Inequality gaps in nanotechnology development in Latin America

Guillermo Foladori
Autonomous University of Zacatecas, México
E-mail: gfoladori@gmail.com

Noela Invernizzi
Federal University of Paraná, Brazil

ABSTRACT

Nanotechnology has been spurred by science, technology and innovation policies in most Latin American countries since the last decade. Public policies and funding have been accompanied by a common rhetoric, highlighting the potential of nanotechnology for increasing competitiveness and growth and providing the region with more efficient and innovative products. Based on an assessment of nanotechnology policies and capabilities in nine countries this article highlights three characteristics of nanotechnology in Latin America that might hinder its contribution to an equitable development within the region.

The first characteristic is the conspicuous trend towards an intra-regional gap in capacity building as a result of the unequal historical development of science and technology among these countries and the large differences in equipment and financial resources devoted to nanotechnology.

The second characteristic is the strength of "international signals" vis-à-vis the national needs in the orientation of nanotechnology. On the one hand, nanotechnology is main and foremost oriented to achieve international competitiveness, which may lead its development to international market demands. On the other hand, nanotechnology research in Latin American countries has been configured within internationalized academic networks, which may influence local research agendas towards foreign research priorities.

The third characteristic is the absence of research on potential impacts of nanotechnology on human health and the environment, as well as other societal implications, which may generate new forms of unequal distribution of benefits and risks.

Key words: Nanotechnology, Latin America, Science, Technology & Innovation Policy, Competitiveness, Equitable Development.

Introduction

Several Latin American countries started promoting nanotechnology over the last decade in this new techno scientific field. It has been defined as strategic in the Science, Technology and Innovation Plans of various countries in the region. The process has been headed by Brazil, Mexico and Argentina, not only the largest economies in the region, but also the countries that have historically accumulated the more advanced scientific capabilities. Later on, several other medium-size and small countries followed.

The Brazilian Minister of Science and Technology (MCT) started a systematic support for the area in 2001, with the creation of the first research networks in nanotechnology. In 2004 launched the National Program for the Development of Nanoscience and Nanotechnology, the first of its kind in the region. Re-launched in 2005 as the National Nanotechnology Program, this plan directed efforts for development of qualified human resources, the modernization of infrastructure and the promotion of university-industry cooperation. At the same time, industrial policy reinforced the strategic status attributed to nanotechnology and its role to enhance the countries' competitiveness (Invernizzi, Korbes, & Fuck, 2012). Recently, the MCT launched the SisNANO, a system or multi-users nanotechnology laboratories with a view to facilitate researchers´ and companies´ access to research infrastructure (MCTI, 2012). In 2001, the Mexican Science and Technology Special Program 2001-2006 highlighted the strategic importance of nanotechnology for the first time. Currently, nanotechnology is one of the nine priority areas for scientific and technological development contained in the Science, Technology and Innovation Special Program 2008-2012. Differently from Brazil, Mexico does not have a centrally coordinated nanotechnology plan and the advance of the field has been driven by different research groups, which have succeeded in implementing a well-developed research infrastructure, making use of a variety of public research funds, of university-business cooperation, and international cooperation. In 2009 the National Council on Science and Technology contributed to the creation of a national network in Nano Science and Technology with the purpose of connecting researchers and their facilities (Záyago & Foladori, 2012; Záyago, Foladori, & Arteaga, 2012)

In Argentina, the Science and Technology Secretariat placed nanotechnology within the priority areas in 2003 and started organizing research networks in the field. In 2005, the Argentina Foundation for Nanotechnology (FAN) was created by the Economy and Production Ministry, with the aim of stimulating the training of human resources and the creation of technical infrastructure to promote nanotechnology advance and its adoption by industry. While the preceding programs distinguished funding for the public sector on the one hand (essentially the research networks) and the private sector on the other (projects of the FAN), the nano sectorial funds (FS-NANO) launched in 2010 provided funding for the projects that were dedicated to basic and applied science via public-private partnerships (García, Lugones, & Reising, 2012; Spivak L´Hoste, Hubert, Figueroa, & Andrini, 2012).

Nanotechnology was also encouraged by ST&I policies in various middle and small Latin American countries, such as Colombia, Chile, Venezuela, Uruguay and some Central American and Caribbean countries. In Colombia, it has been defined as a strategic area for the competitive development of the country since 2004 and is associated with a program of development of centers of excellence (Pérez Marteló & Vinck, 2012). In Chile, science and technology policies have driven the formation of nanotechnology research centers since 2004, although the topic had already been the focus of that country's Millennium Institute created some years before (Cortés-Lobos, 2012). In Venezuela, the National Science, Technology and Innovation Plan (2005-2030) highlighted the need to incorporate cutting-edge technologies in the country, among them nanotechnology, but had not implemented any specific plan. Recently, in 2010, the Venezuelan Nanotechnology Network (RedVNano) was established, with members from the productive sector, universities and some State bodies (López, Hasmy, & Vessuri, 2012). Uruguayan researchers created the Uruguay Nanotechnology Group in 2006, and later, in 2010, nanotechnology was included as a transversal priority area in the National Strategic Plan for Science, Technology and Innovation (Chiancone, 2012). In Central America, Costa Rica is notable for the *Lanotec* facility, a laboratory dedicated to nanomaterials created in 2004, which receives support from the Ministry of Science and Technology, universities, high-technology industries and the U.S. space agency NASA (Vega-Baudrit & Campos, 2012). In the Dominican Republic, the Strategic Plan for Science, Technology and Innovation 2008-2018 has a sub-chapter on nanosciences within its priority areas (Piazza, 2012). The following table, organized in chronological sequence, shows the incorporation of nanotechnology in the policy agendas of most Latin American countries.

