Chapter 7

Strengthening innovation systems and technological development

Macroeconomic stabilization and liberalization have been perceived by most policy makers as a sufficient condition for the local acquisition and absorption of the benefits to be derived from liberalizing trade, investment and technology flows. Despite the success of a number of countries in some facets of macroeconomic stabilization, however, the shift in the incentive system that has occurred in the past two decades has not led to entirely satisfactory behaviours in terms of creating technological capabilities at the national level and reducing the productivity gap vis-à-vis the more highly developed countries. Moreover, the region has also been slow in developing its capacity to adopt and disseminate new technological paradigms such as information technology, biotechnology and genetic engineering. These outcomes can be understood by looking at the changes that have occurred in the innovation systems of Latin America and the Caribbean.

This chapter discusses these changes and considers the strategic challenges facing the countries of the region as they seek to achieve a sustained technological development process on which to base their systemic competitiveness and bring their production apparatuses into the digital era. The first section briefly outlines the conceptual framework of the analysis of technological development. The second summarizes the evolution and current configuration of national innovation systems in the region, with emphasis on the main changes produced by external openness and globalization, and looks at the countries' levels of expenditure on science and technology. The third section gives a panoramic view of the regional situation in terms of information and telecommunications technologies and the capabilities needed to computerize production activities and participate in global networks. The fourth section considers the regulatory framework for property rights at the regional and global levels and the options it offers for the development of local technological capabilities. The fifth section contains guidelines for active policies to strengthen innovation systems (at national but also local and regional levels) in the context of competitiveness and technological development strategies, to promote the incorporation of information technologies and to protect intellectual property rights in keeping with those strategies.

I. Innovation systems and technological development

Firms respond to signals from their environment when they acquire and adapt technology and improve it over time in order to enhance their technological capabilities and competitive advantages. Such decisions are influenced by the structure of incentives, factor and resource markets (skills, capital, technology, suppliers) and institutions (in the fields of education and training, technology, finance and so on) with which the firm interacts. Innovation is therefore an *interactive process*, which links agents that respond to market incentives, such as firms, to other institutions that operate on the basis of strategies and rules that are independent of market mechanisms. The combination of agents, institutions and rules on which the absorption of technology is based has been called an *innovation system* —generally a *national* innovation system— which determines the rate of generation, adaptation, acquisition and dissemination of technological know-how in all production activities (Nelson, 1988; ECLAC, 1996b).

According to this approach, the main components of a national innovation system operate and are linked at three different levels, each of which offers a different framework for formulating and promoting economic policies (Freeman, 1987; Nelson, 1993; Cimoli and Dosi, 1995). First, the firms and their production systems are crucial (although not exclusive) recipients of know-how, which in large part is absorbed into operational routines and modified over time on the basis of rules of conduct and higher-level strategies (research activities, decisions on vertical integration and horizontal diversification, etc.). Secondly, the firms themselves become linked through networks with other firms and with non-profit institutions, government agencies, universities and organizations devoted to promoting production activities. These networks and policies, whose purpose is to improve the environment for carrying out scientific and technological activities, play a fundamental role in firms by strengthening or restricting opportunities for enhancing their technological capabilities. Lastly, at the broader national level, modes of behaviour at the microeconomic level form networks where a combination of macroeconomic effects, social relations, rules and political constraints is produced.

The generation and absorption of technology —and the consequent achievement and improvement of international competitiveness— are thus *systemic processes*, since the performance of the innovation system depends on a set of synergies and externalities of various kinds whose scope goes beyond business enterprises' profit-maximization responses to changes in incentives. In this view, technological opportunities and obstacles, together with the experiences and skills acquired by the various agents of the innovation system, which flow through the system from one economic activity to another, establish a specific context for each country or region. This means that any given set of economic incentives generates different stimuli for, and constraints on, innovation. In cases where there is a significant divergence between economic incentives and the stimulus to innovation represented by externalities, a firm's price-based allocation of resources to innovation will be suboptimal.

Ultimately, firms respond appropriately to the challenges of competitiveness if they operate in efficient markets and have well-established linkages to dynamic networks with strong institutions. In developing countries, in addition to the imperfect information and externalities that impede an appropriate response to these challenges, many business-related markets and institutions are deficient or non-existent. Both suppliers and basic service firms may be influenced by factors that lead to a shortage of technological capabilities and a lack of competitiveness.

In the field of scientific and technological knowledge, problems of uncertainty and imperfections in the price system prevent market mechanisms from operating well enough to assure a socially optimal allocation of resources for the generation and dissemination of this scarce good. This is precisely why the developed countries have adopted a proactive attitude in this area that has led them to facilitate the private patentability of government-sponsored university research, subsidize basic and applied research programmes in fields such as information and communications technologies (ICT) or the human genome, channel government procurement towards technologically dynamic firms, etc.

The history of today's developed world shows that in many fields of productive activity it has been the public sector that initially took the lead by promoting the development of a basic and applied research activity and building up a long list of institutions whose mandate is to stimulate the technological behaviour of the private sector. This has clearly worked in the cases of agriculture, atomic energy and telecommunications (leading to the development of the Internet), the broad spectrum of health disciplines (including the recent development of the human genome), the defence industries and many others. This is happening, moreover, in areas that are highly sensitive to international competitiveness, in which the governments of developed countries are especially eager to build an institutional base and national technological capabilities on which the private sector can then consolidate its internationally competitive position.

In Latin America and the Caribbean, the transition towards more open, deregulated and privatized economies has entailed a profound transformation of the innovation systems established in the State-led growth phase. Many recent studies reveal that the shortage of public resources and institutions capable of promoting the creation of dynamic, knowledge-based comparative advantages is one of the factors that explains why the region's innovation systems have not facilitated the accumulation and diffusion of technological capabilities. This transition process has inhibited interaction between the three above-mentioned components and, hence, national technological capabilities. Activities to promote the development of national networks have not had enough support in terms of linkages between the different agents of the innovation system. In other words, the production system has modernized a small part of the economy, owing to the effects of greater openness, but this has not been accompanied by a sufficient effort to stimulate the creation of national networks, such as a system of linkages with knowledge-producing and knowledge-diffusing institutions operating outside the market, i.e., an entrepreneurial culture and institutions that would help businesses interact with one another.

II. The evolution of innovation systems

1. Innovation systems in the State-led industrialization phase

During the State-led industrialization phase, a vast universe of public goods- and services-producing research and development (R&D) enterprises and institutes arose and spread throughout the region. In the great majority of countries, the public sector undertook to provide telecommunications, energy and transport services, among others, while it developed and expanded public education and health systems. This process created an enormous range of R&D institutes and laboratories, which were provided with equipment, skilled personnel and budgets to support the tasks directly related to the production of goods and services. Public development banks also helped in the work of expanding the production and technology infrastructure. In general, it can be said that during this period a widespread and sustained institutional "supply" model prevailed (Katz, 1987).

