelan researchers as a function of their commitment to research by examining their publication pattern throughout time. Four categories can be considered according to the compliance with a set of logical conditions listed in Table I. An 'Active' (researcher) is one that has at least one entry in the WoS/ISI/Biblios dataset in a given year. He also has an entry in the dataset before that year and exhibits at least another entry after that year. A 'Retiring' (researcher) is one that has published before and during the selected year but no entry can be found after the current year. A 'New' (researcher) is one that for the first time exhibits an entry in the databset during the selected year and has entries for subsequent years. A 'Helper' is someone that only appears publishing in the year under consideration.

TABLE I
TRUTH TABLE FOR DEMOGRAPHIC ANALYSIS OF VENEZUELAN RESEARCHER

	Before	Current year	After
Active	TRUE	TRUE	TRUE
Retiring	TRUE	TRUE	FALSE
New	FALSE	TRUE	TRUE
Helper	FALSE	TRUE	FALSE

The segmentation of researchers according to the logical criteria set in Table I permits to study the evolution in time of demographic variables such as the number of researchers that publish from Venezuela and their age. The results obtained are listed in Table II. For the sake of brevity, a five-year interval is chosen to list data that was obtained on a yearly bases. The historic series for the number of researchers that publish in an indexed journal, configured as the sum of active, new and retiring researchers, shows a growth rate of 7.3 ±1.8% annually. This is displayed graphically as the dashed lower curve in Figure 1.

Up to 1998, the magnitude of the Venezuelan scientific community revealed by this approach is consistently smaller (by 23%) than the membership figures of the overall PPI membership. For example, in the year 2000, just before the modification of the bylaws of the Program, the membership was recorded at 1 802 researchers, while Table II lists 1 178 researchers as derived from a demographic analysis of the researcher that publish from Venezuela in journals indexed in the WoS/ISI/Biblios dataset. After 2002 the discrepancy becomes significant: in the year 2005 the PPI membership was 3 710 scientists while the number of researchers, as derived from the WoS/ISI/Biblios dataset, has barely increased to 1 700 researchers. For 2008, the number is identical to that recorded for 2005.

In reference to the age of the Venezuelan researcher, Table II shows that the average scientist is aging at an alarming rate. In the last twenty years, the average age of an active researcher has gone up from 41 years old in 1985 to almost 48 years old in 2005. It should be recalled that when the scientific community is looked at as an open system, with each new year and as researchers abandon the system (retire), new ones come in, adding to the group of those that remained there.

In a steady state system, the average age of those that remain in the system should be constant in time. However, for this to occur, it is necessary that the average age of those that leave and enter into the system remain constant, a matter that also depends on the absolute number of those moving out and into the system. In the case at hand, age constancy is almost true for 'new' researchers; on average, they enter the publication circuit at 37 years of age. However, that is not the case for those 'retiring' from the system; in twenty years it went from 42 up to 48 years of age with a peak of 50.1 years in 2000. Regarding numbers of researchers, while in the last twenty years the number of researchers 'retiring' from the system increased six fold the number of 'new' researchers just grew twofold. Thus, being the product of number times age for those that enter smaller than that for those that leave the system, aging in the ones that remain is inevitable.

As an example of the quality of the demographic data obtain-

TABLE II
HISTORIC COURSE OF NUMBER AND AGE OF VENEZUELAN RESEARCHERS, GROUPED IN FIVE-YEARS PERIODS

Year	1985		1990		1995		2000		2005	
Type	Number	Age*	Number	Age	Number	Age	Number	Age	Number	Age
Active	307	41.3	413	43.3	585	45.4	816	46.9	1035	47.6
Retiring	58	42.1	53	44.0	102	45,0	120	50.1	375	47.8
New	139	33.8	137	36.6	190	37.0	242	38.2	290	37.2
Sum	504		603		877		1178		1700	

* Age expressed in years.

able by the method of analysis chosen herein, the data referring to the age for the historic series of 'Active' Venezuelan researchers is displayed in Figure 2. It shows how the average age of the researchers is growing steadily. Indeed, if the points are connected by a regression straight line, the slope reflects an ageing of 4 months for each calendar year.

