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UNESCO FORUM
on Higher Education, Research and Knowledge

Study on National Research Systems
A Meta-Review

REGIONAL REPORT ON LATIN AMERICAN COUNTRIES

Compiled by R. Waast

2007

UNESCO

THE UNESCO FORUM ON HIGHER EDUCATION, RESEARCH AND KNOWLEDGE

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Study on National Research Systems

A Meta-Review

Compiled by Roland Waast

Drawn from monographs prepared by D. Villavicencio and Team.

Other Sources referenced in the text.

United Nations
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Latin American Report

Table of contents

SECTION 1: INTRODUCTION AND SOURCES.

This Report draws mainly from monogaphs prepared by **D. Villavicencio *and his team*** (See their compilation in a special volume). These documents follow the standard format we asked for, and each of them compiles a number of other monographs and sources (cited).

As good as such documents may be, they cannot replace a direct and recent experience of what is going on in the field. This is why they themselves go beyond what we expected, because our format appeared narrow or unsuited to their authors. This is why we ourselves supplemented their information by an intense reading of articles dealing with S&T and R&D in Latin America, recently published in specialized journals[1].

However we remain conscious that our tentative synthesis is more unsteady than others we did about regions of the world (Africa, Arab countries) which one of us lately visited or where he conducted field work and keeps permanent contacts.

[1] Such as *Research Policy*, *Science Technology & Society*, *Social Studies of Science* etc.

There are three lessons in that.

- One is that there exists a lot of *grey literature* of good quality[2] about the S&T systems in most of the developing countries. A first task is to compile them even before launching new studies.
- The second lesson is that it is possible to rely for such a task on *a body of specialized scholars* and their network. This body does exist (especially in Latin America, which is the continent where studies of science are most developed and professionalized) and deserves to be supported and extended through the world.
- The last point is that, whatever the templates of standard monographs, they will be deceptive in some ways; they cannot apply to "all fields in any situation". They should be completed by a compilation of stimulating articles written by specialists, assessments by scientists and direct acquaintance with the context.

Let us now with ingenuousness try to realise our brief. After looking at ***Indicators*** and ***Descriptors***, we'll give some ***summary findings*** from the country reports. We'll pick out salient traits of this continent. We'll then pay heed to the main contemporary trends in governance and policy; in the institutional framework and the status of human resources. We'll distinguish different "clusters" of countries, which show distinctive features.

SECTION 2: INDICATORS.

**** Economic indicators***
**** Social Indicators***
**** University***
**** Research***

[2] Such as national policy documents, assessments commissioned by donors, or in Latin America: studies launched by national or continental Observatories – such as RICYT.

INDICATORS for LATIN AMERICA

Economic Indicators

	GDP $ billions 2003b (WDI 2005)	PPP gross national income/ Per capita $/ 2003(Wdl 2005)	PPP gross national income/ Per capita / Rank 2003(WDI 2005)	GDP per capita annual growth rate % 1975-2004 (UNHDR 2006)	Manufacturing, value added (% of GDP)(WB2003)	Personal computers per 1,000 people 2003(WDI 2005)	Technology Achievement Index (UNDP 2001) rank	High-technology exports (% of manufactured exports)(2003WB) UNIDO report
Latin America and Caribbean								
Argentina	140,1	11410	66	0,4	23,92	82	34	8,67
Bolivia	7,9	2490	151	(.)	14,77		46	7,86
Chile	68,7	9810	77	3,9	19,71	119,3	37	3,39
Colombia	80,5	6410d	97	1,4	16,03	49,3	47	6,5
Costa Rica	17,2	9140	79	1,3	21,28	197,2	36	44,79
Cuba	..	3.900 / 1.700	..	..	..	31,8	..	..
Ecuador	23,8	3440	137	0,3	10,11	31,1	53	5,97
Jamaica	7,9	3790	134	0,6	13,46	53,9	49	..
Mexico	637,2	8980	80	0,9	17,97	82	32	21,34
Panama	12,1	6420d	96	1,1	7,7	38,3	42	0,95
Peru	58,2	5080	117	-0,5	15,37	43	48	1,82
Trinidad and Tobago	10,2	10390	74	0,3	6,9	79,5	42	1,22
Uruguay	12,9	7980	84	1,1	18,03	79,5	38	2,11
Venezuela	89,7	4750	125	-0,9	18,09	60,9	..	4,09

Years and Sources : as indicated

Social indicators

	Total Population millions 2003 (WDI 2005)	Fertility rate, total (births per woman)(WB2003)	Health expenditure, total (% of GDP)(WB2003)	Total public expenditure on education	HDI rank (UNHDR 2006)	Poverty headcount ratio at $2 a day (PPP) (% of population)(UNHDR2006)1990-2004	Net migration thousands 2000(WDI 2005)	Urban population (% of total)(WB2003)
Latin America and Caribbean				as a % of GDP				
Argentina	36,8	2,33	8,9	4,0	36	23	-100	90
Bolivia	8,8	3,8	6,7	6,4	115	42,2	-100	63
Chile	15,8	1,99	6,1	4,1	38	9,6	60	87
Colombia	44,6	2,4	7,6	4,9	70	17,8	-200	72
Costa Rica	4	2,08	7,3	4,9	48	7,5	128	61
Cuba	11,3	1,63	7,3	...	50	..	-100	76
Ecuador	13	2,77	5,1	...	83	37,2	-300	62
Jamaica	2,6	2,44	5,3	5,3	104	13,3	-100	53
Mexico	102,3	2,21	6,2	3,9	53	20,4	-2 000	75
Panama	3	2,67	7,6	4,4	58	17,1	11	69
Peru	27,1	2,82	4,4	3,0	82	31,8	-350	72
Trinidad and Tobago	1,3	1,61	3,9	4,3	57	39	-20	12
Uruguay	3,4	2,1	9,8	2,6	43	5,7	-16	92
Venezuela	25,7	2,69	4,5	...	72	27,6	40	92

Years and Sources : as indicated
Total public expenditure on education: UNESCO, HE Global Digest

University

	Total enrolment 2004			Gross enrolment ratio Tertiary Edu 2004	Public expenditure per student as a % of GDP per capita	Teaching staff		Total number of graduates	
Latin America and Caribbean	MF	%F	%Private	MF	Tertiary	MF	%F	MF	% F
Argentina	2 026 735	59	21	61	13,1	127 077	50	...	...
Bolivia	346 056	...	...	41	35,9	17 759	...	19 326	...
Chile	567 114	48	74	43	15,3	...	...	64 364	51
Colombia	1 112 574	51	55	27	26,3	87 544	33	65 720	57
Costa Rica	79 499	52	...	19	...	4 494	...	26 463	62
Cuba	235 997	56	-	33	...	44 669	37	...	...
Ecuador	...	...	...	...	...	...	...	...	...
Jamaica	45 770	70	...	19	44,4	2 006	60	...	...
Mexico	2 236 791	50	33	22	27,0	231 558	...	18 927	50
Panama	130 026	61	19	46	28,2	10 381	44	...	...
Peru	831 345	51	47	32	14,0	56 070	...	...	...
Trinidad and Tobago	16 751	55	10	12	...	1 720	34	3 176	60
Uruguay	98 520	65	10	38	19,0	11 989	...	7 476	67
Venezuela	983 217	51	27	39	...	...	...	101 112	...

