It is the academic sector which is the most dynamic actor in creating innovation systems in Latin America… As a result, local knowledge is underutilized by productive sectors that have little demand for it.

Mario Albornoz, Mariano Matos Macedo and Claudio Afbaraz
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Mario Albomnoz, Mariano Matos Macedo and Claudio Alfaraz

INTRODUCTION

The global economic recession has struck Latin American countries with varying intensity: in 2009, growth slowed in some countries, like Brazil, and was negative in others, like Argentina. However, the impact of the recession seems to have had a less dramatic impact on the region than on other parts of the world. At the time of writing in early 2010, the worst appears to be over, with Latin American economies now on a path to recovery. Peru, Chile and Brazil should lead with growth rates of more than 3.5% in 2010. The Brazilian government announced in late 2009 that the country had relegated the recession to the past; effectively, Brazil’s employment rate has risen steadily since the second half of 2009. Argentina’s economy is also showing signs of recovery and should grow by 1.5% in 2010, albeit at a slower pace than before the recession. Mexico, on the other hand, has been deeply affected, due to the imbrication of its economy with North American markets. However, Mexico should bounce back in 2010, with growth forecast of around 3%. Venezuela will not be so fortunate, as its economy is expected to contract slightly again in 2010 (Casamérica, 2010).

In the meantime, the gap between rich and poor in Latin America remains one of the widest in the world. The region faces pressing social issues such as poverty and marginalization, which deprive many of education, health care and housing, among other basic rights. The impact of the current recession on employment will probably exacerbate social tensions and push some communities farther to the margins of society.

According to 2006 data from the United Nations Economic Commission for Latin America and the Caribbean – the last year for which data are available – more than one-third of Latin Americans, or 200 million people, live beneath the breadline and 13.4%, or 80 million, in extreme poverty. The stratum composed of 48% of Latin American homes in the lowest income bracket concentrates as little as 14% of aggregate income, on average (ECLAC, 2007).

Even though these figures have improved slightly since 2002 as a result of growth, the structural weaknesses of Latin American countries persist: economies oriented towards commodities, low levels of industrialization, a regressive income distribution rate and limited access to international funding as a result of difficulties in repaying foreign debt in earlier decades.

Paradoxically, the fact that Latin American countries are producers of commodities has been a comparative advantage in the past few years of growing international demand. Recent data show that international prices for commodities are going up again, which is very good news for Latin American economies. If this is confirmed as a long-term trend, the pace of economic growth will not be so negatively affected in coming years by price fluctuations.

One of the main symptoms of persistent poverty is growing urban segregation, with slums spreading in many of the region’s major metropolises. In parallel, a report by the International Labour Organization (ILO, 2007) notes that, among Latin American youth aged 15–24 years, 30 million out of a labour force of 48 million are employed in the informal economy where working conditions are poor. A further 10 million are unemployed. Of the 22 million young people who neither study nor work and have never registered as unemployed, 79% live in urban areas. This shows that equity, an intrinsic dimension of development, has still not been attained in Latin American countries, despite being a long-standing goal.

Even an emerging economy like Brazil presents the urban–rural, rich–poor divide that is widespread in Latin America. The problem of uneven development, with scientific institutions being concentrated essentially in the capital and other major cities, is typical of the region and can be observed, for example, in São Paulo and Rio de Janeiro, Buenos Aires and Mexico City.

It is difficult to consider Latin America as a whole, since one of the most prominent characteristics of the region is its heterogeneity, both between and within countries. Just five countries concentrate 80% of regional GDP (Figure 1). This concentration highlights the need for very diverse development strategies, which will in turn have an impact on the type of science, technology and innovation (STI) policy adopted by each country.

New development paths must be explored in Latin America if the region is to generate more wealth and improve wealth distribution. These new paths must value available resources, among which knowledge must take a central place. STI must play an increasingly important role in achieving growth and equality.

1. Latin America refers in the current chapter to the countries in Figure 1. See also the individual chapters that follow on Brazil and Cuba.
Most of the region’s existing institutions were inspired by what is now known as the ‘linear model’. The aim of the linear model was primarily to ensure good-quality basic research. It was assumed that this would guarantee the availability of applied research and that the benefits of science would in turn overflow into society as a whole. The linear model met with some success in creating or consolidating the scientific community of each country but was of little efficacy when it came to transferring knowledge to the productive sector; this gave rise to the configuration of an academic sector relatively isolated from society. The outdated linear model is still alive and well in many countries of the region.

The Conference on Science, Technology and Innovation for Sustainable Development in Latin America and the Caribbean, organized by UNESCO in Havana, Cuba, in 2005, addressed the lack of correlation between the spheres of production and the use of knowledge, which in turn leads to a mismatch between the expectations of the scientific and business communities as to the use of knowledge. The conference also addressed the issue of existing tensions between democratization, on the one hand, and the satisfaction of social needs, on the other, and emphasized the effect of those tensions on science and technology (S&T) policies, in the sense that research and development (R&D) could make a remarkable contribution to social cohesion and the exercise of citizenship.

With Latin American countries now attempting to promote innovation within a development strategy that includes social equity, it has become necessary to revisit science policy models and instigate institutional modernization. Signs of change can be detected in the organization of R&D and STI policies in many Latin American countries. Since the mid-1990s, Argentina, Brazil, Chile, Colombia, Mexico and Venezuela, among others, have all been implementing institutional reforms to speed up procedures for resource allocation and make these procedures more transparent. In more recent years, other countries have followed the same path, among them Paraguay, Peru and Uruguay. Reforms have also focused on assessing R&D results, promoting innovation, strengthening the relationship between research centres and business, designing long-term policies, employing strategic intelligence tools, monitoring public opinion on S&T issues and disseminating knowledge. Among other reforms characteristic of the
most advanced institutional systems is the adaptation of universities to the new social reality, with the development of linkages to enterprises and other social actors.

There has been a shift in policy from the linear model towards a more dynamic model, in which R&D is demand-driven and based on specific needs for knowledge and policy is supportive of innovation. One example is the creation of the Agency for the Promotion of Science and Technology in Argentina in 1996, which has been endowed with funds to finance R&D and innovation (Box 1). In Chile, multiple funds have been set up since 1981 to finance a wide range of projects ranging from centres of excellence to projects for innovation and the creation of networks linking public and private R&D institutes. In Brazil, sector-specific funds were created in 1999 to raise the level of R&D funding (see page 106). More recently, Uruguay established the National Agency for Research and Innovation (ANII) in 2005 to consolidate competitive funds. The same year, a loan from the InterAmerican Development Bank enabled Peru to set up a Science, Technology and Innovation Fund to finance R&D programmes and projects of private enterprises. The Fund’s Board of Directors is made up of representatives of the scientific and academic communities, the government and private sector.