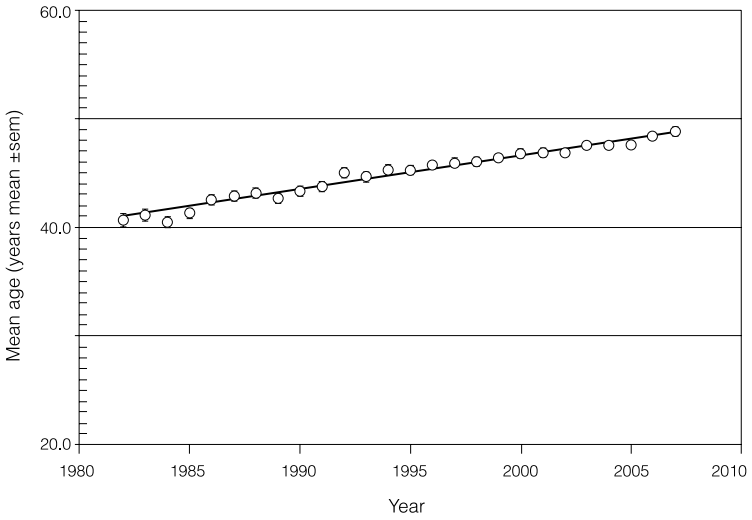

Figure 2. Historic series of the average age of 'active' researchers as obtained from the WoS/ISI/Biblios dataset. Points represent mean ±sem, mostly within size of point.

Output

The scientific output of Venezuela can be appraised as the number of original articles published in the country in a medium indexed by the WoS/ISI. An analysis of the database purged to remove false entries, as described in Methods, is shown in Figure 3, where it can be seen that since 1981 the production of original indexed papers has undergone a steady growth, from a few hundreds produced at the onset of the series up to 1412 publications in 2008.

These data exhibit two bumps in the output curve, one in the first years of the survey, the other at the end of it. These two transient increases in output correspond to the transitory presence in the WoS/ISI index of journals edited in Venezuela with a strict local character. The first bump corresponds to the years 1981-1984 and reflects the presence of *Acta Científica Venezolana* of AsoVAC and *Visión Tecnológica* of INTEVEP. The most recent bump corresponds to the inclusion in the WoS/ISI/Biblios dataset of several new journals from the *Universidad del Zulia* in western Venezuela.

While for the purposes of this study no distinction is made over the nationality of the journal where the publication appears, it is of interest to look at the presence of Venezuelan scientists only in foreign journals. The dashed line in Figure 3 joins the points of the data set where journals edited in Venezuela but with a strict local character were left out. For that particular series, representing publications from Venezuela in foreign journals, a steady average growth rate of 4.4 ±1.4% publications per year can be inferred. The WoS/ISI index started first to register journals that mainly deal with natural and experimental sciences over periodicals devoted to social sciences. Around the year 1991, the ISI index started to cover more areas related to arts and humanities. Table III lists the historic series of the percentage of Venezuelan publications devoted to arts, humanities and social sciences as referred to the total output from the country, displayed every three years for the sake of brevity. While there seems to be a steady increase, this most probably reflects the enlargement of coverage of the WoS/ISI index as an increment of publications from Venezuela in those areas of knowledge. In any case, the listed percentages set a limit to the error in evaluating national productivity on a parameter based mainly on contributions in natural and experimental sciences as it used to be WoS/ISI for many years. This factor could be of the order of 4-5% for most of the historic series; however it should be noticed that in the last couples of years it has doubled.

