Nanotechnology for Development
or Knowledge Enclaves?
The World Bank Case for Latin America

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Abstract

A great deal has been written in recent years about nanotechnology, its revolutionary significance for science and real-world applications that are touted as being capable of profoundly transforming the world in which we live. Yet very little has been written about how they are incorporated into the context of the knowledge economy. In this article, the authors analyze the World Bank's intention to develop Scientific Millenium Initiatives as Centers of Excellence in Latin America to boost competitiveness and encourage economic growth, which is understood by the World Bank as a requirement for development. Nanotechnology is a strategic area within these projects. However, the authors conclude that rather than leading to development, these centers are more likely to become knowledge enclaves with little impact on the real development challenges of the region.

Keywords: N*anotechnology, Latin America, Knowledge Economy, Scientific Millennium Initiatives, Development.*

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Introduction

A great deal has been written in recent years about nanotechnology, its revolutionary significance for science and real-world applications that are touted as being capable of profoundly transforming the world in which we live. Little, however, has been published that situates nanotechnology within the broad context of development. One approach to placing it in context is an examination of nanotechnology as part of the "Knowledge Economy" paradigm. Our interest lies in exploring that subject and how it is applied to the context of Latin America.

In part one, the concepts with which we examine how this new industry is portrayed by its supporters and those who call for a deeper analysis of its adoption are presented. In part two, some aspects of the historical context and some relevant theoretical underpinnings of "development" are offered, as a foundation for analyzing nanotechnology's status as a key development mechanism according to the World Bank's prescriptions. In part three, the global trade regime as it pertains to intellectual property and patent protection in the context of the use of knowledge to aid economic growth is discussed. Part four looks at Latin America's experience with nanotechnology development under the World Bank's guidance, and examines the resources being committed to the development of "knowledge enclaves." Also examined here are some of the challenges facing countries as they attempt to develop a top-down high technology approach in areas where infrastructure and educational base are less than ideal.

1. Nanotechnology and the Question of Development

The "development debate" has existed for decades, with definitions offered, discarded and reformulated. Whereas the generation of profit and economic success lay at the core of much institutional development policy, today most development theorists and practitioners favour a wider-ranging perspective that includes the environment, gender, labour, culture and various other related aspects of societal change, focusing upon the

improvement of the material quality of life for all citizens. This is the window through which the question of nanotechnology should be examined.

What, then, is an appropriate definition of development as it pertains to the question of nanotechnology? The presently emerging revolution in the nanosciences and corresponding nanotechnology represents, perhaps, one of the most profound technological revolutions humankind has experienced, with great potential for altering at the atomic level the very properties of matter.

In describing this new industry, proponents often cite the potential in particular for the developing countries to embrace nanotechnology as an excellent solution for countless problems, ranging from safe water; energy production; and health care. A core tenet of the nanotech revolution is the potential for significant new economic opportunities, and since developing nations are poor, nanotechnology is thus seen as a way to "catch up" if only they are able, or assisted, to take advantage of the technology quickly, to jump aboard the ship before it sails out of reach. In reviewing the debates on nanotechnology development, we noticed that the University of Toronto Joint Centre for Bioethics (UTJCB) and the Task Force on Science, Technology and Innovation of the United Nations Millennium Project talk about the potential benefits of this revolution for development, but are scant on the details, proposing a technical solution without – it seems – being sufficiently conscious of the broader problems of development (Salamanca-Buentello, et al., 2005; Juma & Yee-Cheong, 2005).[4] Those authors could be identified as having a *technology-neutral* approach, as they view underdevelopment as the result of a lack of technology, and thus nanotechnology is portrayed as a solution. Another perspective is that of the ETC Group (2003) and Invernizzi & Foladori (2005), these authors represent a *contextual* approach as they favour an analysis of the socioeconomic context parallel to influencing technology development. In addition, they understand development as a socioeconomic problem and technology as no more than a tool subsumed to economic trends.

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[4] A chronological survey of positions on nanotechnology & developing countries can be found in Invernizzi, Foladori & Maclurcan (2007).