Currently, S&T policies in the region are based on specific legislation, much of which was drafted in the founding moments of countries’ respective S&T systems.

Nevertheless, a significant change came about at the turn of the century in many countries with the passing of legislation that restructured S&T institutions and, in many cases, incorporated innovation, thereby creating an STI system: Argentina’s Congress passed a Science Law in 2001, a year before Mexico passed its own Science Law, followed by a second law establishing the statutes of the National Council for Science and Technology (CONACyT) in 2006. The National Council of Innovation for Competitiveness was created in Chile by President Lagos in 2005 and renewed in 2006 by President Bachelet to provide the presidency with a permanent advisory body. This set of institutional novelties reflects, on the one hand, the growing visibility of S&T policies within the framework of broader development policies and, on the other hand, the beginning of a new generation of policy instruments incorporating innovation.

As regards the composition of the institutional systems of S&T, the heterogeneity across the region is again apparent here. Although there are public organizations dedicated to R&D in every Latin American country, the circumstances in the various countries vary from those having large and complex systems – such as Brazil, Argentina, Mexico and Chile – to those with only a sprinkling of weak institutions of higher education and no S&T system worthy of the name. A study published in 2009 by the InterAmerican Development Bank and the Centre for Studies on Science, Development and Higher Education (Centro REDES) identifies 10 different types of S&T policy instruments grouped in six main categories. The only countries having instruments for every category are Argentina, Brazil, Chile, Mexico and Uruguay. Colombia and Venezuela have very incipient S&T systems compared to those of the five leaders, according to Emiliozzi (2009) and Lemarchand (2009).

In recent years, many countries have implemented mechanisms and programmes to evaluate the performance of public STI policies. The evaluation of public policies, through different assessments, follow-up, monitoring and accountability mechanisms, has been one of the elements promoted by the state reforms introduced throughout the region since the 1990s.

On a political level, there has also been greater government interest in promoting a science culture and citizen participation. Latin America has been no stranger to the trend towards democratization of knowledge. Many surveys of the public perception of science have been conducted in recent years, as a result of the creation of a network within which academics and officials of national S&T organizations in Latin American countries have been working together to build a consensus on methodology (Box 2).

R&D INPUT

Trends in R&D expenditure

The Achilles Tendon of STI policies in Latin America remains the low level of investment in R&D, with the notable exception of Brazil, which contributes as much as 60% of the region’s investment in R&D. There has, however, been an upturn in the region since 2004. After remaining stable at around US$ 10 billion from 1996 to 2004, gross domestic expenditure on R&D (GERD) jumped to US$ 23.1 billion in 2007, boosted by economic growth (Figure 3).

In 2006, GERD in Latin America and the Caribbean represented 0.68% of GDP, or 1.9% of global spending on R&D.
Box 1: Promoting innovation in Argentina

Founded in 1996, Argentina’s National Agency for the Promotion of Science and Technology (Agencia Nacional de Promoción Científica y Tecnológica, ANPCYT) channels funding into R&D projects and infrastructure development. A decentralized body, it reports to the Ministry of Science, Technology and Productive Innovation (MINCYT) set up in 2007. The agency manages the following funds:

- the Technological Fund of Argentina (Fondo Tecnológico Argentino, FONTAR), which finances technological modernization and innovation in the productive sector, including via technological services for institutions and small and medium-sized enterprises, technical assistance and training, entrepreneurial incubators and technology parks and poles;
- the Trust Fund for Promotion of the Software Industry (Fondo Fiduciario de Promoción de la Industria del Software, FONSOFT), which was created by law in 2004 and finances development of the software industry in small and medium-sized enterprises;
- the Sectoral Fund (Fondo Argentino Sectorial, FONARSEC), which provides subsidies for the upgrading of R&D capacities for transfer to the productive and social sectors.

In 2008, the agency awarded a total of US$ 234.6 million for the execution of 2293 R&D projects. Of this, US$ 135 million went to FONCYT, US$ 94 million to FONTAR and US$ 5 million to FONSOFT. Some 22% (US$ 30 million) of the total amount allocated to FONCYT in 2008 was awarded within its Programme in Strategic Areas (Figure 2).

The Observatory of Venture Capital, a non-profit organization, was set up by the Science and Technology Ventures Institute (IECYT) in 2003 to group entrepreneurs and researchers. According to a 2008 survey by the observatory, the most attractive sectors for venture capital in Argentina are software and computer sciences (17%), the food industry (14%), Internet (7%), non-financial services (13%), media and entertainment (10%), biotechnology (10%), automation (7%) and health (7%). Start-up companies tend to attract the most funds (77%). Although US$ 70 million in venture capital was available in 2008, the observatory found that less than 10% was actually invested. The survey also found that venture capital was mostly mobilized from national sources, even though European funds and funds from the InterAmerican Development Bank and other multilateral agencies were also available.

Source: ANPCYT (2009); Jacobsohn and López (2008)

Figure 2: Sectors benefiting from FONCYT’s Programme in Strategic Areas, 2008

In US$ millions and as a percentage of the total

- Human health (cancer, vaccines, tuberculosis, stem cell research)
- Agribusiness (sunflower, wheat, milk, wine, etc.)
- Nanomaterials and nanodevices
- Information, communication and electronic technology
- Energy resources
- Food security
- Cultural industries

Source: ANPCYT (2006) Biotechnology and Biotechnology for the Promotion of Agriculture and Food Production
If we convert this figure to reflect purchasing power parity (PPP), the percentage climbs to 3.0% of the world total (see page 2). This suggests that Latin America’s GERD/GDP ratio has remained stable since 2002, even if its global share expressed in US$ PPP is up slightly from 2.8%.

Economic growth across the region has thus not translated into a stronger financial commitment to R&D. Mexico and Argentina even fall below the region’s mean value, although, in the case of Argentina, this poor performance is due to the 2002 economic crash (Figure 4).

In recent years, several countries have instituted reforms to decentralize and allocate resources via competitive mechanisms. Such is the case of Peru, which created the National Fund for Scientific and Technological Development and Innovation (FONDECYT) in 2006 to raise, manage, administer and channel domestic and foreign resources for the activities of the National Science, Technology and Innovation System (SINACYT). Furthermore, a series of initiatives have given public research institutions greater organizational and financial autonomy.

In Latin America, R&D is largely dependent on public funds. Nearly two-thirds of R&D is funded by the government. Moreover, nearly 40% of government funds are invested in university research, the remainder being channelled into public research institutes. This funding pattern runs counter to that of industrialized countries, where up to two-thirds of the resources allocated to R&D come from the business sector.