Incorporation of nanotechnology in the public agendas of selected Latin American countries

Year	**Country**	**Institution**
2000	Brazil	Ministry of Science and Technology
2001	Mexico	National Council for Science and Technology
2003	Argentina	Science and Technology Secretariat
2004	Colombia	Administrative Department for Science, Technology and Innovation
2004	Costa Rica	National Council for Scientific and Technological Research
2005	Guatemala	National Council for Science and Technology
2005	Ecuador	National Secretariat for Science and Technology
2006	El Salvador	National Council for Science and Technology
2006	Peru	National Council for Science, Technology and Innovation Technology
2008	Dominican Rep.	State Secretariat for Higher Education, Science and Technology
2009	Uruguay	Ministerial Advisory Office for Innovation
2010	Panama	National Secretariat for Science, Technology and Innovation

Public policies and funding have been accompanied by a common rhetoric in these countries that emphasize the potential of nanotechnology for increasing competitiveness in the context of a globalized, technology-intensive economy. This rhetoric echoes the World Bank's and other international institutions' views of development in a knowledge-based economy, a path to be achieved through the intensification of the technological content of local production and the insertion in the global markets. Indeed, a number of international bodies influenced this rapid design of policies to promote nanotechnology. From the end of the 1990s, the World Bank created a global network of Millennium Science Initiatives (MSI), which materialized in centers of excellence in developing countries. A number of nanotechnology research institutes were created in Chile, Brazil, Mexico and Venezuela under this project. The OAS (Organization of American States) actively encouraged governments in the region to include nanotechnology as a priority in S&T programs (COMCYT, 2004). The International Center for Science and High Technology of UNIDO (United Nations Industrial Development Organization) organized, in 2005, the conference "North-South Dialogue on Nanotechnology: Challenges and Opportunities," with the objective of promoting the participation of countries in nanotechnology development (Brahic & Dickson, 2005). Also the Union of South American Nations (UNASUR), in a meeting held in Argentina in 2010, agreed upon a path for the pursuit of S&T that held nanotechnology as a strategic area (Hirschfeld, 2010). This international bodies' recommendations converge in emphasizing some traits that have become common in nanotechnology policies in Latin America, such as public funding for research with business participation, the drive for the creation of centers of excellence, the organization of research in networks and a benign and optimistic vision of the impact of these new technologies on the economy and society.

Nanotechnology promotion has resulted in an increase of highly trained human resources, modernization of infrastructure, growing number of scientific publications and the creation of a number of nanotechnology companies. In spite of these indicators that denote success in policy implementation, we argue, in this article, that some traits of nanotechnology development in Latin America might hinder the potential contribution of this technology to an equitable development. Based on a general assessment of nine countries case studies on nanotechnology policies and capabilities carried out by researchers of the Latin American Nanotechnology & Society Network (Foladori, Invernizzi, & Záyago, 2012), we identify three characteristics that are particularly challenging from the point of view of equitable development. The first characteristic is the conspicuous trend towards an intra-regional gap in capacity building as a result of the unequal historical development of science and technology among these countries and the large differences in equipment and financial resources devoted to nanotechnology. The second characteristic is the strength of "international signals" vis-à-vis the national needs in the orientation of nanotechnology. On the one hand, nanotechnology is main and foremost oriented to achieve international competitiveness, which may lead its development to international market demands. On the other hand, nanotechnology research in Latin American countries has been configured within internationalized academic networks between national researchers and their peers from USA and countries from the European Union, which may influence local research agendas towards foreign needs. The third characteristic is the absence of research on potential impacts of nanotechnology on human health and the environment, as well as other societal implications, and the lack of spaces where civil society organizations and potentially affected groups can discuss such issues, which may generate new forms of unequal distribution of benefits and risks.

1. Common policies, unequal development

The stimulation of nanotechnology is common to most Latin American countries and, as noted above, nanotechnology policies are quite similar among countries. Yet, the capacities built are quite disparate, generating strong inequalities among them. If nanotechnology indeed is the strategic technology announced by these countries' policies, this inequality in capacities will have significant consequences for the region. It is important noticing that Argentina, Brazil and Mexico started stimulating nanotechnology earlier, and this is one factor influencing such inequalities. However, the considerable differences in the sizes of the countries (not only geographically, but mainly economically), of their scientific communities, and the levels of investment in S&T seems much more responsible for such inequalities in capabilities. In other words, these countries faced nanotechnology with very different historical accumulation in S&T, which, in turn, generated different conditions to enter this new field. Then, there is a strong contrast between the uniformity of nanotechnology policies and instruments promoted across the region and the unequal conditions these countries have to implement them. Let's consider one key issue: the research facilities.