Many studies document the important technological role played by the public sector during these years in various countries, as it helped create technological infrastructure, train human resources, perform technological outreach work in the agricultural sector. All these efforts contributed to the development of a highly idiosyncratic technological and innovative culture. Far from portraying a failure, many studies show that these projects often led to successful production and technology programmes and to significant modernization of the national production apparatus (Katz, 1987; Stumpo, 1998). Industrial exports increased —often reflecting improvements in locally invented products and processes— as did technology transfer among the countries of the region.

Within this environment, the production system developed its technological capabilities and forms of behaviour depending on the type of firm and the origin of the capital involved. One type of technological behaviour can be seen in the core group of national enterprises, which fall into one of two very distinct subgroups: locally financed small and medium-sized enterprises; and large national conglomerates. The technological behaviour of foreign enterprises, for their part, continued to be dictated by the strategies and capabilities of their parent companies. We shall consider each case separately.

As far back as the 1930s (and in some countries earlier), with the help of tariff protection and the support of development banks, a large number of small and medium-sized local enterprises —many owned and run by families— that produced food, textiles and clothing, shoes, furniture, printed matter, tools and agro-food industrial machinery, among others, arose and flourished in Latin America. Even though they entered the industrial world with manufacturing plants that were little more than improvised craft shops and that were frequently equipped with second-hand or home-made machinery, and despite their low level of technical and production know-how, in time many of these enterprises became leaders in successful growth experiences. They set up their own technical teams, developed innovative product designs and production proccesses, trained their workers and advanced along a highly idiosyncratic, long-term learning curve. In this case, the creation of product and process technologies was undertaken without prior outside support, other than the ability to copy technology and the technical training that many immigrant entrepreneurs brought with them from their countries of origin.

The large public firms and locally-owned private conglomerates, which normally devoted themselves to the manufacture of consumer and intermediate goods or to the provision of services (energy, telecommunications) displayed a different model of technological behaviour. These firms developed their production and technological capabilities in those sectors that were considered strategic for the industrialization policy at the time. The development of technological capabilities was more prominent and included everything from advances in the building and operation of new factories to the establishment of engineering departments and project offices that could design and optimize the use of production facilities. In many cases, these advances were promoted by public institutes, which took charge of many of the necessary tasks. Thus, for example, in the energy and telecommunications sector, State enterprises and research institutes were set up and provided with abundant financial resources.

On the other hand, from the very beginning foreign capital in Latin America functioned as the engine for growth in knowledge-intensive branches such as automobiles, pharmaceutical raw materials, petrochemicals, production equipment and machinery. Rather than considering the possibility of following a development strategy based on local capital and technology, the first steps towards industrialization in these fields focused on finding foreign enterprises to develop these production sectors and to provide the necessary capital and technology. This meant that, from the beginning, producers took foreign product designs, process technologies and production organization routines and adapted them to local conditions rather than designing local models. The presence of these enterprises produced significant externalities. Indeed, capital goods and the flow of engineering, managerial and marketing knowledge from foreign enterprises deeply affected the industrial culture of the era, introducing working habits, labour rules and practices, quality control standards and forms of subcontracting that were often unknown in the local environment (Katz and Ablin, 1978).

In spite of the above and of the many cases where the public sector's technological effor successful sectoral development programmes, from a broader perspective the national innovation systems in those years did not, as a whole, become real engines of growth due to their fragmentary nature and lack of depth. Indeed, although these engineering efforts certainly made it possible to open up and develop a great many new industrial sectors and new factories that could not only replace imports but also produce exports, and while it is also true that many enterprises were able to advance along their learning curve, it must be pointed out that only occasionally were innovative products and processes created on a worlwide scale.

2. Changes in innovation systems brought about by external openness and globalization

Over the course of the past two decades, deep-seated changes in the region's innovation systems have been consolidated (Cimoli and Katz, 2001). These changes are attributable not only to inertial phenomena left over from the State-led development stage but also to more recent causal factors: on the one hand, the pro-competitive structural reforms of recent decades and, on the other, the growing globalization of production processes in which the world economy is involved.

According to recent ECLAC studies, structural reforms led to the restructuring of the region's production apparatus in a way that oriented it, on the one hand, towards non-tradable goods and services and, on the other, towards static comparative advantages (the production of raw materials and industrial processing of natural resources in the Southern Cone countries, and unskilled, labour-intensive *maquila* industries in Mexico and a number of smaller Central American and Caribbean countries). This process failed to create dynamic, knowledge-based comparative advantages that would increase the value added of exports and improve the position of the region's enterprises in world markets (ECLAC, 2001a; Reinhardt and Peres, 2000; Mortimore and Peres, 2001).

Globalization has also helped to transform innovation systems. On the one hand, globalization has led to profound changes in consumption patterns. While it has levelled out differences in taste and reduced selectivity by homogenizing consumers on the basis of internationally recognized brand names, it has also enhanced the value of ethnic, small-scale and handicraft products. On the supply side, the innovation systems of the countries of the region have shifted, tending to become more internationalized owing to greater integration into internationally integrated production systems (IPS), which are managed at the global level by transnational corporations. Organizing production and consumption on a global scale means making the most of economies of scale, capturing the advantages of specialization and making use of opportunities for rationalizing costs. Moreover, it means thinking of consumers as a homogeneous group of people who, regardless of their culture or specific circumstances, exhibit similar preference functions.

The development of these organizational models for production entails a necessary reduction in the degree of independence and vertical integration of each member of the IPS, given the fact that all must operate on the basis of a homogeneous product and production routine, adhere to uniform specifications and use parts, intermediate components and inputs acquired anywhere in the world. Otherwise, there would no longer be any possibility of trading intermediate inputs in real time with the other members of the network, and economies of specialization would decrease. Accordingly, there has been an increase in the acquisition of international licences and better access to foreign product designs and process technologies, encouraged by the rise in the number of firms operating on-line with their head offices or licensing firms abroad. All this has consolidated new organizational models for production, while at the same time radically modifying the paradigm for technological accumulation processes and relations between actors within innovation systems (Cimoli and Katz, 2001; Katz and Stumpo, 2001).

Since planning and organizing production and consumption on a global scale entails operating in a number of different locations, it is clear that the institutional framework —patent rights, tax or customs legislation, environmental regulations, etc.— must not differ too much from one country to another; this helps a global entrepreneur to feel more comfortable in choosing a location for the various segments of the production system. In other words, the model entails endogenous pressure towards institutional homogenization, although this does not necessarily have to be compatible with the national interest of each country belonging to a given IPS. Examples abound, and the growing pressure being exerted on developing countries by developed countries to "level the playing field" —i.e., eliminate national idiosyncrasies in order to pave the way for a more uniform, transnationalized production structure— is clear evidence that globalization leaves national governments with fewer degrees of freedom. This does not mean, however, that these degrees of freedom have disappeared altogether; indeed, the new rules of the game appear to consist in knowing how to identify and take advantage of them.

As part of this process, national legislation has been converging towards intellectual property laws similar to those of the developed countries, which protect intellectual rights over software and regulate the national use of trademarks, domain names, geographical indications, etc. This involves a gradual process of institutional standardization, which has been accelerating in recent years as a result of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) of the Uruguay Round of trade negotiations.