**Box 2: Public perception of science**

Surveys of the public perception of science have been conducted nationwide in Latin American countries over the past two decades. In 2007, one of these surveys focused on six cities: Buenos Aires (Argentina), Bogotá (Colombia), Caracas (Venezuela), Panama City (Panama), São Paulo (Brazil) and Santiago (Chile). The questionnaire was developed around four topics: information and interest in science; citizenship and public policies on S&T; attitudes towards S&T; and social appropriation of S&T.

The survey found that only one in ten newspaper readers and television viewers were interested in topics related to S&T. The same held true for web searches for information on science, reading of science magazines or specialized books and visits to museums, science centres and exhibitions.

Likewise, in the part of the survey devoted to citizenship and public policies on S&T, attitudes towards S&T, and social appropriation of S&T, respondents were unable to name a single scientific institution in their country.

The results were more ambivalent when the question targeted public perception of a country’s prominence in S&T. Optimism was stronger in Bogotá and São Paulo, where half of respondents considered their respective countries to be ‘very’ or ‘somewhat’ prominent. The four remaining cities were more pessimistic, with Santiago (Chile) heading this category.

One set of questions analysed the value people attached to science as a career choice. Most respondents considered the profession of scientist to be rewarding, which is consistent with the high value generally attached to the profession in terms of social prestige. However, not all the cities considered the income of scientists to be adequate; whereas most respondents in São Paulo, Santiago and Caracas said that scientists in their countries were well paid, two-thirds of respondents in Buenos Aires felt that researchers received inadequate compensation.

In terms of the public perception of the risks and benefits of S&T, respondents in all but Caracas said that, in the next 20 years, ‘many’ or ‘plenty of’ risks derived from S&T activities would have to be addressed. However, this did not prevent 76% of respondents from pointing out that S&T could bring ‘many’ or plenty of benefits. Likewise, most respondents said that they were aware of the political and economic implications of science, as well as of the need to consider criteria other than technical elements for the development of laws and regulations. Respondents also tended to be in favour of promoting citizen participation in decision-making related to S&T.

Most respondents were found to attach value to having S&T in their lives. This was reflected in their perception of S&T as being useful for understanding the world, for health care, for conservation of the environment and for decision-making in their capacity as consumers, among other aspects.

Source: authors
Fostering private R&D investment and innovation is an issue of major concern to most countries, as it is a process that requires specific financial instruments to stimulate investment. In this context, those countries with greater relative development have incorporated more ambitious objectives in their STI policies for fostering business R&D. In Argentina, Brazil, Chile, Colombia and Mexico, policies set out to encourage innovation in small and medium-sized enterprises and to foster the development of high-tech industries and sector clusters. Additional measures to support infrastructure, modernization, technology dissemination and the training of skilled personnel are also in place. Some of these objectives are also reflected in the policies of the remaining countries.
Almost all countries in the region have developed instruments and provide direct public funding for business R&D and innovation. Argentina, Chile, Colombia, Mexico and Panama, for example, all use grant funds, basket funds and project-financing mechanisms. In addition, many countries have implemented tax mechanisms to stimulate R&D and innovation in this sector (on Brazil, see page 108). Most countries also employ other public instruments to fund innovation, such as venture capital, seed funds and measures for small and medium-sized enterprises or technology business incubators (Figure 6).

**Trends in researchers**

Disposing of an adequate number of scientists and engineers is a prerequisite for sustaining policies for development and social inclusion. For this indicator, the regional scenario is looking more promising than for investment. Latin American countries counted more than 252 000 full-time equivalent (FTE) researchers in 2007. Although they accounted for only 3.5% of the world total, placing Latin America and the Caribbean in a marginal position, this share is higher than that for GERD (see page 8).

The number of researchers and engineers in Latin American countries nearly doubled between 2000 and 2007 (Figure 7). Between 1996 and 2000, annual growth ranged between 3% and 4%. After a brief deceleration in 2001 when growth stood at around 2%, the positive trend regained momentum. This trend contrasts with the ups and downs in the curve for GERD (Figure 3).

This performance underscores the efforts made by many countries to implement training policies to consolidate their S&T base. For example, one of the main thrusts of Brazil’s Plan for 2007–2010 is to train and retain human
resources in priority areas (see page 118). Similarly, the goal of Argentina’s Medium-Term Strategic Plan (2005–2015) is to attain the ratio of three scientists and engineers for every 1,000 Argentinians who are economically active. Argentina is moving towards this goal. Ever since 2005, Argentina’s primary body for promoting S&T, the National Council for Scientific and Technological Research (CONICET), has taken in 1,500 PhD students annually, leading to a pool of nearly 7,000 active scholarship-holders in 2009. Chile and Venezuela have taken similar steps.

Nevertheless, the distribution of scientists and engineers among Latin American countries confirms the region’s heterogeneity. If improving access to knowledge tools is one of the main strategies for societies wishing to embrace socially and environmentally sustainable development, there is an evident correlation between the distribution of S&T capabilities and the distribution of wealth. Figure 8 shows that four countries concentrate more than 90% of scientists and engineers in Latin America, even though some small countries like Cuba also have a high ratio (see page 124). The region’s heterogeneity must be taken into account in any assessment of regional capacities.

Consolidating a country’s S&T base means being able to count on a critical mass of scientists, engineers and other highly skilled professionals. This depends mainly on two factors, the existence of a university system with a high standard of excellence at the graduate and postgraduate levels, and a set of conditions preventing large-scale migration of the most highly qualified professionals. As regards the first factor, very few doctoral candidates are trained each year in most Latin American countries (Figure 9). This is partly due to a university tradition of prioritizing excellence in undergraduate studies via much more comprehensive curricula than in English-speaking countries. If Brazil counts proportionally more doctoral candidates than Argentina, Chile or Mexico, this is because, since the 1960s, Brazil has implemented a sound, sustainable doctoral training policy (see page 111). Brazil also has the advantage of having a university system based on the Anglo-Saxon model, rather than on that of any other Latin American country.

Most countries offer budgetary and financial incentives, as well as scholarships, to strengthen higher education in S&T disciplines. In some countries, there are specific funding channels for improving the infrastructure of higher education centres in these areas of study. Examples are Argentina, Colombia and Peru. Furthermore, even if they differ, most countries have policies to facilitate education and the placement of scientists and engineers.
Three different aspects of brain drain in Latin America deserve consideration: the magnitude of the phenomenon, the loss of qualified personnel, and, lastly, the educational selectivity of migration streams or, in other words, the ratio of university-trained personnel to the total number of migrants from a country (Luchilo, 2007). Recent censuses on this theme carried out in the member states of the Organisation for Economic Co-operation and Development (OECD) show that approximately 1.5 million Latin American university graduates resided in OECD countries at the time (Luchilo, 2007). The magnitude of brain drain was low for Argentina (4.7%) and Brazil (3.3%), medium for Mexico (14.3%) and Colombia (11%), and high for Nicaragua (30.9%) and Cuba (28.9%).