Nanotechnology is certainly a path which represents great potential. We argue, however, that this potential is far from certain to be realized without due attention paid to the big picture. Technological advances, however revolutionary, do not guarantee better living conditions for the poor and workers. Even in those contexts where nanotechnology could be fully integrated in Least Developed Countries (LDCs) national development plans, socio-economic structures are unlikely to change as a consequence in the absence of progressive planning to control and push mechanisms in favor of peoples needs. Rather, nanotechnology may further the technological and socio-economic isolation of the poor, worsening existing gaps, despite the profits generated.

2. The Knowledge Economy and its Significance for Development

The global race for industrial development is increasingly dependent and based upon a process of "productive transformation," –technological conversion of the industrial production apparatus– In this context, nanotechnology, as the next industrial revolution, presumably provides fertile ground to cultivate the development process in LDCs. However, in order to integrate nanotechnology as a tool for development we need to understand the different theoretical frameworks surrounding the notion of development. The discussion about what development is or is not is wide and is associated with several theoretical currents. As a way of synthesis we can define some of the most important positions regarding the different notions of development.

One of the most prevalent and the first conceptual framework of development comes from the work of W.W. Rostow. His concept of development was directly linked to economic growth, modernization and industrialization, with high mass consumption as the indicator of full progress; presumably LDCs will have to pass through five stages of development to industrialize their economies: *Traditional, Transitional, Take-Off, Drive to Maturity* and *High Mass Consumption* (Rostow, 1960).

Raul Prebisch elaborated the center-periphery concept, using the analysis of the deteriorating terms of trade, the result of the quotient between the export price index and the import price index. By the mid 20th century the terms of trade deteriorated for

countries that exported raw and basic materials in Latin America due to monopolization and unequal relations of power (with the exception of oil). This had a decidedly negative impact upon the industrialization process in those countries. From this analysis, Prebisch concluded that the problems of underdevelopment in Latin America have structural origins (Prebisch, 1950, 1984).[5]

In contrast to these positions, Paul A. Baran (1957), argued that the development of underdevelopment in LDCs was perpetuated by the lack of distribution of power among classes, the control over the economic surplus in all its forms and the inability of LDCs to compete with the advanced capitalist countries.

The current neoliberal process of economic growth that prevails in the world was based upon the working ideas of neoclassical economic theory. First Hayek (1944) and latter Friedman (1962, 1980), argued that the liberalization of trade and the integration of national economies are preconditions to encourage economic growth; as long as they are willing and able to successfully compete in that market, under rules of engagement that they have no ability to influence. In fact, during the military dictatorship in Chile, this theory was put into practice to presumably encourage its economic growth (Cypher, 2005; Valdez, 1989).

The idea that development equals economic growth has been contested by proponents of a broader definition of development. Within this framework it is believed that increased incomes are a means to achieve development but they will never be the end unto themselves (Sen, 1988; Streeten, 1981). The United Nations Development Programme (UNDP) in its 1990 report created a more comprehensive definition of what human development is: *a process of enlarging people's choices* (UNDP, 1990). Through time the notion of development has gone beyond economic parameters to incorporate issues of environment, gender, ethnicity and livelihoods (Ahooja-Patel, 1982; Chambers and Conway, 1998, 1995 and Chambers, 1987).

Nevertheless, it is important to point out that the hegemonic idea of what is development is still defined within an economic framework. On the agenda of development agencies at the international level, such as the World Bank and the IMF,

[5] From the 1970s-on, terms of trade for commodities also experienced a decline.

economic performance remains the core objective of policy prescriptions. There is recognition of the "incidentals" of development, including impacts of progress on culture and society, the environment, labour and the role of government, but these do not distract from the economic focus that is "development" for these agencies:

> The Bank has sharpened its support for the development agenda through a two-pillar strategy for reducing poverty that is based on building the climate for investment, jobs, and sustainable growth and on investing in poor people and empowering them to participate in development (World Bank, 2005).

In addition, within the framework of development as economic growth, the increase in the production of high technology products within the developed economies has been evident since the beginning of the 1990s, and led to the widespread application of the term "Knowledge Economy" (or "Information Society") to refer to an economy in which innovation and knowledge is the driving force.