The performance of innovation systems is directly related to the production structure and the firms and public institutions that constitute it. Four patterns of behaviour are associated with the transformation and new pattern of acquisition of technological and innovative capabilities that today characterizes the production system and its enterprises (Cimoli and Katz, 2001).

The first pattern involves a *simultaneous process of modernization and inhibition of national capacities*. Owing to the globalization of production and greater integration with an international IPS, many local subsidiaries of transnational corporations (TNCs) have narrowed their product mix, specializing in one (or a few) products out of the range produced by the corporation at the global level and, at the same time, importing the remaining items from that product range. On the other hand, the incorporation of computer-based equipment and machinery and the transition to digital forms of labour organization have accelerated integration into global IPSs. This ultimately influences the nature of production processes, which today have less down time, shorter lead times between design and manufacture, and lower defect and rework rates. In other words, productivity has risen not only because of the increase in the capital/labour ratio but also because of the gradual introduction of a more highly sophisticated generation of machinery and equipment that necessarily involves more efficient styles of labour organization.

The decline in the prices of imported capital goods brought about by trade liberalization encourages the replacement of local machinery, equipment and skilled labour. On the one hand, this tends to increase the capital-intensiveness of the various production sectors. On the other, as imported equipment becomes less expensive than locally-produced equipment, the latter is replaced, and the local capital goods industry's market share shrinks. Finally, since the new machinery incorporates operational capabilities previously provided by skilled workers and engineers, the demand for this type of worker declines.

The great advantage of the IPS is therefore that it captures the benefits of economies of scale, but its cost for the countries of the region derives from the abandonment of the local adaptation of products and processes in favour of the "commoditizing" of goods and services. There is thus a significant reduction in the development of national technological capabilities derived from the reduction of these adaptive efforts. Recalling that these efforts were an important part of the technological behaviour model during the State-led growth stage, it is clear that the transition to the IPS world entails a major change in the structure and behaviour of Latin American innovation systems. Linkage with other countries deepens and becomes a determining factor of a firm's behaviour, but this could well be happening at the expense of the inhibition of national technological capabilities or even a decline in the density of network of domestic linkages.

The second pattern is the *marginalization and destruction of national production chains.* While advances in the internationalization of processes are taking place, another part of the production apparatus is being increasingly marginalized from the new industrial organization model now being consolidated. Thus, major pre-existing production chains are being disrupted, and national producers —in many cases small and medium-sized enterprises— have lost access to markets as their products are replaced by imported substitutes. A similar process has occurred in the area of technical services for production (typically technological know-how for improving and adapting products and processes), which can be obtained more frequently on-line and in real time from abroad. This marginalization has been compounded by old and new problems of access to factor markets (cost of long-term capital and asymmetries in access to technological knowledge or land), which has had a significantly greater impact on small and medium-sized family-owned and run firms than on large local or foreign firms.

The third behavioural pattern that has been emerging is *uneven specialization in the production of knowledge*. Although there are sharp differences across countries in terms of the new specialization pattern and the way in which, in each case, firms and industries have been absorbing new sectoral technological and competitive regimes, a common feature in the region is that enterprises have tended to specialize in relatively less technology-intensive production activities and processes. The region is rich in natural resources and in unskilled and semi-skilled labour, but it is rather poor in its capacity to create, adapt, disseminate and use new technologies. Many firms participate in the manufacture of industrial commodities, i.e., highly standardized products in which only limited domestic technology efforts are carried out. Moreover, unlike the major producers of industrial commodities, such as paper and pulp in the case of Sweden or Finland, or minerals in the case of Canada or Australia, the major Latin American conglomerates that produce these goods have made little effort to move towards patterns of specialization involving a greater technological content. Nor have they managed to achieve a greater degree of vertical integration involving the manufacture of relatively high-technology intermediate machinery and equipment or inputs. Instead, these entrepreneurial groups have opted to remain at the low end of the natural resource-processing value chain without attempting any greater technological deepening. One consequence of this is that they have made little or no use of biotechnologies in fields such as forestry or food production. Nor have they involved themselves in new disciplines in such fields as mineralogy, aquaculture or others associated with the sustainable exploitation of their natural resource base. In other words, they have chosen to tap the available natural resources, without subsequently moving towards the acquisition of knowledge rents or committing significant amounts of resources to technological deepening.

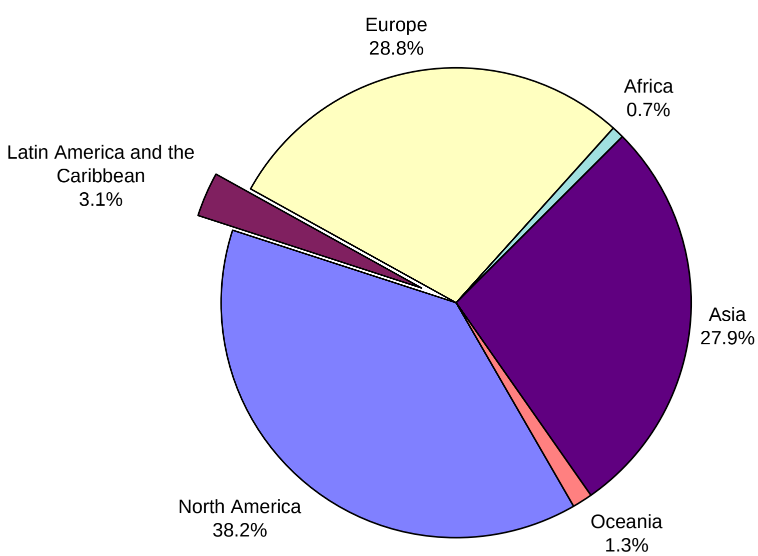
The fourth behavioural pattern is *the transfer of some pre-existing R&D activities out of the region.* Many foreign-based enterprises that have recently established operations in the region, through the purchase of a pre-existing local plant, have chosen to cut back or simply discontinue, national R&D efforts and the project offices that local firms had set up to support their production and investment activities in previous decades.

The transition to an international IPS has led to the outward transfer of engineering and R&D activities previously carried out by local firms. These firms had tended to specialize in the simplest segment of the global production process, which generally involved assembly work (*maquila* activities) or the first stages of natural resource processing, while leaving both product design and the search for new production processes in the hands of the parent company. At the same time, the privatization of State utilities has led to the closing of technical departments and the reduction of expenditure on local engineering activities in fields such as energy, telecommunications or transport. The new foreign operators involved in these sectors are bringing new product, process and labour organization technologies into the region from their respective parent companies and their international suppliers of intermediate inputs and production services. Although the service structure is being rapidly modernized in these cases, this process is, paradoxically, making much less use of local engineering services and local R&D activities.

3. Science and technology expenditure

In general, expenditure on science and technology (S&T) in Latin America is very low. The countries of the region spend only 3.1% of the world total on this item (see figure 7.1).