Within the broader phenomenon of migration of highly qualified labour, it is particularly interesting to analyse the migration of scientists and engineers. Data from the US National Science Foundation (NSF) show that, by the late 1990s, foreigners represented 21.5% of active R&D personnel in the USA. Latin Americans made up 9% of this group, far behind the largest group, the Asians, with 60%. By the turn of the century, Spain had become another pole of attraction for highly qualified Latin American immigrants. The 2001 Spanish population census shows the presence of approximately 9,000 Latin American PhD-holders residing in Spain. In 2001, most were Argentinian (1,247), followed by Colombian (907), Venezuelan (664), Ecuadorian (638) and Peruvian (576) PhD-holders.

Note: The most recent data are 2006 for Mexico and 2004 for Chile.

Source: RICYT (2009) El Estado de la Ciencia

Trends in migration

2. Qualified personnel is defined as the ratio of university graduates to total graduates born in a given country.

3. The next Spanish population census will be conducted in 2011.

Figure 8: Distribution of scientists and engineers in Latin America, 2000 and 2007

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Trends in migration

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Two causes of brain drain are low wages in the country of origin and the underutilization of human resources, owing to the low absorption of professional and technical personnel. In addition to this, younger workers find it highly desirable to pursue graduate and postgraduate studies abroad. They generally feel that studying abroad will offer them better opportunities for their professional and economic future. The combination of a global educational offer, lower related costs and the multiplication of agreements between the universities of different countries only serve to nourish this phenomenon (Martínez Pizarro, 2005).

**Gender issues**

With 41% of all S&T-related jobs held by women, up 10 percentage points on a decade ago, Latin America is one of the regions with the highest female participation in science. This bright picture is counterbalanced, however, by the persistence of institutional practices and preconceptions symptomatic of a devaluation of women's work. This translates into the so-called 'glass ceiling', those invisible barriers that prevent women from attaining senior positions.

In this context, universities represent an institutional sector open to women, female participation being high in faculty and academic research positions. Although there are no aggregate data at the national level for all Latin American countries on personnel distribution by gender and institutional sector, some trends can be derived from observing countries with a high impact on regional science and those universities that enjoy great scientific prestige. In six countries of the region, women hold between 30% and 55% of all academic research positions in institutions of higher education. These participation levels are higher than in other regions, the European Union included. In Argentina, for example, women hold 30% of all research positions in business enterprises, 46% in non-profit organizations and 55% in public universities. A similar distribution can be observed for scholarship-holders. This could translate into a build-up of the pool of women researchers in the near future. However, a not-so-optimistic interpretation points to the progressive exclusion of women as they try to advance in their scientific career.

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If we compare women's participation in the economic and scientific spheres, it becomes apparent that science is more gender-inclusive in Latin America than elsewhere in the world: in half of the Latin American countries studied...
Latin America

(RICYT, 2009), women were better represented in the S&T sector than in the labour force in general. In some cases, there was even a gap of between 4 and 20 percentage points. The question of access to primary and secondary education is relevant in this respect, since a student needs to accumulate a certain number of years of formal education before being admitted to a university programme in science. In Latin America, a region with low- and middle-income countries but one of the world’s highest levels of social inequality, school attendance by girls has progressed consistently to the point where, in some cases, girls and boys have equal access to primary and secondary education.

Gender equality has come to the university campuses of Colombia, Chile, Costa Rica, Cuba and El Salvador in recent years. Women even make up 60% of students in Uruguay, Mexico and Panama, and 55% in Argentina, Venezuela, Paraguay and Brazil. You have to look to Peru, Bolivia and a few others to find a slight gender imbalance in favour of men. Of note is that the ratio of women to total students is higher among graduates than among enrolled students, suggesting a higher graduation rate for women than men.

Female enrollment has also increased gradually at the postgraduate level in almost all fields of study, on a par with the growing availability of courses in the region.

R&D OUTPUT

If scientific productivity in terms of research papers has experienced remarkable growth in the past decade, both quantitatively and qualitatively, the transfer of this knowledge to the productive sectors has made little progress. There is a lack of dynamism in the region when it comes to patenting, suggesting that Latin American countries (led by Brazil) are far more present in the ‘science mainstream’ but unable to translate this into innovation.

Trends in scientific papers

The number of papers by Latin American authors listed in Thomson Reuters’ Science Citation Index (SCI) more than doubled between 1997 and 2007. Although this indicator is controversial for some disciplines, it nevertheless illustrates a substantial increase in the quality of science in Latin American countries.

The share of Latin American scientists in the SCI grew steadily between 1997 and 2007, from 2.3% to 3.4%. Sustained steady growth relies on the performance of the most dynamic Latin American countries, particularly Brazil, which went from accounting for 41% of Latin American papers in 1997 to 47% in 2007. All countries experienced growth, albeit to a lesser degree in most cases. One exception is Peru, where the number of scientific papers tripled between 1997 and 2007. Interestingly, Mexico, with output similar to that of Argentina, has surpassed the latter ever since Argentina’s economic crisis in 2002 (Figure 10).

In other databases, a similar phenomenon can be observed and, in some cases, the progression is even steeper. In PASCAL, a multidisciplinary database created in France by the Institute for Scientific and Technical Information of the National Centre for Scientific Research, the Latin American share nearly doubled between 1997 and 2007 from 2.2% to 3.8%. In the database of the Commonwealth Agricultural Bureaux (CAB), the Latin American share was even greater but growth was smaller: from 5.4% in 1997 to 7.8% in 2007. In the Chemical Abstracts database (CA), the share was smaller but did increase from 1.5% to 2.0%. Databases in biology (BIOSS), medicine (MEDLINE), engineering (COMPENDEX) and physics (INSPEC) followed the same general trend (Figure 11).

It is worth pointing out that Argentina, Chile and Venezuela share a common pattern of growing output in papers involving international collaboration, with the flipside being a falling number of non-collaborative papers. On the other hand, the ratio of published collaborative papers to non-collaborative papers for Brazil and Mexico, the countries with the greatest output in Latin America, has remained unchanged.

Trends in patents

The number of patents is one of the indicators used to measure the efficiency of R&D systems in exploiting knowledge in the economic sphere. This indicator is less relevant for Latin America than for more industrialized countries insofar as both the economic structure and legal frameworks discourage patenting in most Latin American countries. However, an analysis of patent data helps to understand the technological situation in the region and confirms the initial diagnosis that research in Latin America is conducted primarily in academic settings with extremely weak ties to industry.