Although there are debates about how new the nanotechnology field is, it is certain that, in many areas, its development was only possible after the invention of new instruments, particularly more powerful microscopes that were created during the 1980s. Initiating the research and development (R&D) of nanotechnology in Latin America has required creating new labs and re-equipping some of the existing ones. Investments have been made across the region, but the difference in scientific research facilities is notorious between the countries. Undoubtedly, Brazil and Mexico have the best endowment for research. Argentina, in spite of being a country that historically developed a significant scientific capacity, is considerably less equipped than the other two largest Latin-American countries (Foladori, Figueroa, Záyago, & Invernizzi, 2012).

Brazil has the only Synchrotron Light Facility (LNLS) in Latin America, located in Campinas, State of São Paulo, in use since 1997. The construction of a second Synchrotron Light Facility (SIRIUS) started in 2010 in a neighbor area, in this case with national-source technology and in partnership with Argentina. LNLS is a multiuser facility with an international scope. Within the LNLS area, the National Center for Nanosciences and Nanotechnologies César Lattes was created in 2008 with advanced microscope labs. By size and quantity of users (about 1500 researchers per year) the LNLS is unequalled in Latin America. Another federally-funded nanotechnology lab is the National Center on Nanometrology, created in 2005 as part of the INMETRO (Institute of Metrology) in Rio de Janeiro. By 2008, it became equipped with several high tech and very expensive instruments, such as the Titan scanning transmission electron microscope, able to offer sub-Angstrom (10^{-10} m) atomic resolution images. The INPE (Spatial Research National Institute) has a nanotechnology lab (LAS – Associated Laboratory of Sensors and Materials) that was also upgraded in 2007. The Brazilian Center for Research in Physics (CBPF) opened their Nanoscopic Lab in 1994, but only inaugurated the LabNano – a huge multiuser facility in Rio de Janeiro – in 2005. Another public NT lab is the CenPRA (Research Center Renato Archer) of the Ministry of Science and Technology, which specializes in micro/nano electronics. In the same research area, in 2008, Ceitec S.A. was created (National Center on Advanced Electronic Technology) in Rio Grande do Sul, a production facility of semiconductors and chips aiming to supply the MERCOSUR. Petrobrás, the state petroleum company has high-tech laboratories for nanotechnology, and in 2006 created a Network of 10 research institutions working together in nanotechnology towards oil research interests. In 2009 a Laboratory of the Ministry of Agriculture, the LNNA (Nanotechnology and Nanosciences Lab. for Agribusiness) was inaugurated by EMBRAPA, the Brazilian Agricultural Research Corporation, in the state of São Paulo. Another laboratory, which also works in nanotechnology as a multiuser facility for the whole country is the LNCC (Scientific Computation National Laboratory), located in Rio de Janeiro. Specifically oriented towards the industrialization of the Northeastern region is CETENE (Center for Strategic Technologies of the Northeastern), created in 2005 in Pernambuco. At a more regional and local scope, more than 20 mainly federal and state universities, as well as public research centers, research on nanotechnology, many of them with well-equipped laboratories, such as the UFRGS (Federal University of Rio Grande do Sul) in Porto Alegre that has at least seven laboratories working in nanotechnology. Starting in 2008, the Ministry of Science and Technology organized Brazilian scientific research in networks named National Institutes of Science and Technology; these institutes allow researchers to move to centers with infrastructure and establish joint research initiatives.

Mexico has more than 50 universities and public centers researching nanotechnology. Among the most relevant is the National Autonomous University of Mexico (UNAM), which has more than a dozen departments and institutes in México City and other campuses in the country where nanotechnology is being done. In the campus of Mexico City, the Institute of Physics has, since 2002, the Central Microscopy Laboratory. Near the Pacific border with the United States, in Baja California Norte, the UNAM campus at Ensenada created the CN&N (Nanosciences and Nanotechnology Center) in 2008 with a well equipped laboratory; and the campus of Querétaro has the CFATA (Center for Applied Physics and Advanced Technology), which has been researching nanotechnology since 1996. Other departments of UNAM, such as Material Sciences, Chemistry, Astrophysics, also have research facilities. Adding all of the researchers in nanotechnology in the country, UNAM has approximately one fifth of them. Another huge public university is the UAM (Metropolitan Autonomous University) in the Federal District Metropolitan Area. Two of the three campuses have laboratories in nanotechnology. The one in Iztapalapa (UAM-I) has housed the Nuclear Magnetic Resonance Lab since 1995, upgraded in 2006 and 2009; the Nanotechnology and Molecular Engineering Lab (since 2004), a Nanotechnology Chemical Lab, and, since 2007, the CI3M (National Research Center on Imagery & Biomedical Instrumentation). The campus at Xochimilco (UAM-X) in partnership with the Health Ministry built the Laboratory of Nanotechnology applied to Medicine (2004 -INNN “MVS”). A third huge public research center, with national scope, is the National Polytechnic Institute (IPN). Its research center CINVESTAV built in 2005 the LANGEBIO (National Laboratory in Genomics for BioDiversity) on the campus in Guanajuato and in 2009 the Center of Nanosciences Micro & Nanotechnology in the campus of Queretaro. Other campuses of the IPN have specialized laboratories, such as the one on semiconductors in Guadalajara (CTS –Semiconductors Technology Center) and on Engineering Electronics in Zacatenco. Three Titan Microscopes were purchased by different Mexican research centers. The first one in 2006, by the Petroleum Mexican Institute (IMP) for its Ultra High Resolution Electronic