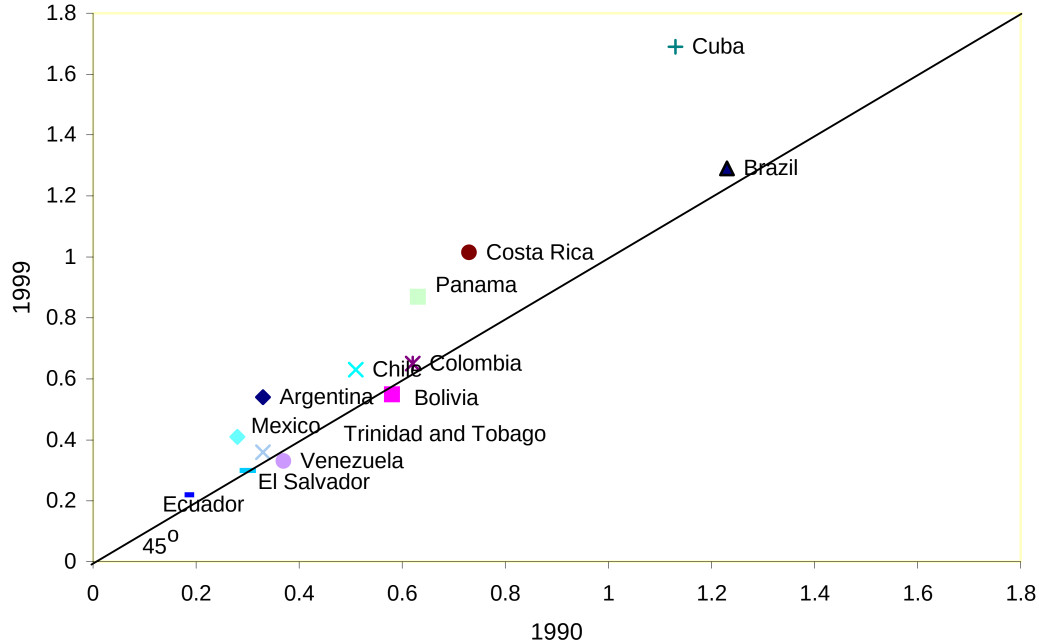
Figure 7.1
WORLD INVESTMENT IN RESEARCH AND DEVELOPMENT, 1996-1997
(*Percentages*)



Source: UNESCO Institute for Statistics (UIS), *The State of Science and Technology in the World 1996-1997*, Montreal, Quebec, 2001.

During the long period when the State-led industrialization strategy prevailed, S&T expenditure —even in the large countries of the region— in no case exceeded half a percentage point of GDP, with the bulk of this being spent by State enterprises and public sector-institutes. In the 1990s, S&T expenditure by most countries of the region remained at approximately the same levels (see figure 7.2). The highest relative expenditure levels continue to be posted by Brazil, Costa Rica and Cuba. This stability of spending as a percentage of GDP clearly indicates that the allocation of resources for the creation of new technology is still not a high priority in the region.

Figure 7.2
LATIN AMERICA AND THE CARIBBEAN: EXPENDITURE ON SCIENCE AND TECHNOLOGY AS A PERCENTAGE OF GDP



Source: United Nations Educational, Scientific and Cultural Organization (UNESCO), Ibero-American Network of Science and Technology Indicators (RICYT) and ECLAC.

In Latin America and the Caribbean R&Dexpenditure is largely government-funded; the private sector finances only a third of total R&D activities (see table 7.1). This situation stands in contrast to that of the United States, where private enterprise finances 69% of R&D.

Table 7.1
LATIN AMERICA: EXPENDITURE ON RESEARCH AND DEVELOPMENT, BY FUNDING SECTOR, 1999 a/
(*Percentages*)

	Government	**Business**	**Other** b/
Argentina c/	40.40	26.00	33.60
Bolivia	24.00	20.00	56.00
Brazil	57.20	40.00	2.80
Chile	64.30	21.50	14.20
Colombia	70.00	13.00	17.00
Costa Rica	53.46	20.16	26.38
Cuba	58.80	41.20	
Ecuador	39.80	32.50	27.70
El Salvador	51.90	1.20	47.00
Mexico	71.10	16.90	12.00
Panama	44.60	0.70	54.70
Uruguay	9.40	35.60	55.00
Venezuela c/	31.50	44.80	23.70

Source: United Nations Educational, Scientific and Cultural Organization (UNESCO), Ibero-American Network of Science and Technology Indicators (RICYT) and ECLAC.

a/ Latest available year.
b/ Includes funding from higher education, private non-profit organizations and foreign sources.
c/ Data corresponding to funding for science and technology activities.

Latin American and Caribbean researchers represent between 3% and 7% of the world total, according to the standard sources and estimation method used for this purpose. Still, although the gap vis-à-vis the more industrialized countries remains large, the region has a considerable endowment of human resources. Among the Latin American and Caribbean countries, Argentina, Uruguay, Chile and Costa Rica have the highest ratios (more than one per 1000) of researchers to the economically active population (see table 7.2).

Table 7.2

LATIN AMERICA AND THE CARIBBEAN: NUMBER OF RESEARCHERS PER 1,000 MEMBERS OF ECONOMICALLY ACTIVE POPULATION

Country	**1999** a/
Argentina	2.57
Bolivia	0.38
Chile	1.35
Colombia	0.47
Cuba	1.2
Ecuador	0.31
El Salvador	0.2
Mexico	0.74
Nicaragua	0.29
Panama	0.78
Trinidad and Tobago	0.66
Uruguay	1.8
Venezuela	0.45

Source: United Nations Educational, Scientific and Cultural Organization (UNESCO), Ibero-American Network of Science and Technology Indicators (RICYT) and ECLAC.

a/ Most recent year available.

During the implementation of liberalization policies and strategies in the region, a steady increase over time in S&T spending as a proportion of GDP would have been advisable in order to bolster international competitiveness. In general, public policies kept a low profile during the reform period, however. This, combined with the region's low starting point in this respect, further weakened Latin American and Caribbean innovation systems in terms of knowledge production and diffusion. In addition to the fact that the production system had been encouraged to specialize and become part of the global production system in non-knowledge-intensive sectors, public policy perpetuated the structural weakness of most science and technology activities.

III. Information and communications technologies (ICTs)

1. The nature of changes generated by ICTs

The Latin American and Caribbean countries are gradually moving into the digital era. Digital production raises four different sets of issues. The first is that of infrastructure, which includes computers, telephone lines, fibre-optics networks, wireless telecommunication networks and any other physical components the industry needs to operate. The second is the software applications industry. Products and services traded in these markets are based on the informatics infrastructure and permit production and commercial activities to be carried out on-line. The third level is that of intermediaries, which enable agents to interact with one another and hold virtual meetings in the horizontal and vertical portals market. Finally, the fourth level is that of on-line transactions in the broad sense of the term, which includes e-commerce, e-health, e-government, etc. This is where effective use is made of digital interaction to conduct commercial, educational, health-care and other transactions.