The number of resident patent applications in Latin America grew by more than one-third over the period 1997–2007. The number of non-resident patent
UNESCO SCIENCE REPORT 2010

Figure 10: Scientific publications in Latin America, 1996–2007

Share of papers for top 4 Latin American countries

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<td>Chile</td>
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Share of papers for middle 6 Latin American countries

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<td>Cuba</td>
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Source: RICYT
Latin America

applications grew even faster, by almost 60%. By 2007, non-resident patent applications were three or four times more common than those filed by residents: of 63,000 patents filed in 2007, just 21% were filed by residents (Figures 12 and 13). This distribution is in marked contrast to the figures for industrialized countries.

International patent databases provide a measure of protected inventions in the main markets around the world: the European Patent Office (EPO), the United States Patents and Trademark Office (USPTO) and the Patent Co-operation Treaty (PCT) database of the World Intellectual Property Organization (WIPO). The USPTO database is a very important indicator of technological development around the world. Over 180,000 patents are granted each year in the USA to holders from all countries. In the 2000–2007 period, the four Latin American countries with the greatest presence totalled 1,591 patents, 43% of which belonged to Brazil. The EPO database, which registers over 55,000 patents a year, included 222 patents from the most dynamic Latin American countries, 138 of

Figure 11: Latin America’s presence in various bibliographic databases, 1997 and 2007

Figure 12: Evolution in patent applications in Latin America, 1997–2007
which were granted to Brazilian patent-holders. The last database is that of the PCT treaty, administered by WIPO. This database contains a total of 3,824 records from the top four Latin American countries, 62% of which are accounted for by Brazilian authors (Figure 14).

Various diagnostic studies and S&T policy documents elaborated by experts and governments in the region show that S&T systems in Latin America are characterized, with some exceptions and nuances, by a lack of strong links and poor co-ordination between the public R&D sector – encompassing universities mainly – and the business sector.

The policies implemented show that the question of stimulating co-operation between the public and private sectors has been a fairly recent concern. This concern has translated into the creation of instruments to promote public-private sector co-operation in R&D and innovation. In this area, Chile, for instance, has chosen innovative formats (Box 3). The creation of centres of excellence and sectoral clusters comprising both public and private institutions and the promotion of business incubators and technology parks are also part of this experiment to dynamize links between the private and public sectors. Most countries have put in place technology transfer and dissemination policies, as well as programmes for the development of technology infrastructure and access to new technologies. Technological development and extension centres have become widespread in the region.

NEW R&D PRIORITIES

R&D priority-setting in the region via related policies has undergone different stages. Initially, the criteria for resource allocation were exclusively oriented towards excellence, in keeping with the guidelines for basic research. During the years when emphasis was placed...
Latin America

Priorities were established around productive sectors and public administration. Currently, in line with the new institutional orientations mentioned above, issues related to innovation and the generation of a competitive advantage have made their way onto the agenda. Countries with greater relative development have incorporated priorities in those S&T fields with the greatest potential, such as biotechnology, nanotechnology and information technologies. In parallel, several countries have developed medium- and long-term strategic plans.

There is an array of different instruments in Mexico for promoting S&T. These policy tools have three main thrusts: training of scientists and engineers, scientific research, and innovation and technological development. The first of these thrusts includes several postgraduate scholarships, as well as employment services and instruments for co-operation. The second thrust includes specific instruments for supporting basic and applied research as well as incentive measures for the repatriation of researchers residing abroad. Last but not least, the area related to innovation and technological development provides businesses with tax incentives, programmes offering researchers sabbatical stays in the industrial sector and mechanisms designed to foster innovation networks.

In Argentina, the Medium-Term Strategic Plan (2005–2015) has been designed to address challenges related to innovation and social development. The Plan establishes four strategic goals to guide the medium- and long-term development of S&T. The first goal has a social dimension and relates to improving quality of life and social development. The second goal addresses the responsible exploitation of natural resources and environmental protection. The third goal relates to strengthening innovation in industry and agricultural production, particularly in the most advanced fields, those that nurture the development of a knowledge economy and society. The fourth goal sets out to strengthen Argentina’s S&T capabilities and develop its support infrastructure.

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**Figure 14:** Patents held by Latin Americans in international databases, 2000–2007

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Source: Prepared by CAICYT (CONICET)
Nanotechnology

Nanotechnology is witnessing rapid development worldwide, as reflected in the number of scientific publications and patents: around the world, the number of scientific articles on nanotechnology and nanosciences listed by the SCI doubled between 2000 and 2006 and the number of patents granted through the PCT increased by more than 30%. Latin America has followed the global trend: its publications on nanotechnology grew by 95% between 2000 and 2006. Several countries in the region are striving to seize the opportunities offered by this field.

As in other fields, Brazil is the most prominent country for nanotechnology: in 2006, it ranked 18th in the world for publications related to nanotechnology, with 827 articles indexed by the SCI. Mexico came second with 376 articles (26%) and Argentina third (37%) with 320. Trailing these countries, we find Chile (with 104 publications), Colombia (60) and Cuba (45). Taking into account that, in 2006, 49,433 articles on nanotechnology were indexed by the SCI, the total output of these six countries amounts to 3.3% of the total. This percentage share tallies with Latin America's average contribution to the large databases on exact and natural sciences. However, this number greatly exceeds the region's average contribution to the fields of physics, chemistry and technology.

Nanotechnology tends to give rise to collaboration. An analysis of the publications produced jointly by Latin American and non-Latin American authors shows strong co-operation between the USA and Brazil, through which other Latin American countries such as Colombia and Cuba are participating in the global network.

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Box 3: R&D technology business consortia in Chile

Consortia are instruments designed to strengthen the relationship between science and the users of scientific advances in the public and private sectors at national and international levels, with a view to creating new business opportunities and boosting competition. A technology consortium is an association of business entities and academic, scientific and technological institutions formed to undertake joint development of a research, development and innovation programme. This instrument seeks to make a significant impact through the adoption, transfer and commercialization of research results.

The consortia in Chile were created in 2006 to develop cutting-edge S&T research through public–private partnerships. The aim is to apply knowledge to industry, with a view to bringing together the different links in a given production chain. These mechanisms have been designed to enable productive companies, universities and other technological entities to form alliances to solve production challenges, have a bearing on competitiveness and, in the process, develop new products, patent any breakthroughs and commercialize them.

These consortia receive support from three quarters: the Bicentennial Science and Technology Programme of the National Commission on Scientific and Technological Research (CONICYT), the INNOVA Chile programme of the Production Development Corporation (CORFO) and the Fundación FIA (Foundation for Agricultural Innovation) of the Ministry of Agriculture. The consortia receive considerable financial support of around US$ 34.5 million in public funds, in order to implement initiatives over a maximum period of five years.