Source : *UNESCO, HE Global Digest*
Year: 2004

Research

	TOTAL:Number of Researchers - Includes Researchers, PhD scholars, R&D assistants. Excludes "Other supporting staff, S&T services staff"		Number of degree holders, expatriate in USA and working in R&D*s (1999)	Expenditure on R&D	Teaching staff	Publications in SCI Search	Publications in SCI Search per capita population	Publications in SCI Search per GDP	Publications in SCI Search per R&D Expenditure	Publications in SCI Search per 100 researchers FTE
Latin America and Caribbean	Headcount unesco)	FTE (country profiles)		%of GDP	MF		Publications per 100 000 population	per billion US$	per million US$ (Calculated)	
Argentina	43609	27 000	4 200	0,41%	127 077	5640	15	40	8	21
Bolivia		1 000	1 000	0,28%	17 759	129	2	16	4	13
Chile	8658	7 000	1 500	0,61%	...	2972	19	43	6	42
Colombia	10851	5000	4 700	0,16%	87 544	840	2	10	5	17
Costa Rica	1171	1 000	1 000	0,36%	4 494	285	7	17	4	30
Cuba	6027		5 900	0,65%	44 669	726	7		3	18
Ecuador	845	600	2 000	0,07%	...	193	2	8	9	30
Jamaica			4 800	0,07%	2 006	189	7	23		
Mexico	33558	12 000	7 500	0,40%	231 558	6602	7	10	3	55
Panama	432	300	1 600	0,34%	10 381	222	7	18	5	
Peru	4965		2 800	0,10%	56 070	423	2	7	5	
Trinidad and Tobago	518	500	2 000	0,12%	1 720	127	9	12	9	25
Uruguay	3839,00	1 000		0,26%	11 989	418	12	32	11	42
Venezuela	6100,00	3 000	2 500	0,28%	...	1235	5	14	4	41

Sources : *UNESCO, HE Global Digest, Year = 2004*
Country Profiles = Our monographs
Publications in SCI Search = SCI Search
Expatriates in USA = Jean Johnson, NSF in R. Barré, JB Meyer et al. *«Scientific Diasporas »*, 2003, Paris :IRD

SECTION 3: DESCRIPTORS.

**** Historical setting (The case of Argentina)***
****
**** Output (Publications)***

3.1. HISTORICAL SETTING

The long march to carve a space for Research: Argentina

Extracts from: **Hebe VESSURI** (1997), "Bitter harvest : the Growth of a Scientific Community in Argentina", in *Scientific Communities in the Developing World*, Sage: Delhi, 307-353.

In her very detailed and thoughtful analysis of this case, Hebe Vessuri writes:

> "The Argentine "promise" consisted of the combination of European immigration, *universal education*, European capital and natural wealth. This is supposed to be at the bottom of the "miracle" of the 1880-1930 period… Around the 1880s the structure of education at all levels suffered deep changes. Argentina, the same as Uruguay, Costa Rica and to a lesser extent Chile accompanied [its export economy] with a social and legal organization that involved the inclusion of all the population in the basic circuits of cultural diffusion. The global mass of population had access to a minimum of basic schooling… The progressive Argentine democratic free public school was aimed at spreading secular values, republican principles and a certain scientistic outlook which reflected the cultural order of the most dynamic sectors of society. The elite had access to more elaborate intellectual manifestations in the Universities…
>
> These educational changes had a deep and long lasting impact on society. By the 1920s the growth of secondary schooling was massive. Many young people started on the road to upward social mobility through education. They entered the university or began to dispute places in the cultural domain and the liberal professions.
>
> H. Vessuri then distinguishes *three periods of the institutionalization and professionalization of science:*
> * the "*formative period*" (1880-1915) during which vocations grew and key figures strenuously won an appropriate context for developing their theories and experiments. "The key institutions of the new "positive science" were the observatory, the natural science museum and the university" (specifically three of them: Cordoba dating back to 1613 and more subordinated to liberal education, Buenos Aires (founded in 1900) and La Plata (starting in 1905 with the explicit project to develop physical and exact sciences with a strong emphasis on research, on the basis of pre-existing non-university institutes and following the German model of a strong partnership museum-institute-faculty). A number of high flying expatriate Europeans were hired and delivered up to date teaching and advanced research, while their best students went to Europe and improved in renowned laboratories where they worked with Nobel prizes and other creative researchers. This period is rich in illustrious names of founding fathers (researchers and managers[3]). During the same time "the international trend of development of scientific laboratories received government support. State laboratories and research Centres for a while became a model in their kind (with specific concern for public health and agriculture). Agricultural experimental stations, the modernization of cities and ports etc. were clear manifestations of progress and industrialization… *The state* was the main patron of research and educational programmes in the universities and other institutions".
> * *institutionalisation ("national* soul searching: 1916-1945"). By the 1920s, Argentine science was "ripe to produce its own transformation". A number of autonomous research institutes were established inside (and sometimes outside) the Universities. Graduates occupied positions in segments of the society and the state bureaucracy. An incipient scientific market had emerged. The intellectual field became more autonomous and differentiated vis a vis other

[3] F. Ameghino in paleontology, B. Houssay in plant physiology, E. Bose J. Laub and K. Simons in physics, R. Gans and his distinguished pupil E. Gaviola, O. Krause in engineering etc. Among them several Nobel Prize winners to be.

social domains. From then on, the support of the state experienced ups and downs (since 1930). But the history of science, and of the university to which it was closely associated for a long time, can no longer be reduced to political history. The more visible universities continued to grow, with faster rhythm. Less visible science was also making progress. Some of the research centres began to bear their most valuable fruits, while the coexistence of research and teaching in the university became more common[4]. Learned Societies developed rapidly, with their journals and congresses[5]; and as early as 1934 the *Association for the Advancement of Science* became established. Its proposal (in 1937) to create a National Council for scientific and technological research (as in the most developed countries of the time) wasn't supported by the state until the beginning of the 1960s. However it was able to carry on its own activities on an autonomous basis and do so with a large audience which was transformed into a *scientific community*.

* Unsteady relations of the state with this scientific community were the typical feature of the next forty years (1945-1984); but they were also years for a new *professionalism*. 1945-1975 was marked by the ideology of "Developmentalism", strange socio cognitive blocs between the government and factions of the scientific community (as between Peron and the physicist Richter around a controlled nuclear fusion programme – which failed) and ostracism of others (Gaviola in physics, Houssay in physiology or Leloir in biochemistry). But this too was the time for emblematic *ambitious and long lasting programmes*, driven by nationalism[6], organizing scientists in a new way which offered a favourable environment, with both applied and fundamental research, interdisciplinary work, large teams and a culture of results. The most famous one (and most successful in many respects) was conducted under the Atomic Energy Authority (founded in 1951) and led to the acquisition of much know-how as well as to efficient technology transfers. Parallel to such Agencies the new form of professionalism took roots in new Institutes (autonomous in the Universities, as with the Instituto de Sociologia at Buenos Aires; or outside their boundaries, free of political pressure and *private* as with IBME for experimental medicine or Fundacion Campomar for biochemistry). They were founded by some brilliant groups of (often) young scientists through local private patronage and international Foundations (Rockefeller for Campomar).