The first level is a very dynamic global industry that embraces both the digital infrastructure needed for network integration and the production of computer and telecommunications equipment to operate within these networks. The installation of such infrastructure and the achievement of connectivity are essential steps for any country wishing to enter the digital era. On the other hand, local production of equipment is not a necessary condition and, in fact, international experience shows that it does not lead directly or automatically to the computerization of the national production apparatus, nor to a more intensive use of ICTs. Thus, there are countries such as the Republic of Korea that produce a significant amount of ICT equipment but are behind the times in terms of e-commerce, while others that have virtually no ICT production sector, such as Australia, are e-commerce pioneers (OECD, 2001b). Accordingly, even though —unlike a number of developing economies in East Asia— only a few Latin American and Caribbean countries have developed the capacity to produce parts and equipment, this does not hinder them from computerizing production activities or hooking up to global networks.

In general, the Latin American and Caribbean countries have increased their use of human resources and software to gain access to local and international networks. This process has accelerated in recent years for export-oriented firms that have joined a global IPS. Moreover, the restructuring of the region's production apparatus is paving the way for the emergence of a new set of local technological capabilities for the provision of production services —transport, marketing, packaging, etc.— and computer software and applications, in which many new small and medium-sized local enterprises are showing signs of development. In contrast, most of the more traditional small and medium-sized enterprises that produce for the domestic market are having tremendous difficulties in absorbing information technologies into their activities.

This process of modernizing production and adopting software began years back with the spread of CAD/CAM (computer-aided design/ computer-aided manufacture), which reduced both lead times and inventories in the manufacturing process. This was only the beginning of a long road towards the computerization of operational routines, which later included the dissemination of Enterprise Resource Planning (ERP), Supply Chain Management (SCM) and Customer Relationship Management (CRM). The incorporation of these systems, as a whole, involves the operation in real time of the entire value chain in which a firm operates, including not only its own internal processes but also those of its suppliers and customers. This has facilitated the spread of much more highly sophisticated production organization routines. These routines operate on the basis of a complex series of high-cost software, which limits their availability to small and medium-sized enterprises.[1]

This software is often produced within the firm itself by vertically integrated industrial organization departments. Lately, however, a dynamic application service providers (ASP) industry has arisen. This industry has been taking over the preparation and finalization of specific services of this type, which are subject to significant economies of scale.[2] The use of these new production technologies is inducing a profound change in the way work is organized and in firms' management and administrative principles, as well as giving rise to a local infant industry in this field.

1 The available information indicates that the operational software needed for the integrated application of ERP, SCM and CRM costs nearly US$ 1 million and requires at least a year to set up and learn to use.

2 Years ago, the choice facing firms was "develop or buy". Today, the choice of developing software seems justified only in the case of large enterprises or in those with very specific functional requirements which cannot find adequate solutions in the market (see Novis, 2001).

2. The progress of connectivity in the region

All the major Latin American and Caribbean countries began the year 1998 with less than 1% of their population connected to the Internet. Since then, Internet use has increased tremendously, turning the region into the fastest-growing Internet community in the world. Although connectivity is still low in some countries of the region, it is expanding rapidly. In the region as a whole, 84% of the existing telecommunications infrastructure is digital and almost all of it is automated. The fastest-growing network is mobile telephony, with 70 million cellular phone subscribers as of the first four months of 2001. Together with the development of infrastructure, the use of the Internet has been expanding rapidly, although it is still at an early stage. For example, less than one fifth of the agents in the region with Internet connections engage in e-commerce. Moreover, although some countries of the region, such as Chile and Brazil, have started using the Internet as a means of interacting with the public and providing services (telephone service, banking or government offices), and this practice is expanding to other countries, there is still a great deal of scope for progress in this and other areas (Hilbert, 2001).

Table 7.3 shows the speed at which this dimension of technological progress is evolving in the world. In 67 countries for which comparable data are available, the median number of Internet hosts rose from 0.3 per 10,000 inhabitants in 1995 to 7.2 in 2000, and the average went from 3.6 per 10,000 inhabitants to 30.4. There was also less dispersion across countries, which means that the countries that were further behind made a great effort to close the gap during that period. As a whole, Latin America and the Caribbean took a giant step forward. Indeed, in 1995, only three countries (Chile, Costa Rica and Panama) showed a greater degree of connectivity than expected, based on their per capita GDP. Five years later, nine countries (Argentina, Belize, Brazil, Chile, Costa Rica, Colombia, Mexico, Trinidad and Tobago, and Uruguay) did so (see figures 7.3a and 7.3b).

Table 7.3 also illustrates trends in connectivity gaps between different groups of countries. Taking the most technologically advanced countries as the basis for comparison, 17 Latin American and Caribbean countries narrowed this gap; this can be seen more clearly in the mean ratios (from 1.6 to 4.4) than in the index based on the median number of Internet hosts per 10,000 inhabitants. It is noteworthy, however, that, far from widening, the digital divide between the region and the leading countries narrowed for middle- and high-connectivity countries and remained virtually stable for the seven Latin American countries with a lower level of connectivity.

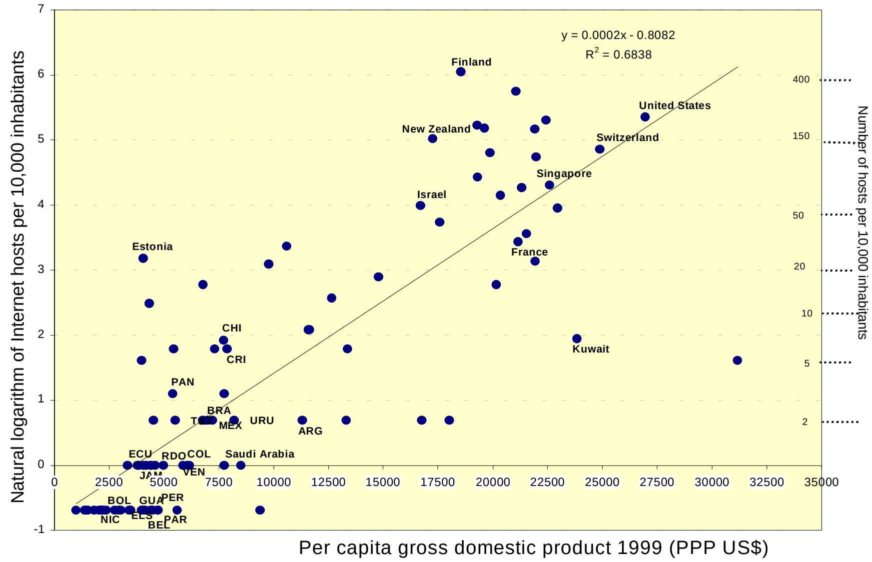
Table 7.3
CONNECTIVITY LEVELS AND GAPS, a/ **1995-2000**
(*Means, medians and variation coefficients for the number of Internet hosts per 10,000 inhabitants, and mean and median ratios*)