Turning to the private sector, the idea here is to mobilize much larger sums of money from the participating companies and technological entities. Each initiative has to take the form of a business entity, the specialization of which will ensure excellence in research and the application of the results to the productive sector via the adoption, transfer, commercialization and dissemination of research findings, as well as training and inclusion of highly qualified personnel in areas of crucial importance for both Chilean industry and the regions. The first technology consortia are focusing on fruit farming, the dairy and wine industries, forestry, health research, aeronautics and the development of by-products from waste generated by export industries.

Source: authors

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Latin America

Mexico likewise has direct ties with the USA. Spain, meanwhile, serves as a rallying point to the global network for countries such as Argentina, Chile, Uruguay and Venezuela.

The region’s weakness in terms of productivity becomes apparent when we examine the number of patents filed in the PCT database. This database lists 43,887 nanotechnology patents granted between 2003 and 2006, out of which only 100 (0.22% of the total) are held by Latin Americans. In this context, Brazil is, once again, the leading country insofar as it holds 45 of the 100 patents, followed by Mexico with 20, Argentina with 11 and Chile with 9. The remainder of the patents belong to Cuba, Honduras, Panama and Uruguay. Of note is that, in 2006, Brazil doubled the number of patents it had held in 2003.

The region’s showing improves slightly when it comes to inventors: according to the PCT database, 277 patents (0.51% of the total) belonged to a Latin American inventor for the period 2003–2006. Once again, first place goes to Brazil, with 84 patents. Argentina ranks second, with 46 patents, followed by Mexico, with 41. Chile trails this group with 18 patents and Colombia with 13 – reflecting the fact that Colombian investors participated in developing patents even though the country does not own any. There were ten other Latin American countries where local investors owned patents.

Going against the global trend, the specialization of Latin Americans in the field of nanomedicine and nanobiology (BIO) is remarkable and has earned them third place in the world. This field represents 82% of the patents granted to Argentina, 69% of Brazilian patents and 45% of Mexican patents.

In conclusion, there are encouraging indicators for nanotechnology in Latin America, in spite of the fact that the region is going through an incipient stage of development in this field. Both the number of articles published in scientific journals and the volume of patents have grown in recent years. However, the region’s percentage share for both articles and patents related to nanotechnology remains low. In this field, the productive structure would seem to be lagging behind the academic capacity. In this regard, Latin Americans conducting R&D on nanosciences and nanotechnology – two fields which are increasingly being integrated into international networks – represent a reservoir of capacity.

Biotechnology

The region’s capabilities in biotechnology are, to a large extent, derived from its historical S&T development. There are various institutions and groups in Latin America with a long-standing tradition in agricultural research and biology, among other areas related to biotechnology research. Brazil, Argentina and Mexico stand out in this field. Among the leading groups in Brazil are those based at the University of São Paulo, the Fiocruz Foundation and the University of Campinas. In Argentina, the University of Buenos Aires, the Institute of Biology and Experimental Medicine (IBYME) and the National University of La Plata occupy a prominent place. The National Autonomous University of Mexico (UNAM) is also of international repute.

Latin America provides 3% of the 365,783 documents on biotechnology available in the SCI for the period 2000–2007. Within Latin America, MERCOSUR countries (see page 96) account for 65% of publications, or 2% of the world total. Brazil’s leadership in this field is unrivalled; the country accounts for 76% of articles produced by MERCOSUR countries and 49% of articles for Latin America as a whole. Brazil’s growth in recent years largely exceeds that of its regional peers. The trend has even accelerated: in 2000, Brazil increased its productivity by a factor of 2.5 over its immediate rival in biotechnology, Mexico; in 2007, Brazil’s productivity grew by a factor of 3.3. If we contain the analysis to the MERCOSUR countries, the picture is similar: whereas, in 2000, Brazil produced twice as many articles as its immediate rival in the trade bloc, Argentina, in 2007 it produced four times as many. Even though Mexico and Argentina have shown very similar production rates and growth patterns over the same period, Mexico has experienced slightly higher growth than Argentina since 2002.

This bibliographical analysis reveals that Latin American countries tend to build relationships with the leading countries in this field. This is hardly surprising, considering the degree of concentration in biotechnology worldwide: the USA, Japan, Germany, UK and France produced slightly more than 70% of all papers on biotechnology published in 2000–2007. As a result, Latin American countries have, for example, developed ties through joint publications with authors from countries beyond the region.
One-third (37%) of the papers written by Brazilians on biotechnology in the period under review were written in collaboration with scientists from other countries. Of the total, 83% is accounted for by five countries: almost half (47.6%) are publications in collaboration with the USA, while between 11.0% and 6.5% are produced in collaboration with France, the UK, Germany and Canada. Meanwhile, 48% of Argentina’s total production in this field results from collaborative work with other countries: the USA accounts for 34%, whereas Spain, Brazil, France and Germany account for between 17% and 10% each.

As regards patents, the WIPO database lists, through the PCT, 73,231 patent filings on biotechnology within the period 2000–2007. Two hundred and thirty patents are held by Latin Americans from 11 countries. Of these countries, only three owned patents for each year during the said period: Brazil (82), Cuba (55), a protectionist country in terms of inventions which fosters patenting over publication, and Mexico (51). Argentina held 15 patents throughout this period, showing significant growth over the last two years.
In sum, the region is brimming with opportunities to develop biotechnology. Several groups are currently working in this field, in tandem with groups which are world leaders. Several successful examples, such as the cloning of calves in Brazil and Argentina at the turn of the century, illustrate the region's potential in this field.

**Technological development**

Despite the fact that many of the plans drawn up by S&T agencies have not translated into effective improvements in productivity, many Latin American countries have succeeded in developing major technologies. This has been achieved either as a result of stakeholder interest or strategic decisions sustained by successive governments over time in the form of state policies. The most outstanding examples of stakeholder interest relate to technological capacities acquired initially to serve the military but which were subsequently adapted by economic interests for peaceful applications. Both the Brazilian aeronautics industry and Argentine nuclear technology are worthy of mention (Boxes 4 and 5). In the field of ICTs, Costa Rica’s policy has been exemplary (Box 6).

**Box 5: Argentina’s technological showcase: the case of INVAP**

INVAP is an enterprise that has excelled in the field of nuclear, space and industrial development over the past 30 years. It was founded in 1976 as a joint venture between the National Atomic Energy Commission and the government of the Province of Rio Negro. It is an exceptional case in the region, as it is a leading international supplier for the global nuclear and satellite technology market.

Run like a private enterprise, INVAP has attained a high level of sophistication in technological development equivalent to that of enterprises from most developed countries.