* *The first appearance of an official body dedicated* to S&T governance at a national level *was much later* than this whole history of the scientific community and feats. It was only in 1957 that a National Council (CONICET) was put in charge of promoting, fostering and carrying out (if necessary) scientific and technological activities in all areas of knowledge throughout the country. During the sad dictatorship of 1976-1983, its power and budget grew considerably and its focus was on the creation and management of an important sector of government institutes outside the Universities (mainly to control the researchers and often reduce research to applications and services). Since 1987 there has been a clear recovery of the Universities (very ill treated in the previous period) and a new mandate of the CONICET with a role of technology transfer.

[4] Houssay's Instituto de Fisiologia was founded in 1919 and was the nursery for very productive researchers. Genetics has been taught at La Plata since 1915, immunological studies were run and an Institute of genetics opened in 1929: it brought out numerous applied results and important innovations for wheat-rye and corn. Etc.

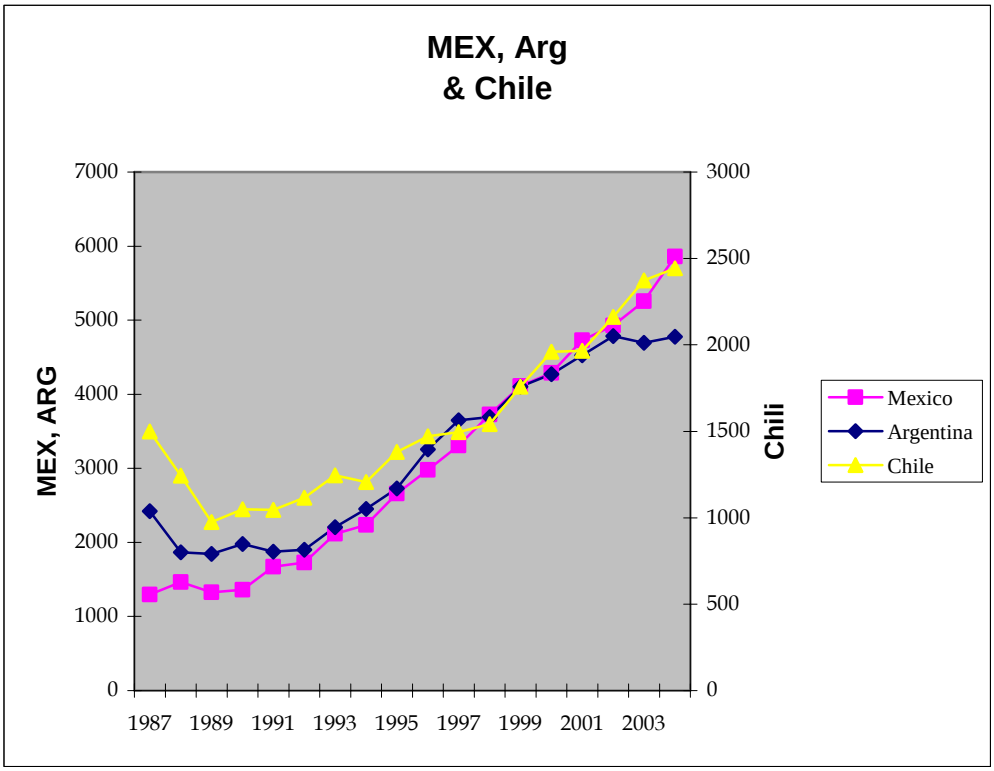
[5] Among the most renowned are the Society of Biology (created by Houssay in the 1920s) and that of Physics (created by Gaviola in 1942).

[6] And or aiming at ripening comparative advantages, strengthening local technological capacity and supporting a scientific-technological system.

3.3. OUTPUT (1987-2005)

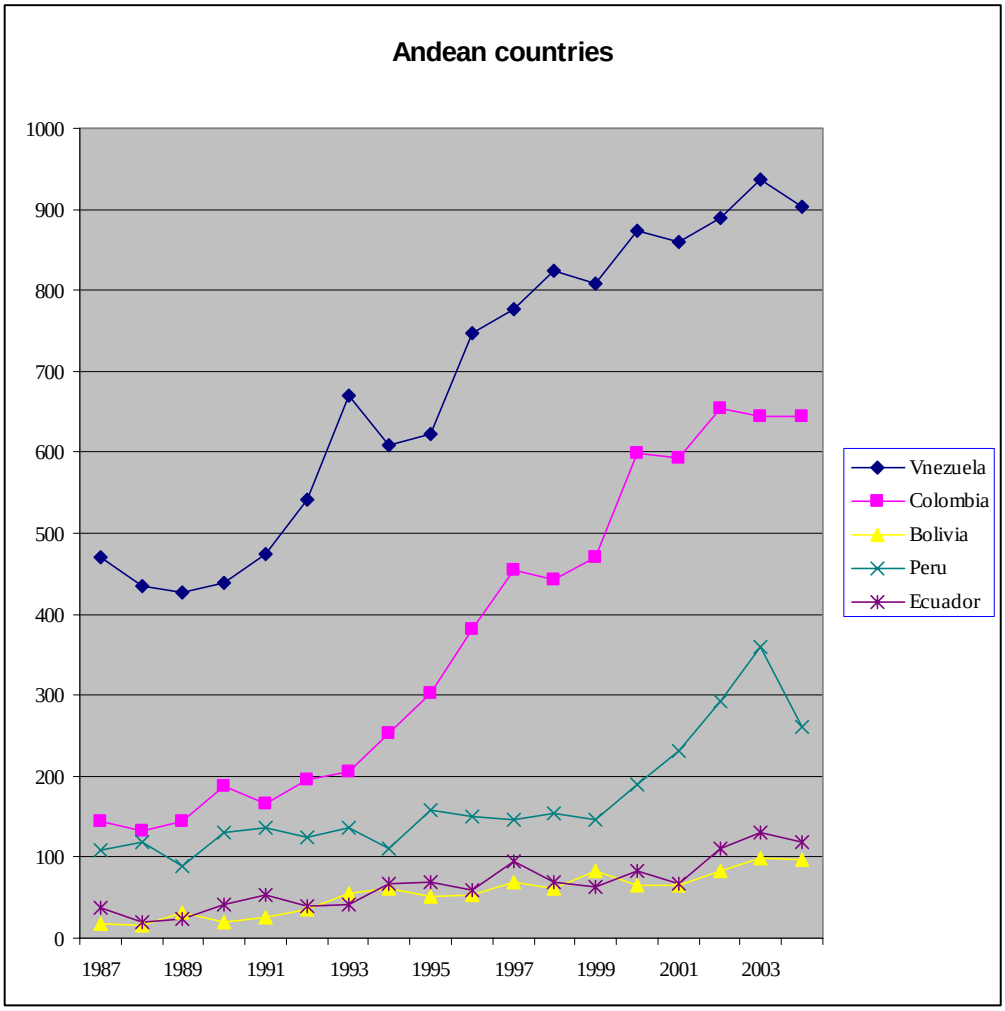
(Publications, Some Countries from Latin America;)

1) Countries with "Innovation" policies and linked Action plans for Research
(= Candidate Countries to become "Emerging" ones).