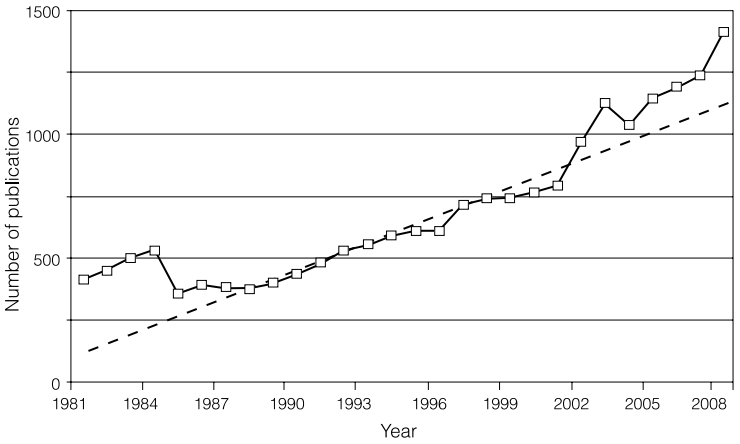

Figure 3. Historic series of number of articles recorded in the WoS/ISI/Biblios dataset as produced by a Venezuelan scientific or academic institution.

National productivity

A national productivity index for S&T can be obtained relating a parameter that measures output with the magnitude of the work force that produced those publications, i.e. the number of indexed papers in a comprehensive database referred to the number of certified researchers registered in a national program like the PPI. Figure 4 shows the historic series for the classical scientific productivity index number of publications per researcher. The figure reveals that since reaching a maximum productivity index in 1993 of 0.61 publications per researcher, a steady downward trend is exhibited, reaching an all time minimum of 0.23 publications per researcher in 2008. The result shown in the graph should not be surprising; it has already been shown that while during the last two decades of the 20th century the ISI indexed output of publications from Venezuela almost trebled, the increase in the membership of the PPI augmented fivefold.

While the productivity index displayed in Figure

TABLE III
HISTORIC SERIES OF PERCENTAGE OF VENEZUELAN PUBLICATIONS RELATED TO SOCIAL SCIENCES PRESENT IN WOS/ISI/BIBLIOS DATASET

Year	1981	1984	1987	1990	1993	1996	1999	2002	2005	2006	2007	2008
%	2.7	2.6	2.3	5.3	5.4	3.8	2.6	3.0	3.1	3.6	6.9	9.0

Note: WoS/ISI/Biblios dataset filtered using the UNESCO code criteria bigger than 50xxxx, excepting Psychology, code 62xxxx.

4 is restricted to 1990 onwards in account of the inexistence of the human resources data corresponding to the PPI at earlier times, it should be mentioned that some other productivity data is available. For instance, a value of 0.29 paper per researcher was computed for the productivity index in the year 1983 (Lemoine, Morán, Valencia and Requena, 1985). Thus, it is obvious that a sizable loss of scientific productivity in the country occurred after a period of substantial growth throughout the eighties and well into the nineties.

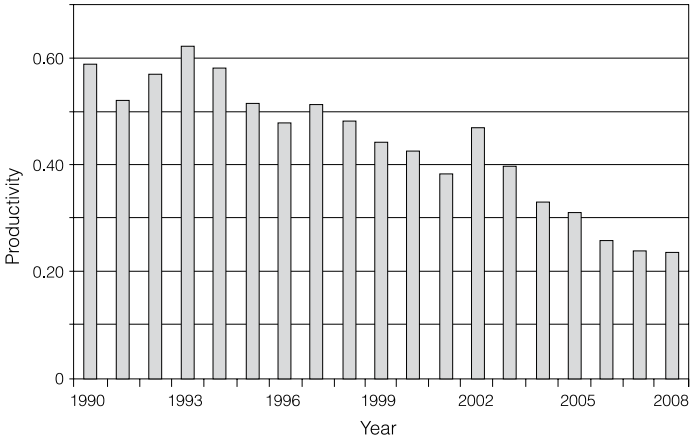

Figure 4. Historic series for the bibliometric productivity index of Venezuelan researchers between 1990 and 2008, calculated yearly as the ratio of the number of WoS/ISI/Biblios dataset entries and referred to the numbers of members in the PPI program officially engaged in conducting scientific research in Venezuela and authors of those publications.