The World Bank ranks countries according to the share of high technology products in total exports. "High technology products" are considered to be those which are the results of intensive research and development (R&D), including aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery. In 2004, for example, 34% of Ireland's exports were high-tech products; in South Korea, 33%; in the USA, 32%; but in Latin America, Chile exported only 5%; Brazil 12%; and México 21%[6] (World Bank, 2006). The World Bank analysis suggests that R&D has come to play an essential role in development, and this is the path that developing countries should follow to rise up from underdevelopment.

Organizations such as the World Bank, the OECD and the World Trade Organization (WTO) came to see knowledge and innovation as prerequisites for Third World countries in the process of development. The transformation of the industrial apparatus in LDCs now relies on the Knowledge Economy (World Bank, 1999).

With economic success weighing down the standard definition of development in the halls of the most influential development organizations in the world, efforts to orient

[6] In the case of México, the weight of maquiladora production and the strong intra-firm trade of US transnationals suggests that there is a need to be cautious in the analysis (Delgado Wise & Invernizzi, 2002).

nanotechnology toward serving the broader developmental interests of LDCs would appear to be an uphill battle. Can one expect that this technological revolution will have different results than those that came before? Or will nanotechnology simply be the latest method of creating profit that bypasses the interests of the majority of people who live in the developing world?

3. **The Knowledge Economy and Developing Countries**

Developed countries are, increasingly, exporting high technology products. At the end of the 20th century, the percentage of those exports was between 18 and 25% in the European Union, Japan and the United States - not including Ireland, with approximately 38% (UNDP 2006). The manufacture of high tech production is seen as the evidence of a transition to the knowledge economy.

In promoting the theoretical importance of knowledge, groups and organizations like the World Economic Forum and the World Bank created indices of Competitiveness for Growth and tables that rate different countries according to their position in the knowledge economy.[7]

In a capitalist world, the ability to bring about development through the use of knowledge requires that it is oriented toward and in the service of businesses that can realize innovations to be transformed into commercial advantages. The Knowledge Economy implies an *education+innovation+competitivness* triad. This signifies a growing tendency toward the privatization of education and its placement in service to business. At the same time, business ventures would need to increasingly dedicate themselves to attaining international competitiveness. The result is that the market, as the blind force behind competition, ends up orienting production. Although all current

[7] See the World Economic Forum's Global Competitiveness Network: Global Competitiveness Report 2005-2006 at http://www.weforum.org/en/initiatives/gcp/index.htm [Last accessed 23 May 2007]

debates about innovation and the knowledge economy refer to "innovation with equity" or "competitiveness with sustainability" and similar terms, the fact is that all forms of economic planning remain regulated by unrestrained market forces. It remains to be seen over the decades to come whether economists who set development policies in LDCs will in fact be able to achieve the reduction of inequity and poverty.

How, then, can this dynamic be incorporated into countries that historically developed through primary material exports with scarce value-added? This is one of the issues that enthusiastic proponents of the knowledge economy must face. While in the developed countries the infrastructural conditions, training and human skills in Science & Technology (S&T) have been built over decades, and in particular with attention given to the relatively recent technological revolutions in informatics and computers, biotechnology and telecommunications, in developing nations there does not exist the material infrastructure nor the subjective conditions of professional training to embark upon the knowledge economy path. The "solution" that they have found is a top-down mechanism, or "knowledge enclave" plan. Developing countries could create "Centres of Excellence," institutes or research bodies with few researchers but significant resources, and with a strong relationship to industry.

During the 1980s, the World Bank concentrated its efforts in financial liberalization. A part of that orientation involved closing the Department of Science and eliminating the position of Scientific Advisor to the World Bank, embracing the idea of "free trade for development."

In 1994, the WTO instituted the worldwide patent regime TRIPS (Agreement on Trade-Related Aspects of Intellectual Property Rights) in order to guarantee patent protection of foreign trade operations. TRIPS sets down minimum standards for many forms of intellectual property regulation. TRIPS also established a legal system and mechanism for dispute settlement, including sanctions, for countries that do not comply with the legislation. Patent protection for new technology products permits the owner to set monopolistic prices for that product over a period of twenty years (WTO, 1994). In this way, the WTO with TRIPS ensures that large corporations that possess the majority of the patents have assured future monopoly profits.