Microscopy Laboratory in México City. The other two in 2008: one by CIQA for its LabMic –one of the several CONACYT Research Centers, specialized in Applied Chemistry and located in Saltillo, Coahuila-, and the other by the UANL (Autonomous University of Nuevo León) in Monterrey at CIIDIT (Center for Innovation Research and Development in Engineering and Technology), within a Science and Technology Park that is also the headquarters of the Cluster of Nanotechnology. Another two CONACYT Research Centers won a call for national laboratories in 2006, so the CIMAV in Chihuahua created the NaNoTeCH (National Nanotechnology Laboratory), while the IPICyT in San Luis Potosí created the LINAN (National Laboratory for Nanoscience and Nanotechnology Research); both of them aimed to cover national demands. Still other public centers have important laboratories, such as the one at the National Institute on Astrophysics, Optic and Electronics (INAOE) in Puebla that opened in 2001 and has steadily upgraded its lab over the years to the recently-created Laboratory for Innovation in Nanotechnology & MEMS (2010).

Argentina is well behind the two previous countries in terms of technical equipment and building infrastructure for NT. Nevertheless, some pre-existing laboratories were upgraded over the decade, and some others newly created. A Virtual Center on Nanosciences and Nanotechnology was created in 2005, in order to coordinate efforts that include the National Center of Atomic Energy, the University of Buenos Aires and the University of La Plata/INIFTA. The three main institutions that research nanotechnology are: the National Commission for Atomic Energy (CNEA) in its campuses at Bariloche and Constituyentes; the University of Buenos Aires (UBA); and the La Plata National University (INIFTA – the Microscopy and Physics-Chemical Surfaces Laboratory is a research center opened in 1992 by Conicet / UNLP). INQUIMAE (Institute of Materials Chemist and Physics, Environment and Energy) is a research center CONICET/UBA that started in 1995 in Buenos Aires. The Institute of Nanoscience and Nanotechnology, created in 2007 by the Bariloche Atomic Center, was upgraded in 2009. Other NT laboratories include the newly-built Center for Material Science & Technology, also a joint project of CONICET with the National University of Mar del Plata. Other laboratories include the one specializing in medicine (Strategic Design for Targeting of Drugs) housed by the National University of Quilmes (UNQ); the Laboratory of Tissue Engineering, Regenerative Medicine and Cellular Therapies, by the Government of the Province of Buenos Aires; a laboratory of the ministry of Defense, and the one at the National Institute for Industrial Technology, with its laboratory upgraded in 2005.

Medium and even small countries have created laboratories and infrastructure of different magnitude, but far from the countries mentioned before. Examples are the LANOTEC (Laboratory of Nanotechnology) in Costa Rica, the CEDENNA (Center of Nanosciences and Nanotechnology) in Chile, or the CEAC (Center of Advance Studies) in Cuba. Nevertheless, after one decade of sustained growth of the sector, the distance between Brazil and Mexico over the other countries is increasingly notorious. These differences raise the question: is nanotechnology becoming an instrument for deepening the regional development gaps?

2. The strength of "international signals" in the agenda

Almost all the official documents from the Latin American countries refer to the drive to compete on an international scale as one of the main aims for fostering nanotechnology. This is not new. In the developed world the same argument can be found. The National Nanotechnology Initiative of the United States, for example, justifies the allocation of federal funds for nanotechnology research in order to maintain international competitiveness (National Science and Technology Council, 2000).

In Latin America, the Brazilian Work Group for Nanosciences and Nanotechnology, which prepared the first document voicing support for nanotechnology research, also justifies public support for nanotechnology to ensure competitiveness:

> "The aim of this program is to create and develop new products and processes in nanotechnology, implementing them in order to increase national industrial competitiveness and to train workers to take advantage of the economic, technological and scientific opportunities of nanotechnology (GT, 2003). "

We find the same rationale in the decree that created the Argentinean Nanotechnology Foundation in 2005:

> "… a program to encourage, lay the foundations for and promote the development of human and technical infrastructure in Argentina so that, through its own and related activities, conditions can be established that allow the country to compete at the international level in the application and development of micro and nanotechnologies that increase the earned value of products for internal consumption and export (República Argentina, n.d.) "

In Mexico, nanotechnology appears as a strategy in the *Special Science and Technology Program 2001–2006*. A few years later, in the *Special Science and Technology Program 2008–2012*, the importance of nanotechnology, along with other fields, was justified as follows:

> "The S&T sector establishes as fundamental the development in this field of quality education and the strengthening of basic and applied science, technological development and innovation to help improve the overall standard of living in our society and achieve greater competitiveness (CONACYT, 2008). "

And the announcement of the creation of the Nanoscience and Nanotechnology Network in 2009 reads:

> "Research into nanotechnology can afford our country the necessary innovation to create hi-tech companies to increase our level of competitiveness and create well-paying jobs (CONACYT, n/d)."