Infrastructure

In terms of real new R&D facilities, the most favored scientific institution seems to be the *Instituto de Estudios Avanzados* (IDEA) in Caracas, which received funds to build two new laboratory buildings that increased its research space by 3200m^2 or 22% of its previously existing space; an immunoproduction laboratory and a national agribiotechnology facility. At the *Instituto Venezolano de Investigaciones Científicas* (IVIC), the main research center of the country, research space has been added to the tune of 3% of its existing 83400m^2 of laboratory space in the form of an annex to its blood derivatives industry. At IVIC, physical extensions remain to be completed at the Biophysics Center, Library/General Services and a Satellite/Telecommunications facility. As for the agribusiness sector, the most notorious new facility is a laboratory for a pilot animal reproduction station that was built in a farm that was confiscated 5 years ago in Barinas State; this lab has not yet started operations.

In respect of national universities, except Zulia (LUZ) in Maracaibo and, perhaps, Carabobo (UC) in Valencia, that have devoted some of their budgets to building new administrative and lab facilities, little has been built in other national universities. The government has pledged to create 40 new universities, but some of them are simply an upgrading of technical colleges already in operation and a good deal rest in the planning stage, while the remaining few are at the earliest construction phase. Nevertheless, little is known whether these new universities are going to be endowed with research space and staffed with certified researchers.

The Simón Bolívar University (USB) can be used as an example of the policy regarding educational or research facilities within autonomous academic environment. USB is the most technologically oriented university in the country, and although relatively young (it was created in 1967 and started operations in 1970) its scientific output is second to Central University (UCV), but with ten times fewer staff and students. The physical plant of the Caracas campus of USB amounts to 137500m^2 of construction in 44 large buildings. In the last ten years, the USB has not been able to enlarge its physical plant. Contrarily, part of its endowed land has been transferred to the governmental research agency IDEA. The USB case is dramatic in as much as its Caraballeda site, comprising several buildings and occupying an area of 19000m^2, was totally destroyed during the mudslide of December 1999. The reconstruction effort called for construction of seven buildings with 30 000m^2 of space. Ten years after the disaster, only 2/3 of the work planned has been done. More recently, the campus at Caraballeda is getting a new 4000m^2 marine biology facility funded by LOCTI.

National investment in R&D

The main provider of funds for R&D activities in Venezuela has always been the State; through direct budgetary allocations to higher education institutions, official centers for R&D and its own administrative structures. For the last decade of the 20th century, on average, the level of Venezuelan investment in R&D was of the order of 0.40% of the Gross Domestic Product (GDP; Requena, 2003). Even though the level of this internationally accepted indicator is well below the minimum of 1% set by UNESCO, it allowed Venezuela to develop and build the scientific infrastructure that could exhibit at the turn of the century. Table IV shows that during the first decade of the present century the government direct support to R&D activities has been kept similar, amounting to 0.42% of the GDP.

However, the situation of scarce level of funding for science described is bound to change with the reform of the *Ley Orgánica de Ciencia y Tecnología* (LOCTI) in the year 2005. This Law brings the private sector of the country into play with the introduction, as from 2006, of some sort of tax to locally finance science and technology ativities. Its figures are listed in Table IV together to that corresponding to another source of financing identified as *Misión Ciencia*. Values are expressed as historic series and either in absolute terms or as percentage of its representation into the GDP.