	Mean & VC. b/		**Mean ratio**		**Median**		**Median ratio**	
	1995	**2000**	**1995**	**2000**	**1995**	**2000**	**1995**	**2000**
Total (67 countries)	3.56	30.37	30.1	31.9	0.30	7.20	3.8	9.2
	2.04	*1.65*						
Total excluding LAC (50 countries)	4.71	39.27	39.8	41.3	8.09	55.30	102.4	70.7
	1.72	*1.41*						
Leaders (18 countries)	11.83	95.07	100.0	100.0	7.90	78.25	100.0	100.0
	0.86	*0.62*						
Potential leaders (19 countries, 4 LAC)	1.15	14.12	9.7	14.8	0.60	11.40	7.6	14.6
	1.08	0.67						
Dynamic followers (24 countries, 12 LAC)	0.14	2.26	1.2	2.4	0.05	0.40	0.6	0.5
	1.72	1.97						
Dynamic followers excluding LAC (12 countries)	0.15	0.98	1.3	1.0	0.05	0.15	0.6	0.2
	2.21	*2.43*						
Dynamic followers, LAC only (12 countries)	0.13	3.54	1.1	3.7	0.10	1.20	1.3	1.5
	0.65	1.61						
Marginalized (6 countries, 1 LAC)	0.05	0.18	0.4	0.2	0.05	0.15	0.6	0.2
	0.00	*0.72*						
Latin America and the Caribbean (17 countries)	0.19	4.18	1.6	4.4	0.10	1.90	1.3	2.4
	0.99	*1.23*						
Latin America and the Caribbean (medium and high group, 10 countries) c/	0.28	6.82	2.4	7.2	0.20	6.70	2.5	8.6
	0.73	*0.78*						
Latin America and the Caribbean (low group, 7 countries) d/	0.06	0.41	0.5	0.4	0.05	0.40	0.6	0.5
	0.38	*0.35*						

Source: United Nations Development Programme (UNDP), *Human Development Report, 2001. Making New Technologies Work for Human Development,* New York, 2001, table A.2.4, p. 62; *Human Development Report, 1998. Consumption for Human Development,* New York, 1998, table 1, p. 130.

a/ Gaps are calculated on the basis of the values of the leading group adjusted to 100.
b/ The variation coefficient is italicized.
c/ Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Mexico, Panama, Trinidad and Tobago and Uruguay.
d/ Bolivia, Ecuador, El Salvador, Jamaica, Nicaragua, Paraguay and Peru.

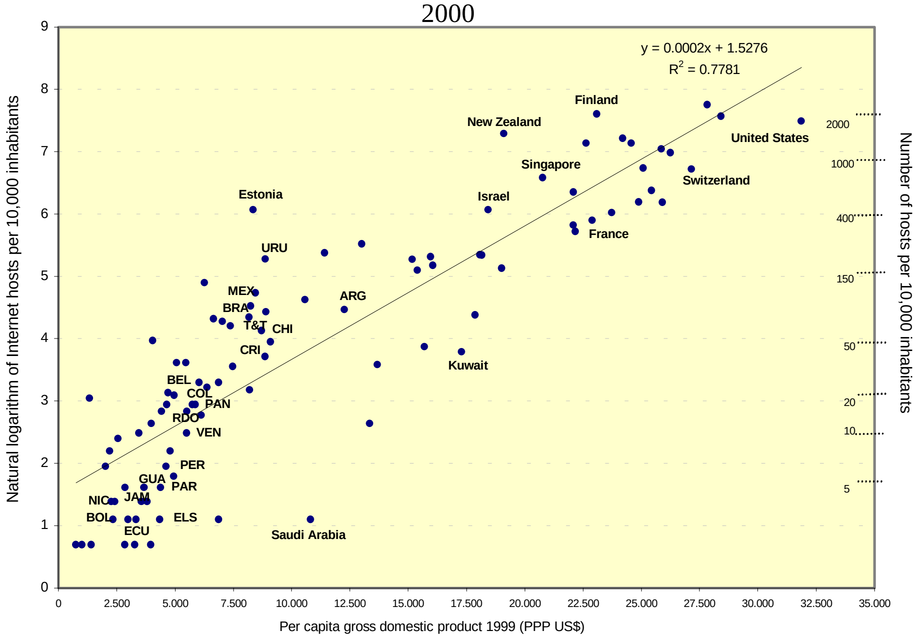
Figure 7.3a
CONNECTIVITY a/ **AND GDP IN THE WORLD** b/
1995



Source: United Nations Development Programme (UNDP), *Human Development Report, 2001. Making New Technologies Work for Human Development*, New York, 2001, table A.2.4, p. 62; *Human Development Report, 1998. Consumption for Human Development,* New York, 1998, table 1, p. 130.

a/ Number of Internet hosts per 10,000 inhabitants.
b/ For 89 countries. Excludes those with 0-1 hosts per 10,000 inhabitants in the year 2000 and countries for which no data was available.

Figure 7.3b
CONNECTIVITY a/ **AND GDP IN THE WORLD** b/
2000



Source: United Nations Development Programme (UNDP), *Human Development Report, 2001. Making New Technologies Work for Human Development,* New York, 2001, table A.2.4, p. 62 and table 1, p. 146.

a/ Number of Internet hosts per 10,000 inhabitants.
b/ For 96 countries. Excludes those with 0-1 hosts per 10,000 inhabitants in the year 2000 and countries for which no data were available.

Table 7.4 summarizes the changes in connectivity in Latin America and the Caribbean in the second half of the 1990s. It shows the increases in the number of Internet hosts per 10,000 inhabitants in Argentina, Belize, Brazil, Colombia, Mexico, Trinidad and Tobago and Uruguay. These countries, which in 1995 were below or near the internationally expected average in terms of their per capita income, rose above it in 2000, together with Chile and Costa Rica. On the other hand, Bolivia, Ecuador, El Salvador, Guatemala, Jamaica, Nicaragua, Paraguay and Peru remained at lower levels of connectivity than those expected in relation to the prevailing world averages in 2000.

Table 7.4

LATIN AMERICA AND THE CARIBBEAN: LEVEL OF CONNECTIVITY a/ **IN 2000 AND TREND BETWEEN 1995 AND 2000, COMPARED TO WORLD PATTERN** b/

Connectivity in year		**2000**		
		High	**Medium**	**Low**
1995	High	Chile (s > s: **6.2**) Costa Rica (s > s: **4.1**)	Panama (s > l: **1.9**)	
	Medium	Uruguay (b > s: **19.6**) Mexico (l > s: **9.2**) Argentina (b > s: **8.7**) Brazil (l > s: **7.2**) Trinidad and Tobago (l > s: **7.7**)		
	Low		Belize (b > s: **2.2**) Colombia (b > s: **1.9**) Dominican Rep. (l > l: **1.7**) Venezuela (b > l: **1.2**)	Peru (b > b: **0.7**) Guatemala (b > b: **0.5**) Paraguay (b > b: **0.5**) Jamaica (l > b: **0.4**) Nicaragua (b > b: **0.4**) Bolivia (b > b: **0.3**) Ecuador (l > b: **0.3**) El Salvador (l > b: **0.3**)

Source: United Nations Development Programme **(**UNDP), *Human Development Report, 2001. Making New Technologies Work for Human Development,* New York, 2001, table A.2.4, p. 62 and table 1, p. 146; *Human Development Report, 1998. Consumption for Human Development,* New York, 1998, table 1, p. 130.

a/ Internet hosts per 10,000 inhabitants. Figures in bold correspond to the rate for 2000.

b/ See figure 7.3. The trend in of the number of hosts per 10,000 inhabitants in 1995-2000 is shown for each country in comparison to the world pattern in terms of annual per capita GDP: *s* indicates that the number of Internet hosts in the country is above the world average; *b* indicates that it is below the world average; and *l*, that it is approximately the same as the world average in terms of the country's per capita GDP. For example, b>s means that the country rose above the average after being below it; b>1 means that it went from being below the average to being near to the expected value in terms of its per capita income, etc.