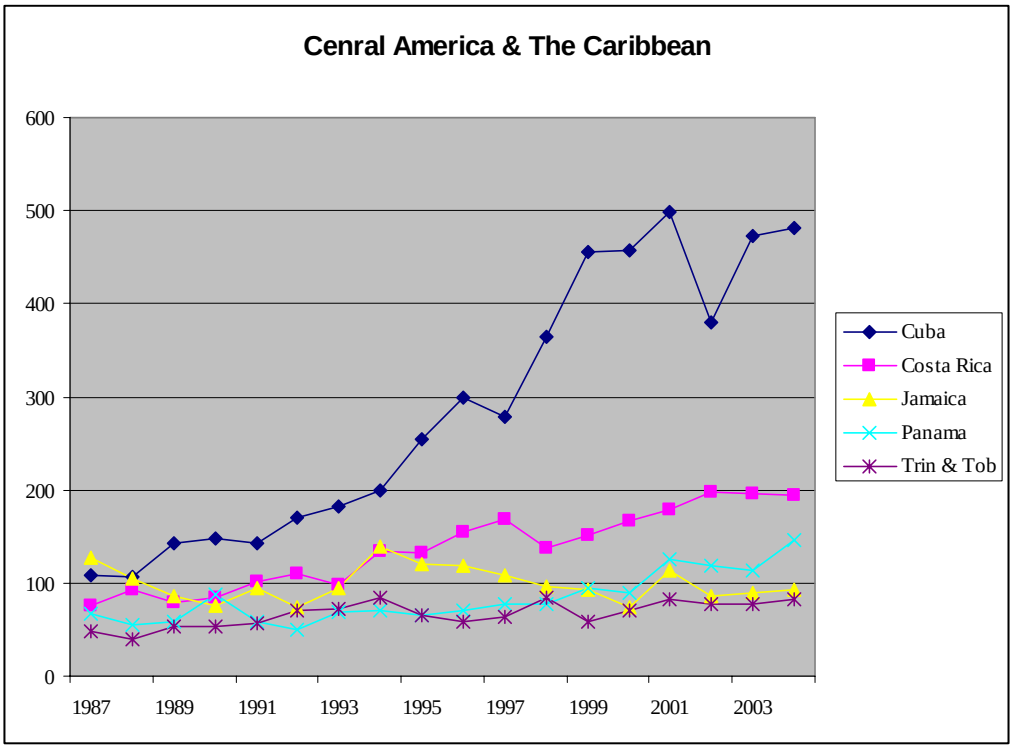


2***) "Hesitating" countries vis-à-vis "Innovation" policies and linked Action plans for Research***

(Andean Countries. Venezuela possibly an exception)



3) Countries of "Laissez faire" policies
(Central America and the Caribbean)
Two Exceptions: ***Cuba*** *and* ***Costa Rica***



SECTION 4: SUMMARY FINDINGS FROM COUNTRY PROFILES.

4.1. GENERAL VIEW.

Salient traits of the Region

Latin America is specific in several ways. These features have an impact on the dynamics of S&T in the continent.

1) Colonial rule occurred in Latin America well before in other regions, as such it did not leave any scientific legacy. This is in contrast to Africa and most parts of Asia. Modern science developed "indigenously", and went with ***a long process of education*** (including tertiary education, at the latest by the end of the 19th century).
2) The carving of a "space for science" has been from the beginning an issue of *key figures and Research Centres* (Museums, Observatories, Institutes and Foundations, often staying aside the regular institutions). The first circles of devotees enlarged and aggregated new converts among the professional staff of Universities and State Agencies. The whole movement culminated in the emergence of ***scientific communities***, which developed their own powerful organisation: Associations for the Advancement of Science (in the 1930s-1950s), national and even continental learned Societies or establishments. These institutions are autonomous and claim the loyalty of researchers independently of the service they are attached to.
3) ***Later,*** government frameworks were adopted in most countries (by the 1960s), with a *very similar and original pattern: that of* ***National Councils*** *for Science* (CONA or CONICYT…) which are autonomous bodies in charge of administering national budgets, elaborating policy and planning the development of S&T. They are under the disputed control of the scientific community (the originators) and the State (which provides them with funding). Supported by the former, they have survived many stormy and bloody changes of regime, as well as the twists and turns of economic policies[7]. They have been maintained as supervisors and drivers of Science for decades, and their similarity favoured their relations, networking, benchmarking, exchange of ideas, persons and good practices, and professionalism. As a result, one can say that there is an implicit *Latino American space for science*, with specialists (often economists of science), Continental institutions (Universities, Research Centres, Observatories) and an intense circulation of scientists and ideas. This is much more the case here than in any other part of the developing world.
4) Nevertheless there is room for ***important discrepancies*** of the S&T systems, linked to the social history, size, resource endowment, development strategy of the various countries and sub regions. We'll identify at least 3 "clusters" of countries (with exceptions inside each of them): Central America and the Caribbean; Andean countries; and the Eastern coast countries (to which should be added Chile and Mexico: See the "Governance" section). This brings to light the fact that, beyond explicit governance (Councils) there is an implicit one (several actors in a segmented system). We will therefore question the resulting force (Science policies, Action Plans and in the last resort the legitimacy of science).

[7] From import substitution, auto centred and "developmentalist" options, to the wildest liberal policies implemented at the opposite of the world trend: Argentina: 1976-1983.

Historical setting

Latin America illustrates the ***long march*** allowing the carving out of a space for science. Argentina is a well documented and an emblematic case. The Descriptors section offers a summary of the thoughtful and detailed analysis carried out by H. Vessuri[8]. She stresses that basically all relies on a *long effort of universal education*, at all levels. In Argentina it was launched as early as the 19th century. Concerning research, Vessuri distinguishes three main periods:
* the *formative* period (1880-1915) during which vocations grew and founding fathers (often expatriates or immigrants) won devotees in some key institutions (outside the university, or in the 3 main Universities which developed the explicit project to go beyond professional training and integrate research and experimental thinking in the degree courses).
* the *institutionalisation* (1916-1945) took place when sufficient talents were available and went in search of a "national soul". A number of autonomous research institutes were established inside (and sometimes outside) the Universities. And the State (under the pressure of industrialisation and urbanisation, and pushed by the ideals of progress and modernisation) established for its own needs laboratories which for a while were a model in their kind. Soon the intellectual field became more autonomous. Norms of scientific (and technological) rigor were internalized. Learned societies prospered and a scientific community took shape (with its own powerful organizations).
* the next period (1945-1975) is one of disputes between the government and the academy (supported by the scientific community), but also the time for a new *professionalisation* in the framework of ambitious programmes (e.g. nuclear), large teams, and a combination of basic and applied research.
* the officialising of *a government for science* is late: CONICET is created in 1957, and the first document of science policy can be dated of 1950.

Though with variations, it is possible to identify the same steps of this slow ripening in most of the countries of Latin America. They are well documented in Brazil, Chile or Uruguay. The first Universities appear almost everywhere at the latest when the 20th century begins. However in some cases the formative and the institutionalisation stages of research come later (Venezuela).

4.2. GOVERNANCE AND POLICIES.

Three features may be stressed:

* The first government framework appeared rather late and took on the *similar and original shape of "National Councils of S&T"*, throughout the Continent.
* Nevertheless, beyond this "explicit governance" there may be implicit ones, and *deep differences in science policy*. We'll distinguish three clusters of countries, with different 'trajectories" regarding their interest and strategy vis-à-vis S&T.