TABLE IV
PERCENTAGE OF GDP OF NATIONAL INVESTMENT IN R&D

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Misión Ciencia	US$300M								
LOCTI (MM BsF*)	As Tax						0.93	0.63	
	In house or third party						4.46	9.71	
LOCTI % GDP	% GDP						1.36%	2.15%	2.61%
GDP (MM BsF)	79.66	88.95	107.84	134.22	212.68	304.08	396.14	489.67	673.73
% S&T/GDP (excl. LOCTI)	0.38%	0.50%	0.43%	0.31%	0,25%	0.34%	0,42%	0.58%	0.40%

Sources: Annual National Budget Laws, various annual *Memoria y Cuenta* of Ministry for Science and Technology, various data sets of the *Observatorio Nacional de Ciencia, Tecnología, e Innovación, Indicadores-Venezuela* such as www.oncti.gob.ve/pdf/PPI_SERIE_2008.pdf as quoted by Chacón Escamillo (2009) and financial data of Venezuela Central Bank www.bcv.org.ve/excel/7_1_14.xlsid?=435.
*MM BsF: Thousand millions of Bolívares Fuertes.

Misión Ciencia or "Science Mission" refers to the extraordinary process launched in April 2005 for massive articulation of social and institutional actors through economic, academic and political networks and devoted to the utilization of knowledge for endogenous development (see Discussion). In turn, LOCTI refers to the tax imposed to industries, business and enterprises, public or private, with gross annual revenues above ~2 million USD equivalent to 0.5% of its income (except oil and mining businesses that are taxed at 2%). LOCTI articles 34 through 38 establish that the floor is 100000 tax units, currently at 65 BsF each, while the official exchange rate is 4.30 BsF/USD. The money can be spent in scientific or technological research under three modalities; in house, donation to third parties at universities or research centers, and finally, cash into a LOCTI official account. These last funds are to be redistributed by government accordingly to its goals and policies.

As shown in Table IV, LOCTI should have trebled and quadrupled in the years 2006 and 2007, respectively, what the government was already investing in direct support of science in the country. LOCTI is considered a major plus for R&D activities in Venezuela, and as such has been presented by the government; an extraordinary instrument to promote science and technology in the country. According to government figures and recorded in Table IV, only last year, it catapulted the investment indicator from a 0.34% of the GDP up to a phenomenal 2.61% (in 2009 the level should have reached 3.06% of the GNP).

Discussion

The evaluation of the progress of a system of S&T requires the measurement of parameters such as the level of infrastructure, human resources, quantity (and/or quality) of the products it delivers and investment. An outstanding feature of the Venezuelan scientific system is the quality of the infrastructure that houses the research labs of universities and centers of research. This was noted and recorded by David Dickson back in 1978 when he praised the infrastructure of IVIC (Dickson, 1978). Regarding universities, the best example is that of the *Ciudad Universitaria* of Caracas, where the main university in the country, UCV, seats. Its infrastructure was renewed around the forties. In the sixties, the example set by UCV was followed with remarkable infrastructure built for the other important national universities: Andes, Oriente and USB. During the eighties, the last centers of research developed in the 20th century were created and built: IDEA and *Instituto de Ingeniería* in the Caracas region.

Since most of the university infrastructure was built during the early part of the second half of the 20th century, some decay was to be expected towards the turn of the century. To repair the damage caused by time, abuse and lack of maintenance, in the mid nineties a law was unsuccessfully presented to the National Congress, seeking funds for the refurbishing of the national university infrastructure. The piece of legislation was reintroduced some years ago but it has never been enacted.

During the last ten years, there has been no appreciable change in the situation and little has been done in terms of new facilities for research. From the governmental point of view, probably the most notorious claim for new infrastructure facilities is the land-based station to handle satellite communications and the so-called *Infocentros* (Chacón Escamillo, 2009).

The use of a data derived from WoS/ISI has not been free of criticism. Most of it relates to the coverage of the journals processed by ISI. While it is true that journals from developed countries represent its main target and periodicals produced in languages different from English were not favored in the past, it is also a fact that every day more and more journals from nontraditional countries and less sought areas of knowledge are included into the index. In any case, the standards imposed by the ISI indexing, namely peer review, periodicity and constancy have propelled national and regional journals to embrace them and acquire the visibility that comes with being indexed by WoS/ISI.