The World Bank's *World Development Report 1998/99* carried the subtitle, *Knowledge for Development*, referring to the gap in knowledge between rich and poor countries (Masood, 1999). The basis for this change was the recognition that the economic liberalization of the 1980s had not attained the anticipated results, but rather had increased the gap between rich and poor countries, and increased their foreign debt. The Bank also indicated that the patent regimen had not resulted in the promotion of private research in areas of greatest impact on development. The mechanisms of the market were not sufficient to create incentives for research in areas with little return, for example, the "neglected diseases" or illnesses of the poor, such as treatments against malaria. In these cases, the Bank recommended that public funding should be directed toward subsidizing research (Nature, 1988); and it showed concern for the extension of intellectual property rights beyond products, to cover biotechnology achievements (Butler, 1998). According to the World Bank, the proposed course of action at the end of the 1990s was, then, to incorporate themes of innovation, S&T and the transfer of technology as key objectives of the Bank for developing countries.

4. Nanotechnology and "Knowledge Enclaves" in Latin America

Since the end of the 1990s, the World Bank and various other institutions have planned for the creation of a global network of "Millennium Scientific Initiatives." These will be centres of excellence in developing countries, with the objective of promoting research in S&T under equal conditions of infrastructure and resources as exists in research centers in the developed countries (Macilwain, 1998).

The Chilean project was the prototype. In 1999, the government of Chile created the National Commission of Scientific Initiatives for the Millennium, with the objective of enhancing capacities in scientific research (DORCH, 1999); shortly thereafter, the World Bank provided a 5-million dollar loan for the first two-and-a-half year period, supplementing a 10-million dollar national budget (ICM, n/d a). The Millennium Scientific Institutes' (ICM) objectives were:

> ...to foster growth in scientific research capacities, employing and stimulating the best talent in the country, as a key factor for sustainable socio-economic development. The Programme anticipates that the creation of Centres of Scientific Excellence will give rise to Scientific Institutes and Scientific Nuclei under a competitive and transparent process. These centres will pursue scientific research on the frontier, the training of scientists and the establishment of links with the productive sector and other institutional agreements (ICM, n/d a).

Instead of adjusting the research lines to a particular national development plan or project, the Programme worked to identify talented Chileans within the country and beyond to drive research in the direction that they had an interest in pursuing. This science policy could appear elitist, but it was based on the idea that whatever the orientation of innovation, it would result in greater international competitivity and would guarantee development (understood as to winning space in the international market to promote the process of economic growth). Although terms such as "sustainable development," "combating inequity and poverty," and others that were aimed to humanize the concepts of innovation and competitivity were included in the formula, it is clear that the concept of development behind these sort of projects is based on the idea that the improvement of competitivity increases wealth in a country, and then such wealth would be automatically redistributed. Another way to view this issue is the argument that without an increase in capital there would be no possibility of distribution; and in any case, the policies of distribution of wealth, rather than those promoting innovation, are responsible for combating inequity and poverty. In this way, responsibilities are separated, but the reduction of poverty and inequity is directly linked to the increase in monetary supply.

Other objectives of the Chilean Millennium Initiative included attracting foreign talent and avoiding "brain drain." In this sense, the World Bank plan that Chile implemented as a pilot project, is *top-down*. Centres of Excellence were created for the most distinguished scientists, with the hope that they would facilitate alliances with private enterprise and lead to productive innovation. Although the spirit of the plan was to create the conditions for the researchers to stay in Chile and not migrate, it is debatable whether this could be achieved in enclaves of excellence with short support and without a concurrent basic educational reform effort to nourish and allow the replication, in the long-term, of a path for technological innovation. These enclaves of excellence would

have to survive in a country where only 0.6 % of the GDP is destined for S&T; a very low figure, only a few decimals above México's commitment and clearly inferior to Brasil's (0.95%) in the Latin American context; it is certainly below the support provided in the developed countries and the ones that have adopted innovation in the last decades as a strategy for development, like South Korea (2.63 %); USA (2.68%); and México (0.41%) (OECD 2005) and the regional leader, Venezuela (2.11%).[8] Many other countries in the world followed variants of the Chilean example. In Latin America, Mexico, Venezuela and Brazil established agreements with the World Bank to develop their own Millennium Initiatives.