[8] Bitter harvest : the Growth of a Scientific Community in Aregentina, *Scientific Communities in the Developing World*, Sage: Delhi, 307-353. See also in the same book: R. Rengifo, A. Pirela & R. Arvanitis, Science and Production in Venezuela: Two Emergencies, p. 354-380.

* Over the past decade this *scientific order has been rapidly changing*. There is a shift in policies and governing bodies, as the function of research is reconsidered. This is mainly true in some countries, and the gap between clusters is widening.

Explicit governance: The National Councils for S&T.

In spite of its long and brilliant history of modern science, Latin America did not inscribe research *as an affair of state* until the beginning of the 1960s. Indeed in the first old "formative period" the state had been "the main patron" of research and educational programmes. But their advancement and organization were left to key figures and were undertaken by autonomous Institutes or Faculties, and regulated by the burgeoning scientific community. In this case, *the State is not the instigator* of Science, as it appears to be in other parts of the developing world (Africa, Maghreb, parts of Asia).

Under the double pressure of a mature scientific community and of international bodies (UNESCO was instrumental), most governments came together over the idea of research being a lever for development. Such research needed planning, and the consistent participation of the State. This idea was embodied in the institutional framework of National Councils, which were put in charge of designing a national policy, coordinating foreign cooperation and administering budgets mainly provided by the public sector. These Councils were autonomous and under the control of specialists – mainly the scientific community. The benefit of such Councils was to ensure the minimum attention of the State whatever the government of the time and to guarantee a long term competent management of scientific endeavours.

This arrangement has been *sustainable* and successful in many instances. It persists in most countries, though in a number of them (Chile, Costa Rica, Argentina…) it has been recently reduced to the function of administering funds rather than policy making. This in turn is the result of a permanent (if largely unseen) split in the scientific community, between "academic" supporters of fundamental research, and advocates of an applied "useful" one. National Councils (often under the control of the former) never really brought to a close *the dispute between "excellence" and "relevance"*, as the main function of research.

Science policies: three clusters of countries.

Beyond the explicit inscription of Science among governments' concerns, it must be acknowledged that "*real policies*" (translated into budgets and action plans) are very diverse.

The private sector is supposed to be an actor, though its contributions are generally weak. Contributions by the state are fragmented: they come from different Ministries, which have their own agendas and often operate their own Institutes. They may also come from powerful State owned companies which are in the same position, and do not really care about the National Councils agendas (Venezuela). One result is that *the system is fragmented*, with weak coordination. Another is that main actors are *not always convinced by the legitimacy of the research* offered by National Councils and do not support funding for it.

This is why science policies may vary from intense support to pure laissez faire. We'll distinguish ***three "clusters"*** of countries, according to *the "**trajectory**" of their interest* in Science.

a) ***Central America and the Caribbean*** are small populated countries, with ethnic diversity and deep social inequalities. Their records in qualification of the labour force are poorer than elsewhere in Latin America. The GDP per capita is generally low, but not in all countries[9]. Up to the recent past these countries did not voice any concern for S&T. Even the wealthy countries were not interested in industrialisation (but rather in the development of services and trade). Therefore it can be said that they do not care much for research. They have no "National Councils" and it's only been in recent years that some of them have publicly shown interest by establishing a Ministry (T&T: 2002) or strategic plans (Panama: 2006) and dedicated organizations and bodies (Jamaica: under the authority of the ministries of trade and of industry). Nevertheless their trajectory remains one of **laissez faire.** They do not consider their future through activities with intensive use of S&T knowledge. As several monographs note, there is no incentive policies to encourage private investment into research or innovation, and there is no unified and steady science policy. Expenditure on R&D is low (0,1% to 0,2 % of GDP). The universities have no mandate for research (except at their own initiative: West Indies University is an example[10]). The output has ups and downs, depending on grassroots initiatives and foreign cooperation. Globally, it can be said that there is little political interest in R&D, and the attention given to S&T issues is as yet thin and new. ***Exceptions*** in that zone are *Cuba and Costa Rica*. **Cuba** has long been supporting science and research considered as "productive forces". Expenditure in R&D is the highest in Latin America (0,65 % of GDP). There are numerous high-quality Institutes and university laboratories, with up to date collaborations abroad. The main thrusts are on medicine, biotechnologies, and all sorts of basic research. Observers consider that its scientific potential is now an important asset for the economic future of the country – whatever its regime). The other exception is **Costa Rica** which places stress on diversifying its economy, facing globalisation and upgrading its industrial potential. It managed to set up some well known "Triple Helix" endeavours, attracting foreign enterprises and organising technology transfers (e.g. a long term agreement with Merckx in a joint venture to explore and value the local pharmacopoeia). Expenditure on S&T is important (0,4 % of GDP), there has been a constant effort over the past 20 years (a National Council since 1972, and above all a Ministry and policy documents since 1986). Since the 1990s the motto is "innovation". In many respects, Costa Rica looks like Argentina or Chile today (see below).

b) another cluster is that of ***Andean countries***, which began early with the development of Universities and the establishment of a few renowned research centres (like IBBA in Bolivia or INGEMET in Peru: geology and mining). The National Councils were established as in other countries of the sub continent (1968 in Colombia with its planning and funding wing COLCIENCIAS, 1969 in Peru and Venezuela). But the investment in R&D has remained at a low level over the past decades, the potential is declining (many brilliant scholars have left) or resigned to mediocrity with establishments of poor standards (cf. monograph Peru). However there are *ups and downs*. There was a revival in Peru in 1975-1980 (GERD = 0,35 % of GDP, instead of 0,1% before and after); another one in Colombia (with the "1990 Law 29" and an

[9] Generally around 3000 US$ per cap ; but 6400 in Panama (benefiting from the opportunities of the Canal) and 10500 in Trinidad & Tobago (which is rich in oil).

[10] This is at the clever initiative of individuals and small teams, in the field of Agriculture, Medical and Social sciences and through the ways of an original action research in topics of health care, dealing with poverty, and some industrial small projects. Funding comes from different ministries, and from foreign Agencies.

important boost to COLCIENCIAS). In *Venezuela*, a significant batch of measures has been promulgated through successive National Plans, since 1976 and the creation of a dedicated Ministry. They ensure contributions of the enterprises (through taxing) and insist on the need to stimulate the technological development: one can say there is here a research system, with an influence of economists and planners. Venezuela could well be an exception in the Andean cluster as it aims seriously at an "innovation path". Nevertheless the *"trajectory" remains unsteady, there is dispute* over the function of research, and in spite of references to a policy of innovation the action plans place a great deal of emphasis on traditional activities (either scientific or technological, oriented toward industries with scant added value and limited use of know-how).

c) On the contrary countries of the ***southern Cone*** (Chile, Uruguay, Argentina) recently turned to run for the status of ***emerging countries*** - as Brazil ***and Mexico*** are already. They are boosting their support to R&D.

   Science has here a long tradition, founding fathers and dramatic advancements (such as the story of aeronautics, or the nuclear endeavours of Argentina). Past Nobel prizes and vigorous key figures went down in legend. Vocations are plentiful and a scientific community is established. National Councils were created decades ago. Nevertheless political turmoil caused many a time the collapse of science establishments, exile and persecution of hosts of researchers and abrupt withdrawal of any support to Science.