In the case of Venezuela, an answer has been already given to the question about how well the WoS/ISI/Biblios dataset constructed represents its scientific output. It was shown that if the output of WoS/ISI/Biblios dataset is filtered to obtain the publications produced only by IVIC and that data set are compared with the publication output that the researchers of IVIC considered to be their overall scientific publications (as listed in IVIC's Annual Reports, and comprising articles in periodical journals, editorials, corrections, letters to the editor, reviews and peers reviewed proceedings but not abstract, thesis or reports), around 68% of the publications of IVIC scientists are included in the WoS/ISI/Biblios dataset (lapse 1981-2004; Requena 2003, updated to 2004). Thus, it would seem that the use of publications from WoS/ISI/Biblios dataset is an adequate representation of the Venezuelan scientific output.

The magnitude of the scientific work force in the Venezuelan can be appraised from demographic studies of publishing authors, censuses or academic surveys and government statistics such as PPI membership. Officially, Venezuela counted in year 2008 with 2.1 PPI registered scientists for each 10000 inhabitants, a good figure for the UNESCO indicator. However, if the figure for the number of researchers derived from the WoS/ISI/Biblios dataset analysis, of 1 720 researchers, is used instead of the 6032 PPI membership, the value of the UNESCO indicator drops to 0.61.

Indeed, up to the turn of last century, there is a good correspondence for the number of scientists extracted from the various sources of data but this ceases to be the case lately. For instance, as shown in Figure 1, the curve corresponding to the number of researchers obtained from the WoS/ISI/Biblios dataset, the curve depicting PPI data without social scientists and minus social scientist and *Candidato* level members, starts to diverge around 2002.

The numbers of researchers derived from the demographic analysis of the WoS/ISI/Biblios dataset correspond to those professionals that have published more than one article in any kind of journal in their lifetime, which happens to be almost the same condition and requirement established by the PPI program for membership in the hierarchy above the level of *Candidato*. Thus, if for a year such as 2008, the *Candidato* level membership and all social scientist are removed from the PPI membership, a value of 3121 researchers is obtained. This number still is significantly larger than the 1720 researchers obtained from the demographic analysis. Obviously, a good share of the PPI membership, social scientists but especially those at the lowest level of the hierarchy, does not publish in mainstream journals.

As stated by Barbara Casassus in a article on the academic crisis in Venezuela (Casassus, 2009), the crux of the matter would seem to be the notion of "researcher" and of "science" implicit in the current Venezuelan scientific policy, which seems to differ from the traditional meaning or sense of these words. The notion of scientists as referring to any person working near a research laboratory, regardless of his/her

level of training, nature of work, use of intellectual faculties or product delivered, seems to be favored by the present administration of Venezuela. Being this so, it should not come as a surprise that Venezuela in the year 2009 does not appear to have 1720 researchers derived from the demographic study of the WoS/ISI/Biblios dataset or the 6032 professionals currently registered in the PPI, but 10187 persons, as stated by the Minister of S&T in a Letter to the Editor of *Science* (Chacón Escamillo, 2009).

Regarding the concept of science and its social relevance, it calls the attention that the classical primary result of the scientific activity, the scientific publication, is not mentioned at all in the policy discourse of the current S&T authorities of Venezuela. Even though it has not been explicitly defined, for Minister Chacón Escamillo (2009) science is a) the operation of a telecommunication satellite bought from China, b) the operation of public facilities with free access to Internet and powered with microcomputers bought in parts from China and locally assembled or c) the marketing of low-cost cell phones bought in parts from China and assembled in Venezuela.