The same argument can be found in many other countries. These examples illustrate a kind of mechanical reasoning in which increased competitiveness will ensure improved living conditions. However, on the one hand the possibilities of competitiveness are not the same for developed countries than for developing ones. On the other hand, the wealth that comes from increased competitiveness is generally not distributed equitably, so competitiveness can lead, as some historical cases had shown, to widespread inequality (Delgado Wise & Invernizzi, 2002), and to a research agenda focused on external needs.

This may be reinforced by the considerable connection of the region's researchers with industrialized countries' researchers. The barriers to entry posed by the necessity of equipment shapes, in a significant way, the research strategies of the region (Robles-Belmont, 2012). Either for spontaneous reasons, or driven by S&T policies, the scientists organized themselves into international networks with their peers from USA and Europe. The countries' case studies suggest that the link with international research groups preceded the organization of national networks (Foladori, Invernizzi, et al., 2012). To a great extent it was the link with international networks that initially kicked-off the development of nanotechnology, which is made evident by the abundance of joint publications with authors from industrialized countries (Robles-Belmont, 2012; Robles-Belmont & Vinck, 2011).

In Mexico, publications coauthored with foreigners were predominant until 1998. In the period 2000-2008, publications of national authors represented some 53.60% of the total, while those coauthored with foreigners (with the U.S. being the most represented) reached 46.40%. Collaborations within the Latin American region remained low (the most significant is with Cuba, at 3.07% of the total) (Robles-Belmont & Vinck, 2011). In Brazil, over the period 1990-2006, nationally co-authored publications prevailed over those coauthored with foreign researchers. Even if in Brazil the weight of coauthored publications with peers from industrialized countries is lower, it still accounts for 36% of the total publications. Coauthorships between Brazilian and other Mercosur countries' researchers were only 3 %. In Argentina, in the same period, half of the publications were co-authored with foreigners, while Mercosur collaborations accounted for almost 8% (Kay & Shapira, 2009). In Chile and Venezuela, collaborations with foreign authors still predominate (Cortés-Lobos, 2012; López et al., 2012). Undoubtedly, the greater research capabilities, in terms of human resources and research laboratories, held by Mexico and Brazil, and to a lesser extent, Argentina, strengthened national research networks, while countries with weaker capabilities tended to remain more tightly linked with external networks.

It is interesting to notice the convergence of certain elements in the regional context at the moment that nanotechnology emerged as a cutting edge techno-scientific area. This occurred at a time when regional universities began to gain wider access to resources such as the Internet and online databases of scientific magazines, which together, along with expanded opportunities for post-graduate studies abroad and, in the case of the Southern Cone, the return of many scientist who had been living abroad in exile since the end of the 1980s, contributed to expanding the contact of local scientific communities to more dynamic centers of knowledge production. Thus, to a large extent, the scientists followed the formation of nanotechnology much more closely than they probably followed other scientific areas in the past. Although the local networks expanded in recent years, the international networks did not shrink, as they continue to be essential to maintaining the sustained contact with laboratories at the cutting edge of nanotechnology research and also to maintaining access to sophisticated equipment. The formation of intraregional networks is more recent and, as the previous data on publications suggest, much frailer. Brazil works as a common node of several of the more structured regional cooperation initiatives (Invernizzi et al., 2012). The first initiative was the Brazilian-Argentinean Center for Nanotechnology, created in 2005, next followed the Brazilian-Mexican Virtual Center for Nanotechnology, created in 2009, and the Brazilian-Chilean Center for Nanotechnology. Another initiative beginning in early 2011 was the Mexico-Argentina Virtual Center. Up to what extend these intra-regional networks reproduce the topics and methodologies driven by developed countries is something to be investigated, but will not be a surprise considering the policy context of promoting competitiveness and the larger funds that intercontinental networks receive *vis a vis* regional networks.

The combination of an explicit policy towards international competitiveness with the organization of academic networks with their counterparts in developed countries raises the issue of a R&D agenda not being oriented towards internal needs, but one in which foreign social needs and foreign markets have a strong weight.