Although Latin America and the Caribbean as a whole did not lag behind in terms of connectivity, it is a matter of concern that the countries of the region with lower per capita incomes lost ground in this respect, making it even more difficult for them to become part of the information economy.

Moreover, the fact that a large group of countries in the region show higher degrees of connectivity than would be expected judging from their per capita incomes and have narrowed the gap separating them from the leading ICT countries does not guarantee them a place in the digital era within the next few years or in technological innovation processes, nor does it ensure a sufficient diffusion of technological innovation. In order to mainstream the production apparatus in global IPSs and networks, the alignment of the countries' development levels with international standards will not suffice; what is required is a form of connectivity that converges with that of the technologically developed countries. Moreover, in order to keep the digital divide between the region and these countries from widening if growth in the region proves to be slow and unstable, additional efforts will have to be made to prevent the business cycle from determining how much is invested in technological infrastructure and capabilities, since this could well result in obsolescence or backwardness in this field of rapid global change.

Another source of concern is the enormous "domestic digital divide" that exists in both social and productive terms, which in many ways represents a greater threat to the region than the international gap. Indeed, although service costs have tended to fall, they continue to shut out a large part of the Latin American and Caribbean population. The still relatively low rate of telephone connectivity in the lower-income segments of the region and the cost structure of telephone service are factors that hinder active Internet use on the part of poorer households and small enterprises. Computer equipment also is still too expensive for lower-income households and smaller enterprises and micro-enterprises. Although some governments in the region have taken the initiative in providing Internet access in schools for lower-income groups, no equivalent steps have been taken to facilitate access or the development of special networks for small and medium-sized enterprises. Although fixed telephone lines are currently the simplest and most affordable way to communicate or connect with the Internet, the rapid spread of mobile telephones could begin to make access available to lower-income segments. This would require substantial reductions in the cost of such services, however.

IV. Intellectual property rights

1. Standardization of intellectual property regulations

Over the past two decades, an international debate over intellectual property has been generated by, for the most part, circumstances emerging from the internal functioning of the United States economy. Owing to the relative loss of that economy's competitiveness in the 1970s, a considerable number of pharmaceutical, electronics and entertainment companies lobbied the Department of Commerce to accord a higher priority in its multilateral agenda and in bilateral negotiations to legislation on patents and other forms of intellectual property with a view to strengthening protection for agents holding such rights. What lay behind this position was the idea that research findings were diffused much too rapidly to competing firms of other nationalities and that the patent system did not provide enough protection to United States firms, which were spending money on creating new technologies. It was in this context that two important legislative changes were made in the United States: the Patent and Trademark Amendments Act of 1980, better known as the Bayh-Dole Act, and the Federal Courts Improvement Act of 1982 (Coriat and Orsi, 2001; Abarza and Katz, 2002; Slaughter and Rhoades, 1996). These changes authorized public R&D institutions (especially universities) to patent their research findings and exploit them through joint ventures with private firms, or through the creation of start-ups by academic groups or university researchers. At the same time, important breakthroughs were being made in the field of human genetics, informatics and computer sciences in academic centres, and these institutions made highly significant advances in those years with the support of public research and development funds (Mowery and others, 1999).

The authorization of private patents on these discoveries and the founding of scientific firms to market them help to explain why the annual register of patents in the United States economy has grown so rapidly since the 1980s and why the competitive position of that country was revitalized in many high-technology markets during the 1990s. A change in United States requirements for the patenting of an invention was another factor in this connection. This change took the form of a 1982 regulation that relaxed the novelty requirements for the issue of a patent. Thereafter, proof of commercial success gradually came to win greater acceptance as grounds for patenting an invention.

As a result, patent applications and the issuance of patents to residents and foreigners by the United States Patent and Trademark Office increased significantly (see table 7.5). At the same time, the Office has become increasingly important as a global centre of patenting activity, since it is where most countries, enterprises and institutions prefer to have their inventions and discoveries recognized. As for the most dynamic sectors, as represented by the number of patents issued by this Office, there has undoubtedly been an enormous increase in patenting in the sectors of molecular microbiology, drugs, pharmaceutical raw materials, transistors and other electronic elements (see figure 7.4)

Table 7.5

UNITED STATES: PATENTS OBTAINED, BY COUNTRY

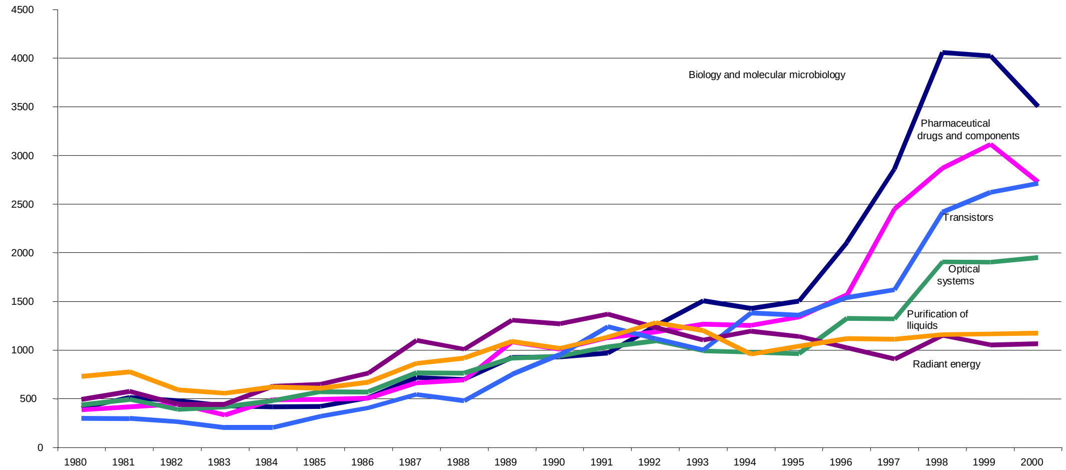
	Ranking 2000	Pre 1987	1987	1990	1995	2000	Total
Total		1,559,118	82,952	90,364	101,419	154,497	3,081,418
United States origin		1,047,922	43,520	47,390	55,739	85,072	1,870,059
Foreign origin		511,196	39,432	42,974	45,680	72,425	1,211,359
Japan	1	131,465	16,557	19,525	21,764	31,296	452,737
Germany	2	122,423	7,884	7,614	6,600	10,324	231,330
United Kingdom	3	62,376	2,775	2,789	2,478	3,667	101,680
France	4	46,050	2,874	2,886	2,821	3,819	89,218
Canada	5	26,102	1,594	1,859	2,104	3,419	57,290
Switzerland	6	27,404	1,374	1,284	1,056	1,322	44,635
Italy	7	16,044	1,183	1,259	1,078	1,714	34,146
Taiwan, province of China	10	950	343	732	1,620	4,667	24,646
Republic of Korea	11	259	84	225	1,161	3,314	18,169
Israel	15	2,069	245	299	384	783	8,161
Mexico	24	1,253	49	32	40	76	1,907
Brazil	28	453	34	41	63	98	1,263
Argentina	32	504	18	17	31	54	904
Venezuela	36	197	24	20	29	27	557

Source: United States Patent and Trademark Office.