INVAP is also a shining example of co-ordination between the public and private sectors. Emerging initially as a spin-off of the Argentine National Commission for Atomic Energy, the enterprise is a reflection of a policy for training highly qualified personnel which has been sustained over time by the Rio Negro government. At the same time, INVAP is the living proof that a national technology producer can find a place in the global market.

Most notably in the field of nuclear energy, the firm has positioned itself as a supplier to various emerging economies, although sales to countries with greater relative development have also been recorded. INVAP did not take long to become an exporter of nuclear technology. By the early 1980s, it had sold equipment and systems to Romania, India and Peru. The most noteworthy exports in the enterprise’s history have been, however, those of research reactors.

INVAP has built this type of equipment in Peru (1978), Algeria (1988), Egypt (1995) and Australia (2000). Construction of the reactor in Peru constituted a strategic decision that would ultimately make Argentina an exporting country for this type of technology. This initial step enabled the enterprise to accumulate extensive skills that have favoured its growing integration in foreign markets, driven by an aggressive export policy that has been sustained ever since.

In parallel, the enterprise has developed capacities in nuclear medicine. INVAP develops and manufactures equipment and accessories for radiotherapy and related areas, in addition to offering consultancies and other services for the development and operation of radiotherapy. The enterprise has exported equipment to Venezuela, Syria, India, Egypt, Brazil and Cuba.

In a more recent development, INVAP has ventured into the construction of space satellites. In co-operation with the National Space Activities Commission (Comisión Nacional de Actividades Espaciales, CONAE), the enterprise has to date designed and built three Scientific Applications Satellites that are still in operation. The space agencies of the USA, France, Italy, Denmark and Brazil have all used these satellites to install their own apparatus and services, and other countries have expressed interest in adding their own. Thanks to this work, INVAP has become the pivot for co-ordination between Argentinian space and nuclear networks.

Source: authors
The Mercado Común del Sur, or MERCOSUR, groups five countries: Argentina, Brazil, Paraguay, Uruguay and Venezuela. At the time of its founding in 1991, there were only four members. They were joined by Venezuela in 2007. In 2005, the MERCOSUR adopted the Science, Technology and Innovation Framework Programme for 2006–2010, to promote the advancement of knowledge in strategic areas, including scientific knowledge of natural resources. This framework programme established four programmatic goals. The first relates to the strategic dimension of some research fields and includes STI activities to address adequately the challenges facing the region and its particularities. The issues to be considered in this area relate to advanced and alternative energy (hydrocarbons, hydraulic, nuclear and biomass energy), sustainable development (non-renewable natural resources, urban development, sanitation, etc.), ICTs, biotechnology, nanotechnology and new materials.

We can see from the foregoing that explicit R&D policies formulated by those Latin American countries with greater capacities in S&T have in common that they tend to be aligned on major world trends with economic goals, particularly investment in biotechnology and nanotechnology. They give little priority to social issues and emphasize some advanced fields, such as nanotechnology and biotechnology, in accordance with the economic relevance of both. However, it is worth questioning whether the magnitude of the effort being made will suffice to bring about major achievements. Some common activities, however, have been developed in biotechnology and information society technologies, with the financial support of the European Union.

Latin American countries have grasped the importance of internationalizing R&D. In many countries, programmes have been put in place to promote international co-operation in R&D as well as programmes for co-operation in specific areas, such as energy, biotechnology and ICTs.
Almost all Latin American countries are linked to one another through bilateral co-operation agreements which include horizontal co-operation mechanisms in S&T. One example is the Argentinian–Brazilian Biotechnology Centre (CABBIO), which dates from 1987. It co-ordinates a network of biotechnology research groups that implement binational projects. High-level training is also dispensed via the Argentinian–Brazilian Biotechnology School (EABBIO) run by CABBIO (UNESCO, 2010). The South American Programme for the Support of Co-operative Activities in Science and Technology (PROSUL) was created, at Brazil’s initiative, in 2001. The idea behind it was for a common platform to be established for regional initiatives supported by the programme. In future, the platform will favour the development of projects of common interest that could be submitted to national and multilateral fora dedicated to the promotion of R&D. (For details of other Brazilian initiatives, see page 117.)

Another experience worth mentioning is the Andrés Bello Agreement,4 the secretariat (SECAB) for which administers a forum for co-operation in STI. In the private sector, the impact of the Latin American Association of Technological Management (ALTEC) is noteworthy.5

International organizations have actively promoted co-operation in STI in Latin America, particularly UNESCO and the Organization of American States. Other international bodies have played a prominent role in their capacity as a factory of ideas for development strategies. These include the United Nations Industrial Development Organization (UNIDO), the United Nations Development Programme (UNDP), the Pan-American Health Organization (PAHO) and the United Nations Economic Commission for Latin America and the Caribbean (ECLAC). Last but not least, it is important to mention the pivotal role played by the InterAmerican Development Bank (IDB) in financing the development of R&D activities and infrastructure in the region. Over the past 20 years, the IDB has disbursed hundreds of billions of dollars in loans to several Latin American countries for the purpose of strengthening their S&T capacities. To a lesser extent, the World Bank has also contributed to the financing of S&T policy-making. It has also had an influence on the re-engineering or redesigning of institutions.

4. The member countries of the intergovernmental organization created in 1970 via this agreement are Bolivia, Colombia, Chile, Ecuador, Peru, Venezuela, Panama, Spain, Cuba, Paraguay, Mexico and the Dominican Republic.

5. SECAB was founded in 1978 and ALTEC in 1984.

Latin America's co-operation with the European Union in the field of STI has developed along two avenues since the Interregional Framework Co-operation Agreement between the European Community and Mercosur was signed in 1999: participation in the European Union’s six-year framework programmes for research and technological development, and co-operation specifically oriented towards specific issues defined by the European Commission. One example is BIOTECSUR, a biotechnology platform that is part of the Biotech MERCOSUR European Union project resulting from an agreement signed in November 2005 by the European Community and MERCOSUR (UNESCO, 2010). The homogeneity of the instruments implemented has gradually given rise to co-operation agreements involving several countries and, subsequently, to ‘block to block’ agreements like that entered into by the European Union and the MERCOSUR in 2010 for a political and trade association.

Currently, there is a slew of instruments available for Latin American co-operation in S&T, among which the Ibero-American Programme of Science and Technology for Development (CYTED) has occupied a prominent position since 1984. The purpose of CYTED is to promote a culture of co-operation as a strategic tool for improving and supplementing domestic capabilities, for internationalizing domestic innovation systems, contributing to institutional modernization and fostering the development of a Latin American scientific community.