3. The absence of R&D on potential risks to human health and the environment

The development of nanotechnology in Latin America followed two main paths during the first decade of this century. On one side was the internal impetus toward scientific development. Brazil built the only Latin American Synchrotron Light Source (LNLS - in use since 1997) in the city of Campinas, São Paulo. Numerous nanotechnology research projects were undertaken since the 1990s in different countries. One example was supported by the Ibero-American Program of Science and Technology for Development (CYTED) from 1999 to 2002, in which a network of researchers from seven Ibero-American countries (five from Latin America) worked on the "Manufacture and Characterization of Nano-structures for micro- and optical electronics" (CYTED, 2003).

On the other side was the influence of external international organizations. The tendency toward the homogenizations of Science and Technology (S&T) public policy has a long history in Latin America (Albornoz, 1997; Velho, 2011). International organizations such as the World Bank, the Inter-American Development Bank (IDB), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Organization of American States (OAS); and, in the case of Mexico the Organisation for Economic Co-operation and Development (OECD were the driving forces behind common S&T policies in Latin America. This does not mean that their application was identical in all cases, but in the majority of countries one can find common features derived from those directives (Foladori, 2012).

Since the middle of the 1990s, concepts and methodologies such as "knowledge-based economy", "national systems of innovation", "networks" and "S&T priorities" came to dominate the discourse. These concepts and methodologies led to modifications of institutions, financing, organizational structure, evaluation criteria, and participation mechanisms of scientists and other actors in the field of S&T. Nanotechnology emerged and developed in this context. It bore, therefore, the marks of its promoters.

The push first came from the World Bank. From the end of the 1990s, the World Bank and other institutions created a global network of Millennium Science Initiatives (MSI). These initiatives materialized in centers of excellence in developing countries, with the aim of promoting research in S&T with the same infrastructure base and resources that exist in developed countries (Macilwain, 1998). A number of nanotechnology research institutes were created, beginning in 1999 and over the following two years (e.g., in Chile within the Technical University Federico Santa María and the Andrés Bello University). Besides Chile, Brazil, Mexico and Venezuela also received MSI funding. In Brazil, four Millennium Institutes in broad areas of nanotechnology were created in 2001 (Nanosciences Institute, Institute of Complex Materials, Research Network on Systems-on-a-Chip, Microsystems and Nanoelectronics, and the Multidisciplinary Institute of Polymetric Materials) (ABDI, 2010); and in Mexico another nanotechnology project was created in San Luis Potosí (IPICyT) (Rushton, Záyago, & Foladori, 2009). The OAS is also one of the international bodies that had an influence on the homogenization of S&T policies in Latin America. In various high-level conferences of the Inter-American Commission on Science and Technology (COMCyT-OAS), created in 1998, the topic of the role of S&T in development was addressed. Priority themes were discussed in the seminars and, ultimately, four priority areas were selected: biotechnology, information technologies and advanced networks, nanotechnology and materials, clean technologies and renewable energies (COMCYT, 2004).

A variety of constants can be identified in the World Bank and OAS documents, such as the growing orientation toward public funds for research with business participation, the drive for the creation of centers of excellence, the completely benign and optimistic version of the impact of these new technologies on the economy and society, or the incentives for researchers who cooperate via networks. There are other elements that, in their absence, also constitute a constant. The most relevant example is the lack of consideration given to the potential risks to health and environment. This theme appears nowhere in the S&T policy prescriptions of the international bodies to Latin America through the first decade of the 21st century; and yet the countries who lead those bodies, such as the United States and the European Union, have these matters on their internal agendas. The topic was also raised by Non-Governmental Organizations and unions, and even the business sector recognizes those risks as an issue of some importance. Still, the fact that new technologies creates not only benefits but also risks and detriments, is patently obvious for any S&T expert.

Although it is difficult to estimate the amount of public funding involved, some figures are cited by analysts. For Argentina, estimations are of some USD $50-million between 2006 and 2010 (Salvarezza, 2011). Brazil likely invested around USD $190-million between 2004 and 2009 through the Ministry of Science and Technology (Invernizzi et al., 2012), not counting the funds applied by individual Brazilian states. For Mexico, it is even more difficult to estimate; Takeuchi & Mora Ramos suggest some USD $60-million were invested between 2005 and 2010 (Takeuchi & Mora Ramos, 2011). In Chile, the figure reached USD $30-million between 2005 and 2010 (Zumelzu Delgado & Zárate Aliaga, 2011).

Practically none of the public funds in Latin American countries destined for nanotechnology was applied to risk studies, which is rather odd considering the well known awareness by the different social agents and the international organizations advisers from developed countries where the issue was early raised.

The absence of interest on the part of the government to promote health and environmental risk studies is a gap in nanotechnology R&D that has implications in terms of the unequal distribution of benefits and detrimental effects. As workers and consumers are the main subjects of potential harm, not considering health and environmental risks assessment leaves nanotechnology policy without social support.

Conclusions

Nanotechnologies in Latin America would have been developed even without policies to promote them. But the changes in S&T policies in Latin America since the end of the 1990s and during the following decade, which is when nanotechnology came to be designated a “strategic area” or “priority are”, gave a political and financial impulse. Although funds and political support can not be compared with that of developed countries, some Latin American countries, basically Brazil and México stand out over the rest. Nanotechnologies, as any new technology, can easily become an instrument for deepening regional inequalities between countries if no counter-measures are taken.