In relation to finances of the Venezuela R&D system, it seems appropriate to recall some facts. The investment employed to build the scientific system that Venezuela was exhibiting in 1999 (human resources, physical and information infrastructure) was of the order of 5117 billion USD (or 4435 billion USD at constant 1984 value; Requena, 2003). Now, in the last ten years, the government has invested in science and technology 6632 billion USD (or USD 3 200 billion at 1984 value), excluding LOCTI funds allocated lately.

Initially, the funds allocated for *Misión Ciencia* were of the order of 600 million USD but shortly after its start were halved, and this is the figure recorded in Table IV. Although that level of funding was equivalent to the budget of the Ministry of S&T that year, the amount received and its use most probably will never be know since *Misión Ciencia* has never been allowed to be audited. The *Misión* was supposed to support the training of 20000 new Ph.D.'s, provide graduate training to 60000 bachelors and finance hundreds of large and collaborative projects in health, agribusiness, chemistry, nutrition but none in social sciences (see Town Meeting at *Interciencia*, 2006). Almost none of its goals have been fulfilled.

Regarding the new source of financing for S&T projects in Venezuela, the LOCTI law forces enterprises or businesses to use a given fraction of its gross income in three types of scientific and technological projects that need to be first certified by an official ad hoc office. It should be noticed that the magnitude of LOCTI funds listed under "In House" or "Third Party" for years 2006 and 2007, as listed in Table IV, amounts to 82.74% and 93.95% respectively of all LOCTI funds, a staggering amount of money compared with the meager amount that the Ministry was able to collect for itself, and listed in Table IV under "As Tax". This, the fact that the Venezuelan private sector has not much R&D facilities to show and complains of misuse of LOCTI funds by the private sector, are propelling changes in the scheme for distribution of LOCTI resources.

A perturbing issue of LOCTI concerns how come a 'tax' that oscillates between 0,5% and 2% of the gross income of major industries and enterprises, gets reflected on the GDP at a very much higher levels, such as the 3%, as it was seen during 2008. The explanation is that by its nature, LOCTI tax is a cumulative toll operating at every step of a chain of commercialization. No doubt that this design, when contrasted with an added value type of tax, ensures some safeguard against inflation but it is, in itself, inflationary. In complex and long economic productive chains, such as agribusiness or energy, at every commercialization step the value represented by LOCTI ends up being added to the price of the good or service.

While a tax such as LOCTI can be looked as a blessing for S&T, great care has to be exercised by the national administrators in ensuring that the Venezuelan system for research and development has the capacity to take or cope with large funding levels. In this sense, it would be unacceptable that a considerable economic effort does not translate in verifiable and significant scientific endeavor. In this context it is convenient to stress that LOCTI is a sociopolitical instrument that could reverse the course of a situation by all considered as improper. Indeed, LOCTI could very well mean the end of the divorce of the Venezuelan private sector with science and technology, an inbuilt fault into the Venezuelan S&T system and an odd aspect of our culture (Gasparini, 1969).

Conclusions

During the last decade, the Venezuelan scientific system was capable to recruit more talent and count more publications, but so inefficiently that the overall productivity has been in a steady rate of decline. Even if it looks that in the last four years there has been a dramatic increase in the level of investment in S&T in the country, it is worrisome that it shows no major effect on output parameters that depend heavily on it, such as infrastructure, number of researchers or amount of publications. It is very difficult to imagine that while in the last three or four years the investment in S&T has multiplied by a factor of six, most systemic parameters show an increment barely of the order of 5% or less. Either the system is not very efficient in its operations, or funding is not really reaching laboratories. As long as the magnitude of the growth rate of crucial parameters such as number of scientists and the intensity of their research stay close to the overall vegetative growth in the country, the existing gaps in S&T in respect of other nations will not be closed in Venezuela.