The Organization of Ibero-American States,6 with its Science, Technology and Society programme, has also played a key role in orienting Latin American S&T towards the goals of social cohesion and citizen empowerment. More recently, The Latin American Knowledge Pool created in 2005 within the framework of the Latin American summits of heads of state and government, offers an opportunity to achieve this convergence and meet the challenges outlined above. In this context, new instruments are being defined. One example is the Centro de Altos Estudios Universitarios (Centre for Advanced University Studies), which aspires to foster the creation of postgraduate networks among Ibero-American universities.

6. See Annex I for the member countries of the Organization of Ibero-American States.
CONCLUSION

Latin American countries were inspired by the idea of using S&T as an instrument for development in the decades following the Second World War. They had made some remarkable achievements by the 1970s, only for these efforts to be frustrated in later decades by the rise of rigidly liberal policies. The desire to achieve development through S&T did, however, find a favourable terrain in the early years of the 21st century and these conditions prevailed until the current global economic recession. Between 2002 and 2008 when the recession hit, a prosperous cycle of the global economy had favoured a six-year expansion cycle in Latin America which was the region’s longest and greatest since 1980. This has placed Latin America in a stronger position to weather the storm than in earlier times of economic turbulence.

‘The current structural conditions are incomparably more favourable than those in previous decades,’ stated Viotti (2008) just before the onset of the global recession. Although he was referring to the Brazilian experience, the statement is valid for most Latin American countries. These conditions were:

- several years of stability, both in economic terms and in the democratic process;
- an expanding domestic market as a result of stability and recent social policies;
- energy demand that is under control in most Latin American countries. Such is the case of Bolivia with its large gas reserves, of Ecuador with its new oil reserves, and of Brazil, thanks to both the recent discovery of oil fields and ethanol. Brazil has become a leader in technology related to the production and use of ethanol in combustion engines, a technology that also contributes to reducing greenhouse gas emissions;
- a region that appears to be well-placed to benefit from growing global demand for commodities, particularly food, and from the resulting increase in the price of commodities.

Several Latin American countries have seized this opportunity to implement an array of policies to foster innovation and lay the groundwork for a new generation of development policies. This is particularly true of Brazil, Chile, Argentina and Mexico, as well as smaller countries such as Colombia, Costa Rica and Panama.

However, big hurdles remain. The global economic recession has generated an employment crisis that threatens to exacerbate poverty in the region. There is a predominant tension in the labour world between the demand for better wages and the demand for maintaining jobs, with each impinging on the other. The social crisis remains acute in the region. The International Monetary Fund estimates that poverty will grow by 15% in 2009. In this context, countries urgently need to expand their policies for social development, inclusion and citizenship. Institutions responsible for S&T policy have a role to play in this regard.

Some authors consider that Brazil has progressed over the past decade towards a more adequate institutional structure for fostering innovation, having drawn on the experiences of others (Arruda et al., 2006). In their opinion, Brazil now possesses a broad set of instruments similar to those available in developed countries. They admit, however, that there is room for improvement as far as the country’s legal framework is concerned, as gaps remain. It is true that Brazil has a panoply of new instruments inspired by international practices at its disposal, not to mention vast resources for supporting innovation and business R&D.

Most Latin American countries have gone down a similar path. As we have seen earlier, there are now about 30 different types of S&T policy instruments in the region. These instruments cover the full spectrum, ranging from support for basic research according to criteria for excellence to encouraging entrepreneurial innovation (Emiliozzi, 2009; Lemarchand, 2009). However, most of these sophisticated instruments will not suffice in and of themselves to reverse trends overnight. Despite all the advances in conceptual frameworks and the diversification of instruments, the constitution of national innovation systems remains incipient in every country of the region.

R&D and innovation policies were initially designed according to the science-push model, to later be dubbed the linear model. This model still predominates in Latin America, in spite of the aforementioned attempts by the most advanced countries in the region to instigate demand-pull and innovation policies. In the mid-1990s, Bell (1995) described this feature as the survival of conceptual frameworks dating from the 1960s to address the challenges of the 1990s. Today, this phenomenon persists even in those countries that tend to be the most
advanced for the adoption of innovation policies, such as Brazil or Chile. Viotti (2008) admits that, even in his own country, Brazil, the old culture still prevails, despite the new set of policy instruments. Consequently, businesses are reduced to playing the role of users or consumers of the knowledge produced by R&D institutions, even if this knowledge was created with no regard for the actual needs of users.

It is the academic sector which is the most dynamic actor in creating innovation systems in Latin America. Even the design of promotional policies for fostering innovation in the productive sector is the work of academics. Little progress has been made towards fixing an agenda for new industrial and technological policies. As a result, most Latin American countries share the common feature that local knowledge is underutilized by productive sectors that have little demand for it, resulting in a lack of articulation between the innovation process and academic knowledge. Indeed, in many cases, both sectors remain in ignorance of one another and are even reluctant to engage in joint activities of potential mutual benefit. The region demonstrates a paradox in that countries possess an acceptable scientific sector in various disciplinary fields which produces valuable knowledge that is potentially applicable to the productive sector, yet their economies demand very little local knowledge and are scarcely innovative. This is poles apart from what happens in other regions. It is even contrary to the path followed by Asian countries, whose economies have benefited from appropriating knowledge produced elsewhere to compensate for the lack of a well-developed academic sector of their own.

In addition to the lack of linkages between actors of the innovation system, with the exception of a handful of sectoral clusters, the institutional structure is precarious in Latin America. In some cases, there are heavy, inefficient bureaucracies. In Brazil, for instance, duties related to public policy management for industrial development and S&T have been delegated to non-governmental organizations; these have a complex institutional structure and lack the political, technical and operational capacity to exercise such duties effectively.

In conclusion, some of the problem areas of S&T policy pinpointed in reports are the following:

- There are difficulties in integrating and implementing the existing policy instruments.
- There is inadequate co-ordination, not only as far as the instruments themselves are concerned but also on the part of the institutions responsible for implementing them.
- The allocation of resources is fragmented and thus incapable of fostering critical changes in the innovation process.
- Investment in R&D remains very low. Even in those fields which demand advanced knowledge and skills, such as biotechnology and nanotechnology, greater resources are needed to achieve a critical mass.
- In a region with persistent social problems where much of the population is deprived of basic social benefits, it is often difficult to establish ties between S&T policies, on the one hand, and social policies, on the other. For instance, health-related R&D is often separated from general research policies. Moreover, there are conceptual difficulties in linking R&D policies with social inclusion policies.
- The problem of training and retaining a critical mass of highly skilled personnel is a growing concern for governments in the region. In order to address this issue, some governments have implemented policies to modernize the university system, combined with measures to staunch brain drain and take advantage of the human scientific capital scattered around the world.

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