Nanotechnology is considered one of the most important areas within contemporary innovation, and a paradigmatic example of research which must be supported in the transition into the knowledge economy. However, what matters in not the technological innovation per se; rather, it is the incorporation of that innovation in the manufacture of products with an international competitive advantage that makes the difference. In fact, competitiveness is one of the justifications –and in many cases the only one– for making use of public funds to research new technologies. The National Nanotechnology Initiative of the United States illustrates this idea, but is also an important feature for other nanotechnology programs in countries such as Argentina and Brazil, and is present in reports issued by the Mexican and the Costa Rican Governments (Foladori, 2006); it is easily seen in the Malaysian Nanotechnology Centre or behind the official discourse of the Government of Thailand (Tun Razak, 2005; Tanthapanichakoon, 2005). Even though the spirit behind the discourse of competitiveness is to encourage development, and presumably, benefit society overall, the historic experience, which is the body sustaining that spirit, indicates the precise opposite. A country can improve its competitiveness without necessarily improving the living standards of its population, with the cost of increasing inequality, the Mexican case is a perfect illustration of this.

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[8] "Inversión venezolana en ciencia alcanzó 2,11% del PIB" http://www.scidev.net/News/index.cfm?fuseaction=readNews&itemid=3636&language=2 Last accessed 29 May 2007.

Nanotechnology innovation is an important aspect within the United Nations for developing countries. The *Task Force on Science, Technology and Innovation of the U.N. Millennium Development Project*, for example, released a report with the suggestive title *Innovation: Applying Knowledge in Development* (Juma & Yee-Cheong, 2005), where it put forward the idea that nanotechnology will be important to the developing world, because it requires little work, land and maintenance, is highly productive and cheap and requires only modest quantities of material and energy.

In the same vein, in February 2005, the International Centre for Science and the United Nations Industrial Development Organization organized a conference (*North-South Dialogue on Nanotechnology: Challenges and Opportunities*) specifically focused on the participation of developing countries in nanotechnology (Brahic, 2005a, 2005b; Brahic & Dickson, 2005). Representatives from governments, academia, international experts and representatives from industry took part. Of particular interest was the statement of the president of the Third World Academy of Sciences, Mohamed Hassan. He proposed the establishment of Centers of Excellence in Africa, thereby promoting cutting-edge S&T as necessary for developing countries to succeed (Hassan, 2005). The same idea has been discussed by the leaders of the world's most industrialized nations (Group of 8) since 2000, which explicitly backed the creation of Centers of Excellence in Africa to encourage the transfer and sharing of Science & Technology between developed and developing countries, during its annual summit in Scotland in 2005 (Dickson, 2005).

In Latin America, Brazil, Argentina and México are countries where nanotechnology research have made particular advances (Foladori, 2006a). However, there are differences between their approaches. In 2001, Brazil introduced a national plan to form scientific research networks with a one-million-dollar budget. Later, in 2004, it announced the Nanoscience and Nanotechnology Program, within the framework of the *Plan Pluri Anual de Desarrollo 2004-2007* (The Pluri Annual Plan for Development 2004-2007), for which the Brazilian government allocated 39-million dollars (MCT, 2004a, 2004b). Additionally, there are several funds from federal, provincial and international sources to sponsor nanotechnology research in Brazil. Most of these

resources are centrally managed by the Ministry of Science and Technology in Brazil with the objective of advancing nanotechnology research.

The government of Argentina, on the other hand, created in 2005 the Argentinean Foundation for Nanotechnology with an estimated budget of 10-million dollars to cover the research in nanotechnology for 5 years. The Argentinean government, as well as the Brazilian, are trying to regulate all nanotechnology-related research by controlling budgets and by implementing supervisory procedures. But neither Argentina nor Brazil have set up discussion panels to examine the political, social and economic implications of the use of nanotechnology. In both countries, the exchange of ideas about the use of nanotechnology can only be associated with the idea of becoming more competitive (Foladori, 2006a).

The Mexican case is somewhat different from the Argentinean and the Brazilian. There is no specific plan nor national program linked to nanotechnology in México, even though nanotechnology is considered a strategic sector for development, as identified in 2002 in the *Special Program on Science and Technology 2001-2006* (Foladori & Zayago, 2007).