The knowledge-based economy paradigm and the orientation of S&T toward increasing international competitiveness were the theoretical frameworks that justified the designation of nanotechnology as a priority area, even in small countries where the level of laboratory infrastructure and critical mass of scientists is diminished by large capital investments. International institutions such as the World Bank and OAS were key in delivering funding and strategic guidelines of scientific policy. The incentive to create international networks, which ended up being more important those between Latin American countries and their partners in USA or European countries sums up with the orientation towards competitiveness to mark a strong R&D orientation toward international topics and methodologies. To what extend the R&D agenda will distance itself from wide social regional needs is soon to appreciate, but this path will not be a surprise.

Various common characteristics can be identified in the promotion of nanotechnology in Latin America. One of them is the absence of R&D on the potential risks to health and the environment. This area is omitted from nanotechnology policy guidelines. Since workers and consumers are the ones more exposed to nanotechnology risks, the official policy, while omitting the risk topic, distances itself from organized civil society.

References

ABDI. (2010). Panorama Nanotecnología. ABDI (Agencia Brasileira de Desenvolvimento Industrial). Retrieved from http://www.ipicyt.edu.mx/storage-sipicyt/difusion/Reunion2002Nanotecnologia.pdf

Albornoz, M. (1997). La política científica y tecnológica en América Latina frente al desafío del pensamiento único. *Redes*, *4*(10), 95–115.

Brahic, C., & Dickson, D. (2005, February 21). Helping the poor: the real challenge of nanotech. *SciDev.Net*. Retrieved from http://www.scidev.net/content/editorials/eng/helping-the-poor-the-real-challenge-of-nanotech.cfm

Chiancone, A. (2012). Nanociencia y nanotecnologías en Uruguay: áreas estratégicas y temáticas grupales. In *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina* (Foladori, G.; Invernizzi, N & Záyago, E.). México, DF: Miguel Angel Porrúa.

COMCYT, Q., Ecuador, Dec. 10-12., 2003. (2004). Report of the Workshop: Scientific and Technological Development in the Americas. COMCYT (Comisión Interamericana de Ciencia y Tecnología – OAS). Retrieved from http://www.science.oas.org/cOMCYt/prepa.htm

CONACYT. (n/d). Red Temática de Nanociencias y Nanotecnología. CONACYT (Consejo Nacional de Ciencia y Tecnología). Dirección de Redes. DAIC. Retrieved from http://www.conacyt.mx/Redes/Redes-Tematicas/Red-Nanociencias-y-Nanotecnologia.pdf

CONACYT. (2008). Programa Especial de Ciencia, Tecnología e Innovación 2008-2012. CONACYT (Consejo Nacional de Ciencia y Tecnología). Retrieved from http://www.siicyt.gob.mx/siicyt/ docs/contenido/PECiTI.pdf

Cortés-Lobos, R. (2012). Nanotecnología en Chile ¿Qué tan preparado se encuentra el país para desarrollar esta disciplina? In *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina* (Foladori, G; Invernizzi, N & Záyago, E.). México, DF.

CYTED. (2003). Subprograma IX Microelectrónica. Memoria 2001-2002. CYTED (Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo). Retrieved from http://biblioteca.ciens.ucv.ve /CYTED/09%20Subprograma%20IX.pdf

Delgado Wise, R., & Invernizzi, N. (2002). México y Corea del Sur: Claroscuros del crecimiento exportador en el contexto del globalismo neoliberal. *Aportes, Revista Mexicana de Estudios sobre la Cuenca del Pacífico*, *II*(2-4), 63–86.

Foladori, G. (2012). Riesgos a la salud y al medio ambiente en las políticas de nanotecnología en América Latina. *Sociológica*, *27*(77), 143–180.

Foladori, G., Figueroa, S., Záyago, E., & Invernizzi, N. (2012). Nanotechnology: Distinctive Features in Latin America. *Nanotechnology Law & Business Journal*, *9*, 88–103.

Foladori, G., Invernizzi, N., & Záyago, E. (2012). *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina* (Coord.). México, DF: Miguel Angel Porrúa.

García, M., Lugones, M., & Reising, A. M. (2012). Conformación y desarrollo del campo nanotecnocientífico argentino: una aproximación desde el estudio de los instrumentos de promoción científica y tecnológica. In G. Foladori, E. Záyago, & N. Invernizzi (Eds.), *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina.* México, DF: Miguel Angel Porrúa.