   Over the past eight to ten years, these countries have become relatively pacified. They are now betting on a change in their economy and on sustained *innovation* for their enterprises. They are renewing their science policy in order to link the achievements of science to this new goal. This also means that they give *a new legitimacy* to research (even in basic sciences) and they take it seriously enough to rebuild their science system. Their new doctrine (innovation) probably entails its share of reforms of the institutions, and even of the professional model of a number of researchers.

   For example, twenty years ago Mexico (which we join to this cluster) successfully developed an original "Sistemo Nacional d'Investigadores" restricted to the "real" researchers (those who accept to submit to a periodical strict assessment in exchange for notable personal bonuses and facilities to conduct their work). In parallel a number of funding mechanisms have been established to encourage firms to invest in R&D and researchers to collaborate with them in joint projects[11]. *The expenditure on R&D* is clearly more important than elsewhere on the continent, and significantly growing (0,4 % of GDP in Argentina and Mexico, 0,65 % in Chile). Results are growing too in terms of international publications as well as patents[12] and collaborations between firms and academics.

The Function of Research: a debate.

Governance and science policies, in their *substantive* content, depend on the recognition of a research *function* by the government and the society all around. In all Latin American countries there are sufficient organs for research: Universities and State institutes (some of them with an ancient research culture), dedicated Centres (public or private, and renowned), extensive human resources, governing bodies and their information system. Does this whole

[11] See details in monographs : Argentina, Chile, Mexico.
[12] Though this is not the most spectacular result. See the Indicators section, and the trend in monographs.

apparatus function as a system? Are these organs specialized, interdependent, and capable of auto correction if one of them fails? Are they working together toward a common goal, as those of our digestive system which contribute to a vital function in our body? A number of countries seem not to be convinced by such a function of research. The Andean countries are hesitating.
Should science target "Excellence" or "Relevance" in developing countries? This unremitting debate, within the very scientific community[13], obscures the perception of research and involves many issues of organization (which preferred performers?), funding (what is the fair share for fundamental research?), evaluation (which criteria?), partnerships (world scientific community or local stakeholders?), etc. Which knowledge is worth being pursued in one of these countries, and is knowledge creation a public affair?

By adopting *innovation* as the social objective including research, a group of countries now sets forth a new legitimacy of science, removing it from the trap of the "great divide" between excellence and relevance. There is room in the new function for a continuum of researches, spreading from fundamental to applied and development projects. But there is also the need to reorganize institutions, professional practices, topics to be tackled, and the social inscription of science.

4.3. INSTITUTIONAL FRAMEWORK.

It has been said in other reports (Africa, Asia) that three main conditions should be completed for a modern science system to work. Namely:

- There is a core of relatively stable and well-resourced scientific institutes
- There is consistent government and industry investment in these institutes
- Scientific institutions flourish under conditions of economic and political stability and within a science governance system that allows for their autonomous and relatively independent operation

One can say that the three conditions are now fulfilled in the cluster of "emerging" countries. Sufficient funding and steady local investment are lacking in the other clusters. Universities and Institutes have to manage on their own if they want to develop a research scheme. Their professional culture has not always prepared them for it.

Strong potential

Most Latin American countries have a great number of Universities. The gross enrolment ratio in tertiary education is higher than in other parts of the developing world. It is at least around 20 % (in Mexico and the Caribbean: this would be a good level in Asia or in Arab countries); more often around 30 % (in Cuba, Peru and Colombia: the best level in Asian and Arab countries); and generally around 40 % (culminating with 60 % in Argentina: the level of a developed country).

The number of academics is therefore important (there are 200 000 in Mexico and 130 000 in Argentina; nearly 100 000 in Colombia and Venezuela; around 50 000 in Cuba, Peru, Chile; and around 10 000 in less populated countries[14].

[13] Cf R. Rengifo, A. Pirela & R. Arvanitis, 1997, "Science and Production in Venezuela: Two Emergencies" in *Scientific Communities in the Developing World*, Sage: Delhi, p. 354-380
[14] Only 2 000 to 5 000 in some Caribbean countries: Jamaica, Trinidad and Tobago, and in Costa Rica.

Numbers of full time researchers are employed in government Institutes (notably in agriculture and health) or in private Centres and Foundations. In some cases, important firms (often government owned: Oil in Venezuela, Mines in Chile…; but now also multinational firms in automotive, ICTs or pharmaceuticals industries) have their own research Centres.

It is not easy to determine the number among them who are *actually involved* in research; and the share of their time devoted to this activity. Numbers are clearly much lower than the previous ones. Some countries have tried to evaluate them. Mexico counts 12 000 persons accredited by its "National Researchers System" (thanks to their good publications record: see below). Other people (probably as many) practice research of another sort (more applied). The total number (headcount) announced to UNESCO is around 30 000. Venezuela too has an assessment system. Its researchers' programme includes slightly fewer than 3 000 persons; and the total number of researchers sent to UNESCO is 6 000. Argentina is supposed to have 25 000 researchers FTE (full time equivalent, but this is probably an overstatement, compared to the score of SCI publications) and Chile 7 000 (See the ***indicators section***). Other countries are rather around 1 000 (a few hundreds in the Caribbean countries). Such figures may seem excessively harsh, compared with the numbers of potential researchers. It may be a problem of definition (what can be called research?). But it points also at some problems of efficiency, that appear as soon as evaluations are instituted and the results are measured.

Some weaknesses of present institutions.

Several monographs state a number of structural features that become drawbacks as soon as "innovation" is the entire reason for research.

One is that *local doctoral studies are a rather new thing* in many countries, without know-how to launch them[15]. The monograph dealing with Peru puts forward the great number of scattered and mediocre Ph D courses, with a poor yield: 9 Ph D per year for all of the universities in all disciplines. Similar assessments are done regarding other Andean and Caribbean countries (Cuba is the notable exception). There seems to be a need for institutional rigor (assessing, selecting, networking to get external support) in order to address this problem.

Another feature is some self-conceit of academics and their institutions, smug with their function rather than with research (or achievements) records. Values of "excellence" are not in current use (and supposedly discredited in the social environment). This is reported for Peru, but also for Chile; and it may occur in other places. There seems to be *a need to raise ambitions*, take part in international programmes and gain insights into the important stakes of global scientific and technological issues.

Almost everywhere, active researchers are overwhelmingly committed to fundamental science; this is the sort of research which is valued by their institutions and management. This is an important asset. But the ratio may be excessive and there is a need to develop (especially among young scholars) a new culture, *a taste for applied research*, acquaintances in the

[15] Simultaneously there is a need to create them (with teachers who are not always up to date), to support them with choice collaborations abroad, and to maintain a fair share of grants for trainees in foreign countries. Several countries have already bypassed these reefs: Mexico established its national board of masters in 1976 (with accrediting commissions); Chile, Argentina and Venezuela did the same long ago.

productive sectors, and recognition for that. This means new incentives, at the level of individuals *and* of establishments (which could be encouraged by new formulas of funding).

Government institutes and Centres are also challenged. They may have been at one time the main source for new technologies, products and processes offered to local firms and national "import substitution" projects. It is no longer so (as economies are opening). *Their mission has to be rethought*. Will they specialize as the arm of the government for social projects (without market)? Will they offer simple services (certification, etc) or more elaborate ones to international firms which are setting up? Will they compete in the global world to offer anywhere sophisticated services? In all cases they have to change their institutional patterns of funding, working, assessing and valuing their achievements.