In the three countries, nanotechnology development has been supported by their governments. In fact, in order to develop the Millennium Scientific Initiatives (MSI), these governments had to disburse more money than the contribution made by the World Bank. The spirit behind these schemes is to support the development of leading technologies. That objective, leading toward greater competitiveness, justified the creation of enclaves of excellence. The argument is explicit in the case of Argentina and Brazil and very easy to discern from many documents issued by the Mexican government. In short, it is clear that the MSI are key elements of a policy directed to support the concept of knowledge economies through the establishment of Centers of Excellence.

The Millennium Initiatives of the World Bank gave initial, but very reduced, funding to the development of nanotechnologies in Latin America; particularly in Chile Mexico and Brazil. Even though the MSIs pursued nanotechnology research in a very narrow way, they were some of the first to do so, thus they formed the core for

encouraging nanotechnology research and development in those countries. In Chile, for instance, the programme began in 1999 and in Mexico in 2001. Ironically in these two countries there is still no programme or national fund to develop nanotechnology research. In Brazil, funding began in 2001, before the formation of the national networks of nanotechnology and three years before the elaboration of the Nanoscience and Nanotechnology Programme.

Although the spirit behind the MSI was to create research centers or institutes able to compete with their counterparts in developed countries, in practice they were under-funded. In Chile, for instance, the World Bank approved a credit of 5 million dollars for the first stage to be conducted in two and a half years, was added to the 10 million dollars approved by the Chilean government (ICM, n/d a). On average, most projects had a budget of 290,000 dollars for three years, with the possibility of just one renewal, which in the long term weakened the feasibility of the projects (Angel, 2003). In Brazil, during the first stage, the MSI received approximately 36 million dollars in funding for three years with an average of 2.1 million dollars per project (consisting of the formation of networks). The second stage was completely financed by the Brazilian government. In the Brazilian case, since the subjects were entire networks, the number of researchers and institutions involved was very large. The Nanosciences Institute, headquartered at the Federal University of Minas Gerais (UFMG) included 13 institutions and more than 60 Ph.D. researchers in almost 17 research projects (MCT-CNPQ, 2002).

The following chart shows the nanotechnology-related areas that were approved for these countries.

Millennium Science Initiatives in Latin America 1999 -2005 [9]

Country	Start date	# of institutes / nuclei / networks funded	Nanotechnology Institutes or Nuclei founded by MSI	Host Institution
Chile	**1999**	**3 Institutes** **5 Nuclei**	• **Nuclei Condensed Matter Physics**	• **U. Técnica Federico Santa María**

[9] The information on Nanotechnology is approximate. The criteria employed was keyword indicators in the title or project description (nanotechnology, nanosciences, nanoscopic, nanostructured, nanocapsules).

Chile	**2001**	**5 Nuclei**	**------**	**-----**
Chile	**2002**	**3 Institutes**	• **Applied Quantum Mechanics and Computational Chemistry**	• **U. Andrés Bello**
Chile	**2003**	**3 Institutes** **8 Nuclei**	• **Nuclei Condensed Matter Physics (renewed)**	• **U. Técnica Federico Santa María**
Chile	**2004**	**3 Institutes** **12 Nuclei**	**-----**	**-----**
Chile	**2005**	**3 Institutes** **15 Nuclei**	**-----**	**-----**
Chile (funds raised through "royalty fees:)	**2006**	**5 Institutes** **17 Nuclei**	**-----**	**-----**
México	**2001**	**4 Institutes**	• **Physiochemical Studies of novel Nanostructured Materials**	• **UASLP**
Venezuela	**2001** (closed)	**3 Institutes;** **8 Nuclei**	**-----**	**-----**
Brazil (World Bank)	**2001 - 2004**	**17 Networks**	• **Millenium Institute of Complex Materials** • **Nanosciences Institute UFMG** • **Research Network on System-on-a-Chip, Microsystems and Nanoelectronics**	• **UNICAMP** • **UFMG** • **UNICAMP**

Source: ICM, 2006; CNPQ, 2005; MSI, 2005; & World Bank, 2005; ICM n/d.a; ICM n/d. b).

The goal for the MSIs was to link these research centers with industry, in public-private partnerships, to maintain money inflows into research once the external funding expired. However, having the private sector finance scientific research is not standard operating procedure in Latin America, where most research is conducted in universities and public centers. In Brazil, more than 80% of the research is conducted in public centers. In some cases, the public-private partnerships for research are established, but this is not the general trend. On the few occasions when the public-private partnerships for research came into being, the private interest determined the research agenda.