While the most evident recent downturn of Venezuelan science is related to the virtual collapse, on February 2003, of the R&D centre of the nationalized oil industry (INTEVEP) caused by the public dismissal of 2/3 of its work force because they had been engaged in the national lockout that year, the meltdown of the system probably started with the change in public and financing policies of S&T. This was introduced with the creation of the S&T Ministerial office and the quest for centralization of all S&T activities in the country. The justification for the change in the nature, conception and operability of the system, revolves around the need to have R&D activities focus mainly on social relevant issues. Nevertheless, while the word "social" seems crucial and paradigmatic to the Bolivarian Revolution, the deeds of its political and administrative actions speak to the contrary. Even though social scientists are the most numerous research group in Venezuelan, there are no sources of money for their research and, worst, no recognition for it. Suffice to witness the declaration of vacant, two years in a row, of the Annual National Prize for the Best Research Work in Social Sciences (Requena, 2008, 2009).

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CRISIS DE LA CIENCIA EN VENEZUELA

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RESUMEN

Los principales indicadores de un sistema científico: recursos humanos, infraestructura, finanzas y productos, son analizados a fin de revisar la dinámica actual de la comunidad científica venezolana. En la primera mitad del siglo XX, Venezuela no tuvo actividad científica institucional organizada. Entre 1954 y 1983 fue construido un número importante de instituciones de investigación y desarrollo en el sector público, el mayor proveedor de fondos. Mientras el personal científico actual es de 0,61 investigadores activos por 10000 habitantes, un análisis demográfico revela que envejece con rapidez, siendo más los que abandonan la profesión que los que ingresan. La productividad, después de alcanzar un máximo en 1993, ha descendido a su más bajo nivel el año pasado. Mientras algunos parámetros sistémicos, tales como infraestructura o número de investigadores o publicaciones en revistas indexadas muestran incrementos pírricos (4-7%), los números oficiales acerca de investigadores o inversiones reivindican aumentos de varias veces en años recientes. El sistema científico es ineficiente o los fondos no llegan a los laboratorios. En cualquier caso, mientras la tasa de crecimiento de parámetros críticos como el número de científicos y producción se mantienen cerca del crecimiento vegetativo del país, le brecha en CyT entre Venezuela y otras naciones no se reducirá. En conjunto, parecería que la ciencia venezolana está en peligro. Esto debe ser materia de preocupación, ya que la generación actual de investigadores y académicos en Venezuela pudo haber sido uno de los logros más significativos de su democracia.

CRISE DA CIÊNCIA NA VENEZUELA

Jaime Requena

RESUMO

Os principais indicadores de um sistema científico: recursos humanos, infraestrutura, finanças e produtos, são analisados com o fim de revisar a dinâmica atual da comunidade científica venezuelana. Na primeira metade do século XX, Venezuela não teve atividade científica institucional organizada. Entre 1954 e 1983 foi construido um número importante de instituições de investigação e desenvolvimento no setor público, o maior provedor de fundos. Enquanto a comunidade de cientistas atual é de 0,61 investigadores ativos por 10.000 habitantes, uma análise demográfica revela que envelhece com rapidez, sendo maior o número dos que abandonam a profissão do que aqueles que ingressam nela. A produtividade, depois de alcançar um máximo em 1993, tem descendido a seu mais baixo nível no ano passado. Enquanto alguns parâmetros sistêmicos, tais como infraestrutura ou número de investigadores ou publicações em revistas indexadas mostram incrementos irrisórios (4-7%), os números oficiais sobre os investigadores ou investimentos reivindicam aumentos importantes em anos recentes. O sistema científico é ineficiente ou os fundos não chegan aos laboratórios. Em qualquer caso, enquanto a taxa de crescimento de parâmetros críticos como o número de científicos e produção se mantêm perto do crescimento vegetativo do país, a brecha em CeT entre Venezuela e outras nações não se reduzirá. Em conjunto, pode parecer que a ciência venezuelana está em perigo. Isto deve ser matéria de preocupação, já que a geração atual de investigadores e acadêmicos na Venezuela pode haver sido uma das conquistas mais significativas de sua democracia.