A final challenge is taken seriously by the largest countries: that of *decentralising* their research machinery. The objective is to bring closer (and if possible together) researchers and the stakeholders. But most of the Institutes are concentrated in the capital city (or in a small part of the "useful country"). The best renowned research Universities are located in the same area. A number of countries (Argentina, Mexico, Chile, Columbia…) are now considering means and incentives to move the capacities, and build dispersed "clusters" conducive to innovation.

Structuring research

In order to face a necessary "*re institutionalisation*" several countries (particularly emerging ones) took original initiatives which are worth being mentioned.

The first one is to establish a more rigorous running of the "research and innovation system". In various countries *a Ministry* for S&T has replaced the National Council for the tasks of policy making, planning and setting up indicators and control mechanisms. There are now Ministries in Costa Rica (since 20 years), Cuba, Argentina and Venezuela. In Argentina, there is a Cabinet for S&T and its permanent "Secretariat". In Chile, there is a National Commission for Innovation which coordinates the system. In Colombia the Fund for research (COLCIENCIAS) has been attached to the ministry of Planning. The National Councils keep an advisory function, and become basically national Agencies for the funding of research. An interesting device in Chile has split up this Agency into two main Funds: the ancient CONICYT which funds fundamental research, upper training and the creation of regional research Centres; and the CORFO which includes a representation of the industrial interests and funds innovation, R&D in the regions, applied research and transfers of technology. Both organisations are under the supervision of the National Commission for Innovation. Moreover, *Observatories* of S&T have been established in Colombia, Venezuela (and the regional Observatory RICYT checks the data collected by specialized government services in several countries).

Another important step has been the creation of several *Funds specialized in selected goals*. Chile again is a good example. Besides CONICYT and CORFO, the National Commission operates through FONDAP (advanced research in priority new areas), FONDEF (for research in Universities where it lags), FONDECYT (to boost research in underdeveloped regions), FONIS (health research), CHILE INNOVA (technological innovation) and other tools contributing to the coordination of private and public initiatives in research, technology transfers, the dissemination of scientific information, and the development of human

resources (doctoral studies: the output is rapidly growing; post doctoral internships: agreements are actively searched for in foreign countries).

A main idea is to *concentrate resources on "real" players*. Mexico was the first to establish a "*National Researchers System*" (in 1986, now imitated in several countries: Venezuela, Uruguay, etc). In the beginnings, the reason was that the profession was severely hit by inflation and loss of purchasing power. Vocations were drying up, and there was an exodus among researchers. The idea was to rebuild the scientific community from its very basis, by offering a notable bonus to the researchers who would submit themselves to a recurring assessment taking into account proven *results*. There are several ranks in the system (which became sophisticated). In spite of initial suspicion, this mechanism gradually gained popularity. It encompasses now a large part of the active academics[16] and the publications in international journals made progress at a brisk pace.

Another way to concentrate resources is the creation of "*Centres of excellence*", which some countries are now considering (Chile is an example). In all cases *assessments* are prerequisites, and a new culture of evaluation is emerging. Through this and the new competitive ways of funding institutions and professional models are changing.

Nevertheless, there is still a long march before the re institutionalization needed to establish a connection between the worlds of research and production, or those of fundamental and applied research has been accomplished. And there is a growing gap between the "emerging" countries which express the will to develop S&T and take steps to build a coherent research system, and those of other clusters which are hesitating, or which are not interested and implement a laissez faire policy.

4.4. HUMAN RESOURCES.

We have already given a measure of the large research potential of Latin American countries. As H. Vessuri puts it for Argentina "the availability of highly qualified staff was not a problem for scientific and technological development, except for individual specialities. More problematic has been the countries' inability to retain [their] scientists".

There are several factors which can add to this general statement:

* The numbers are impressive. There is a real S&T milieu. But the *research potential is concentrated* in a few flagship establishments[17]. Out of their boundaries the staff may be of poor quality, with restricted ambitions and limited activity[18]. By contrast some researchers are brilliant scientists, cosmopolitan, much sought-after and well connected through the world, credited with important contributions to national and international science.

[16] It is not restricted to Universities: other researchers compete. But the weight of international publications in the evaluation favours the academics.

[17] 2 or 3 Universities in each country : generally the « Central » and often the « Pontifical » (plus 3 or 4 in a large country like Argentina, and a total of 1 in Caribbean countries). To this should be added a small number of renowned Institutes (public or private, and often founded by historical key figures) plus parts of government and industry Centres. The bibliometric data are clear on this point.

[18] Even in Argentina, in 2005, 60 % of academics and researchers had qualifications under the Master degree, and 25 % only had a Ph D.

* Therefore *key figures* always played (and continue to play) a very significant role in the development of S&T, arousing vocations, launching establishments and defending the autonomy of science vis-à-vis the state and the whole society. *Centres* have become the locus of the scientific activity, circles of specialists where the talents were nurtured, rather than large programmes and government Agencies.

The Profession: Manhandled and unwavering:

"Many young people started on the road to upward social mobility through education. They entered the university … graduates occupied positions in segments of the society… the intellectual field became more autonomous and differentiated vis-à-vis other social domains… From then on the history of science can no longer be reduced to political history"[19]. In spite of ups and downs in the support by the state, new candidates filled the ranks which their ostracized masters had to desert. They had been professionalized in accordance with their instructions (style of science, values and norms, choice of topics, "in search of a national soul"). And this profession has stood firm despite all snubs.
Indeed "low salaries, continued political and economic instability, and frequent persecution and repression" hit intellectuals, academics and scientists prolifically. They "contributed to the emigration of a good portion of scientists and engineers and discouraged the vocation among many young in the recent decades"[20].

Latin America has ill treated its scientists for decades. But their community did not disappear.

Brain drain

Such a ***mishandling of the professionals*** led nevertheless to a serious weakening of the quality in tertiary education, resignation to a mediocre fate, marginalisation of talented people, renouncement of bold endeavours and of great hopes in new industries. Above all it led to a tremendous brain drain[21], which took some scientific communities (notably the smallest) to the verge of ruin. Since the crisis of 1930 this phenomenon hit different countries at different times for shorter or longer periods. When in 1986 Mexico established its "Researchers' system" it was just in time to rescue what was left of a previously bright scientific community. In Argentina, the 1960s and 1970s political problems motivated severe emigration. In the 1990s economic reasons took over (low wages, unemployment and collapse of national sophisticated industries). In Colombia migration of highly qualified people is impressive. Chile (under the military dictatorship), Venezuela or Bolivia now and then, the Caribbean countries intensely and permanently are other examples.

In 2003, *Jean Johnson, from NSF, published very detailed figures* of the foreign residents holding a degree in Sciences and Engineering and living in the USA[22]. The latest year for her data is 1999. At this time, Latin America provided about 200 000 degree holders to the United States: nearly half coming from South America and half from Central America and the Caribbean.