GT. (2003). Desenvolvimento da nanociência e da nanotecnologia. Proposta do Grupo de Trabalho criado pela Portaria MCT nº 252 como subsídio ao Programa de Desenvolvimento da Nanociência e da Nanotecnologia do PPA 2004-2007. GT Nanotecnologia (Grupo de Trabalho em nanociência e nanotecnologia). Ministério da Ciência e Tecnologia. Brasil. Retrieved from http://www.mct.gov.br/upd_blob/0002/2361.pdf

Hirschfeld, D. (2010). Latinoamérica define hoja de ruta para innovación. *SciDevNET*. Retrieved from http://www.scidev.net/en/science-and-innovation-policy/latin-america-sets-a-roadmap-for-innovation-.html

Invernizzi, N., Korbes, C., & Fuck, M. P. (2012). Política de nanotecnología en Brasil: a 10 años de las primeras redes. In G. Foladori, E. Záyago, & N. Invernizzi, (Eds.), *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina*. México, DF.

Kay, L., & Shapira, P. (2009). Developing Nanotechnology in Latin America. *Journal of Nanoparticle Research*, *11*(2), 259–278.

López, M. S., Hasmy, A., & Vessuri, H. (2012). Nanociencia y nanotecnología en Venezuela. In *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina* (Foladori, G.; Invernizzi, N & Záyago, E.). México, DF: Miguel Angel Porrúa.

Macilwain, C. (1998). World Bank backs Third World centers of excellence plan. *Nature*, *396*(711), 24–31.

MCTI. (2012, June 28). Governo cria sistema de laboratórios integrados em nanotecnologia. *ComputerWorld*. Retrieved December 3, 2012, from http://computerworld.uol.com.br/tecnologia/2012/06/28/governo-cria-sistema-nacional-de-laboratorios-em-nanotecnologia/

National Science and Technology Council. (2000). *National Nanotechnology Initiative: The Initiative and its Implementation Plan*. Washington DC: Office of Science and Technology Policy. Retrieved from http://nano.gov/sites/default/files/pub_resource/nni_implementation_plan_2000.pdf

Pérez Marteló, C., & Vinck, D. (2012). Las nanociencias y nanotecnologías en Colombia desarrollos con colaboración intranacional e internacional. In *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina* (Foladori, G; Invernizzi, N & Záyago, E.). México, DF: Miguel Angel Porrúa.

Piazza, F. (2012). Nanociencias y nanotecnologías en la República Dominicana. In *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina* (Foladori, G; Invernizzi, N & Záyago, E.). México, DF: Miguel Angel Porrúa.

República Argentina. Autorizase al Ministerio de Economía y Producción a constituir la Fundación Argentina de Nanotecnología., Decreto Presidencial 380/2005. Retrieved from http://www.fan.org.ar/acerca_estatuto.htm

Robles-Belmont, E. (2012). Progresión de las nanociencias en México: una perspectiva a partir de redes. In G. Foladori, E. Záyago, & N. Invernizzi (Eds.), *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina*. México, DF: Miguel Angel Porrúa.

Robles-Belmont, E., & Vinck, D. (2011). A Panorama of Nanoscience Developments in Mexico Based on the Comparison and Crossing of Nanoscience Monitoring Methods. *Journal of Nanoscience and Nanotechnology*, *11*(06), 5499–5507.

Rushton, M., Záyago, E., & Foladori, G. (2009). Center of Educational Excellence in Nanotechnology: The Proposed World Bank Scientific Millennium Initiatives and Nanotechnogy in Latin America. In A. Barrañón (Ed.), *New Nanotechnology Developments*. New York: Nova Publishers.

Salvarezza, R. (2011). Situación de la difusión de la nanociencia y la nanotecnología en Argentina. *Mundo Nano*, *4*(2), 18–21.

Spivak L´Hoste, A., Hubert, M., Figueroa, S., & Andrini, L. (2012). La estructura de La investigación argentina em nanociencia y nanotecnología: balances y perspectivas. In G. Foladori, E. Záyago, & N. Invernizzi (Eds.), *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina*. México, DF: Miguel Angel Porrúa.

Takeuchi, N., & Mora Ramos, M. E. (2011). Divulgación y formación en nanotecnología en México. *Mundo Nano*, *4*(2), 59–64.

Vega-Baudrit, J. R., & Campos, A. (2012). Nanotecnología en la región centroamericana y Panamá: Caso Costa Rica. In *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina* (Foladori, G.; Invernizzi, N & Záyago, E.). México, DF.

Velho, L. (2011). The concept of Science, and the Science, Technology and Innovation Policy. *Sociologias*, *13*(26), 128–153. doi:10.1590/S1517-45222011000100006

Záyago, E., & Foladori, G. (2012). La política de Ciencia y Tecnología en México y la incorporación de las nanotecnologías. In G Foladori, E. Záyago, & N. Invernizzi (Eds.), *Perspectivas sobre el desarrollo de las nanotecnologías en América Latina*. México, DF: Miguel Angel Porrúa.

Záyago, E., Foladori, G., & Arteaga, E. (2012). Toward an Inventory of Nanotechnology Companies in Mexico. *Nanotechnology Law & Business Journal*, *9*, 283–292.

Zumelzu Delgado, E., & Zárate Aliaga, A. (2011). La nanociencia y la nanotecnología, un desafío a potenciar en el crecimiento económico de Chile. *Mundo Nano*, *4*(2), 29–33.