How, then, can the private sector respond according to the national development interest, when research is motivated by profits and oriented toward the political economy of

international competitiveness? That is a question seemingly without an answer within the nanotechnology development plans in Latin America (Foladori & Zayago, 2007). But, from the business perspective, the question can be answered with three arguments: research should be conducted according to the private interest, because this is the sector where the scientists are likely to work; when consumers buy a product they are seen to be confirming that the interest of the enterprise and the public is the same; and the amount and distribution of researchers required by the research centers of excellence will be regulated by the market itself according to the demand, so no shortage or surplus is expected. Therefore, the centers of excellence should not be seen as a process for creating elites, rather as the proper equilibrium between researchers and their demand within the market. This argument is charged with ambiguity because in reality inequality has increased in the last decades in the entire world, which questions its validity as the basis for development. The Mexican case is a good example, from the mid-1980s to mid-1990s, competitiveness significantly increased, but so did inequality, with the Gini coefficient going from 0.49 to 0.55 (Delgado Wise & Invernizzi, 2002).

Another problem without an apparent solution is sustainability from the point of view of the training process. The MSIs are an illustrative example of the knowledge enclaves, which the Chilean and Mexican experiences demonstrate. In several of these countries postgraduate programs of excellence are brought together with a deficient basic education and under-funded high school structures, where both are increasingly becoming privatized. In Mexico, only 19% of people of university age were enrolled; the figure for secondary education reached 57% in 2000 (Delgado Wise & Invernizzi, 2002). In addition, postgraduate programs of excellence are objects for external pressure since they are expected to produce a certain number of graduates, which then can jeopardize their quality (Guzmán del Próo, 2006). However, the most important question is whether these centers would be able to stop or even reverse brain drain, as it is hoped. This is a matter of concern, as research conditions in the centers of excellence in LDCs will never be of the same quality than their better-supported counterparts in developed countries. The latter is a consequence of the research agenda that prevails in developed countries where private interests rule. Consequently, the socio-political significance for researchers

from LDCs, according to national development agendas, is lost. In fact, the private-public alliances encourage migration because such partnerships are established with transnational corporations and universities overseas, mainly in developed countries. This dynamic therefore facilitates personal relations and the insertion of these scientists in other contexts. Even thought the aim is to foster international competitiveness to encourage the process of economic growth, there is the problem of training researchers whose interests may not have anything to do with the national development agenda, understanding the latter as the reduction of poverty and inequality.

Conclusions

Development, in the economic growth-as-development perspective of the World Bank is unlikely to be achieved under the Milennium Scientific Initiative effort in Latin America. There remains too large a gap between the efforts of LDCs and the production of knowledge and corresponding patent production in countries which have better developed and funded research centres. This is particularly important in the essential foundation patents upon which future nanotechnology development will be based. That head start by the developed countries, combined with LDCs challenges in infrastructure and workers with the appropriate skill base to support an emerging nanotechnology industry, appears nearly insurmountable over the long term. Economic growth may well occur and appear in the national accounts as a boost to GDP, but the benefits will accrue to the south-north joint business partnerships, reproducing Latin America's long experience as the *labour* in service to multinational corporations and northern governments' *brains*.

From our broader development definition, one focused upon a decrease in poverty and an increase in equality, the repercussions of nanotechnology under the framework of the knowledge enclaves seems to be negative. Nanotechnology as an area for state investment or facilitation is not outlined within any national development plan beyond *economic growth* via an increase in competitiveness Those proponents of nanotechnology as a solution to the symptoms of underdevelopment in Latin America water quality, crop failure, medicines see the technology but not the structure under which that technology

comes into play. Nanotechnology will create amazing new products and processes that may well have an impact upon our lives in a profound way but the reality is that LDCs will not own much of that technology: the structural challenges to ending poverty and inequality will remain, as the South works in service to the North, licensing patented technology from companies and governments from outside the region, while their capacity to create made-in-Latin America nanotechnology will remain circumscribed by insufficient planning, infrastructural deficiencies and a nanotechnology agenda set more by northern research partners than local needs.

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