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[19] H. Vessuri, 1997, "Bitter harvest : the Growth of a Scientific Community in Argentina", *Scientific Communities in the Developing World*, Sage: Delhi, 307-353.
[20] H. Vessuri, « Bitter harvests…", op.cit.
[21] Beginning with the most connected and brilliant scholars
[22] Jean Jonson (NSF) "Quantification of the scientific diasporas" in R. Barré, JB Meyre etal. Éd *Diasporas scientifiques / Scientific Diasporas*, 2003, Paris:IRD, 197p + CD-ROM

Among these, only 9% had a Ph D, and 20 % a Master; which means that 70 % held only a Bachelor's (or a professional degree). This reflects the late organization of doctoral studies on the continent. It is also consistent with the "under qualification" of higher staff (even in the universities) which we signalled earlier.

The number of these degree holders living in the USA is much lower than the number of those born in Asia (600 000) or in Western Europe (220 000). In total, there are in USA 1 300 000 degree holders of foreign origin (only one out of six coming from Latin America). Nevertheless, this is a very important proportion *compared to the number of degree holders living and working in their own countries*.

Jean Johnson distinguished them according to the sector in which they work in the USA. In particular, she isolated the number of those working in R&D (nearly 30 % of them). These figures are of interest. In the *Indicators section* we compare them to the number of researchers working in their home country in the same sector.

For these degree holders working in R&D the pattern is as follows:
* Those working in USA *outnumber* by far those working in their home (*Caribbean*) country.
* Those working in USA are *equivalent* to those working in their home (*Andean*) country.
* Those working in USA are *less* than those working in their home (*Cone*) country. But the expatriation is significant among Argentinean (and to a lesser extent Chilean) degree holders: 1/5 to ¼ of the scientific community has left for the USA.
There are minimal exceptions (Uruguay, Costa Rica).

These figures concern only the emigration to USA. The departures to Europe are not trivial. It can be said that ***brain drain is a massive and structural problem*** for Latin America. The (tertiary) education sector produces qualified scientific human resources. But the development sector does not seem to be in a position to integrate them. And there is not room enough for them in the academic and the research structures (or they are not attractive enough). In some cases the scientific community is threatened by extinction (or by involution).

To halt this trend there is a clear need of new incentives for researchers, and for a re professionalisation of young generations improving their links with society and production.

Toward the revaluation and re professionalisation of research work?

Various remedies have recently been applied, as governments occasionally expressed their concern: better salaries, new positions in the academic sector (with the role of a sanctuary for research, on hold of its demand by the productive sector) and attempts at benefiting from the brain drain through organized links with the diasporas ("brain gain": see the well documented case of "Red Caldas" in Colombia[23]).

But the "innovation" option alone is trying to tackle the question through an integrated policy. The presupposition is that globalization gives an opportunity for the modernization of the productive sector (or requires it). The suitable human S&T capital should not be lost and it should be enhanced. This is why a revaluation of the S&T profession should be designed, together with a re professionalisation linked to the economic policy.

[23] R. Barré, JB Meyer et al. *Scientific diasporas*, 2003, Paris :IRD, op. cit.

The very dereliction of the scientific community gave an opportunity to concentrate efforts on a group of 'real" researchers of suitable size. While receiving attractive bonuses they have to prove continuously their results. New patterns of funding direct the activity toward strategic research, and consolidate a competitive behaviour. This is the action plan of "emerging countries" (e.g. through "National Systems of Researchers" – see above-, to be complemented by adequate targeted Funds).

This policy is too new to be assessed. But a look at the output gives some first hints.

4.5. OUTPUT.

Publications in international journals are one of the outputs of research. They are generally a good sign of the general health of the activity.

In the case of Latin America, measures on a long period (the 20 last years) show that:

* in spite of ups and downs in the governments' support to R&D, scientific communities managed to *maintain* at least a minimal production.

* nevertheless, the size of the country, which is linked more or less to the size of the scientific community, makes a difference. In "small" countries, with very small communities (less than 600 researchers) the production is erratic. It relies on a few people and it is sensitive to fortuitous events (withdrawal of one person, efficient international collaborations, launching or completion of a particular programme…). There are a few areas of competence (sometimes very specific topics) and in each of them there is a problem of critical mass.

* in "intermediary countries" (sizeable countries and communities: around 1000 researchers; e.g; Andean countries) the production is very sensitive to the policies (or to the action plans) of the government. Colombia is an example (leap forward in 1996-2002 accompanying a strong action of COLCIENCIAS), Peru another one (short bright spot in 1999-2003). When the support withdraws there is a quick return to the normal (stagnant) production assured by the small circle of devotees.

* There has been *a powerful impact of the "National Systems of Researchers"* (e.g. in Mexico and Venezuela). More generally the countries which implement an *"innovation option" enjoy the most sustainable growth of their production*, taking them now at appreciable scores (Argentina, Chile, Mexico). It should be noted that their option is not so old, and beforehand they experienced the throes of mishandling of the scientific community (visible on the diagram). They have not yet made the same take off as Brazil (an emerging country in the true sense, which implemented its science policy earlier).

Other outputs.

Other outputs are more difficult to measure. *Patents* are one item. The monographs show that there is a noteworthy growth in the cluster of "innovative countries" (e.g. see Mexico). In other cases the figures are very low. And patents are probably not the best way to communicate with the social (and even the productive) sector. But there are others, about which we lack data: continuing education, services to industries or communities, support to technological learning, adaptive research and *action research*… All these sorts of activity, especially when carried out under contracts, should be considered as interesting outputs. There are some good examples of such practices run even in countries which have no specific science policy, like the action research handled by the West Indies University (already

mentioned). This may be more efficient than a lot of so-called “applied research” that won’t ever be applied because it did not involve users in its design.

It must be acknowledged that there is a ***need for data*** and on this sort of results (e.g. number of contracts, amount and purpose).

SECTION 5: CONCLUSION.

To conclude, we may stress the following points:

* Latin American countries have *a long record* of education (including tertiary education) and a long history of institutionalisation of science. They have professional scientists and they built scientific communities earlier than most other countries in the developing world.

* Nevertheless the *support to science is unsteady* and has been for more than half a century the story of relations between the State, society and the scientific community has been a stormy one, full of sound and fury and leading to harsh mishandling of technicians and scientists (low wages, unemployment, often persecution). This led to a severe brain drain, which has become structural.

* By now there are *three main clusters of countries*:

- one with “laissez faire” policies, not really interested by science or by a technological development. They may be rich and considering to diversification in services and trade, or poor and focusing on immediate urgency; but they restrict the function of universities to professional training and they nurture very small scientific communities. Many Caribbean countries are in this cluster. Interesting exceptions are Cuba and Costa Rica.

- a second cluster (mainly Andean countries) is hesitating on the function of research. They may have action plans and suddenly withdraw them. A number of devotees and committed people champion science, and struggle to relate its endeavours to socio political expectations. When they fail (temporarily) they have to rely on external supports. The output is sensitive to local policies and safeguarded by a few universities and international cooperation. Its level remains mediocre and it has ups and downs (by now: rather downs).

- the third cluster consists of countries (mainly in the Southern Cone, but also Mexico, and probably Venezuela and Costa Rica) which over the past few years have rallied to an “innovation (economic) policy”. This gives to research a *new and clear legitimacy*, but also requires some *re institutionalisation of S&T and a reprofessionalisation* of the researchers. Vigorous action plans are implemented and they seem to bear fruit. Consequently, these countries have entered into a path of “emerging’ countries, but *the S&T gap is widening* between them and the others.