In this context, the less developed countries experienced strong international pressure to change their patent legislation. The final result of this process was the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) concluded at the Uruguay Round of trade negotiations, which established minimum standards for the regulation of intellectual property in the countries members of the World Trade Organization (WTO) in 1993. The normative content of the agreements and the widespread acceptance of trade liberalization strategies profoundly changed the existing incentive system.

Besides establishing minimum standards, the TRIPs Agreement expanded the number of products or sectors subject to patents (including, for example, pharmaceutical products, whereas previously only pharmaceutical processes were patentable) and permitted the importation of the patented product to be accepted as sufficient utilization of a patent, features that had not previously gained general acceptance in national codes.

Figure 7.4
UNITED STATES: NUMBER OF PATENTS OBTAINED, BY MAIN SECTORS OF ACTIVITY



Source: César Morales, "Situación y Perspectives de los DPI sobre la biotecnología y transgénicos", document presented at the seminar "Genetically modified organisms: their impact on Latin American agriculture" (Termas de Cauquenes, 20-22 November), 2001, on the basis of the United States Patent and Trademark Office (USPTO).

The many studies that have been made through the years on the advantages and disadvantages of the patent system in the developed countries have not managed to demonstrate clearly whether patenting has positive or negative long-term effects.[3] For the developing countries, the net balance is even less clear. Thus, the TRIPs Agreement represented a cost, in raising the price of patented products and technologies, as the World Bank (2002c, chapter 5), among other analysts, recently pointed out. Moreover, this protection can slow down national learning processes and the narrowing of the technological gap between the developing and the industrialized countries by blocking processes —of imitation and reverse engineering— that were common in the developing countries and still are today in the late-industrializing economies. This practice therefore raises costs when the registration of intellectual property rights is not accompanied by an effective use of the technology in the country granting the protection, and in such cases the patent serves little purpose other than to reduce competition. The management of intellectual property is, moreover, a complex and costly business. It requires legal, technical and administrative skills which are generally scarce in the developing countries. This also limits its potential benefits.

Such disadvantages should be offset by the potential benefits which the protection of intellectual property offers to the developing countries, especially the middle-income countries that make up most of the region. Apart from protecting the findings of their R&D activities, which systemic competitiveness strategies should help to increase, it is an essential factor in the development of some markets, in which trademark protection and (in some cases) indications of origin are important, or of service markets such as television products, films or computer software. In many of these cases, protection is particularly valuable in intraregional trade. Other benefits, especially those associating protection of intellectual property with the attraction of foreign direct investment (FDI), are only useful when the investor makes effective use of the technology in the recipient country.

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[3] Thus, one of the first and most exhaustive of these studies, done in 1950 by Fritz Machlup, concluded that, "[I]f one does not know whether a system "as a whole" (in contrast to certain features of it) is good or bad, the safest "policy conclusion" is to "muddle through" .... If we did not have a patent system, it would be irresponsible... to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it. "This last statement refers to a country such as the U.S. —not to a small country and not a predominantly nonindustrial country, where a different weight of argument might well suggest another conclusion".

2. Latin American patent activity

According to information from the World Intellectual Property Organization (WIPO), patenting trends and patterns in Latin America and the Caribbean differ considerably from those in the developed economies and in the newly industrialized countries in South-East Asia (see table 7.5). In these countries, the flow of patents granted to residents has tended to grow at an equal or greater rate than those issued to non-residents. In contrast, in Latin America and the Caribbean the number of patents applied for by non-residents is growing much faster than those requested by residents. This trend is associated with the use of patents by foreign corporations to market and import their products, which in many cases tends to hinder the development of local production and technological capabilities (Aboites and Cimoli, 2001).

In contrast to patent activity in the United States Patent and Trademark Office, where the flow of patents is now the highest in the world, the countries of Latin America and the Caribbean as a whole granted only one fifth the number of patents applied for by the Republic of Korea alone. A difference can also be seen in the structure of patent applications. Latin American applications are concentrated in mechanical and chemical engineering, while the industrialized and newly industrialized economies generate considerably more patent applications in technologies associated with telecommunications, electronics and biotechnology.

Latin America is in quite a different position with regard to the patenting of plant varieties, however. Advances in genetic research and genetic engineering have resulted in a significant increase in applications for these patents, which may be granted to processes and products such as new varieties of hybrid plants, transgenic plants or processes for endowing them with certain desirable features. Plant patents requested from WIPO show a growing Latin American presence (Morales, 2001), which in recent years has come to represent more than 10% of the world total (see table 7.6). Moreover, there has also been an increase in the number of countries of the region that are applying for and obtaining plant patents. In 1994 only Argentina and Chile did so, while in 1999 the list included Brazil, Colombia, Bolivia, Ecuador, Mexico, Paraguay and Peru.

It should be pointed out, however, that despite the existing agreements, significant differences of opinion remain among the WTO countries, and even among the developed countries themselves, with respect to the most appropriate type of protection for intellectual property consisting of plants, animals and processes used to produce them. Thus, for example, the European countries that have signed the International Convention for the Protection of New Varieties of Plants do not recognize patents on plant varieties. To remedy this situation, the TRIPs Agreement recognizes the right of countries to exclude plants and animals other than microorganisms and biological processes for the production of plants or animals from the patent regime. Be this as it may, the countries should take the necessary steps to protect plant species, whether through patents, new varieties of plants or a combination of the two.

V. Policies to facilitate changes in production and technological patterns

As noted in chapter 4, an essential component of national strategies in an era of globalization is an active strategy designed to create, expand and maintain systemic competitiveness. To that end, the strategy must link together the development of technological capabilities, support for changing production patterns, development of production chains and the building of quality infrastructure.

Table 7.6
WIPO: PLANT PATENT APPLICATIONS AND AWARDS

WIPO: Plant patents

Year	Applications			Patent awards			Countries/groups
	Residents	**Non-Residents**	**Total**	**Residents**	**Non-Residents**	**Total**	
1994	120	260	380	104	108	212	Latin America (Argentina and Chile)
	507	247	754	484	223	707	United States
	678	279	957	336	83	419	Japan
	3,003	2,532	5,535	2,348	2,341	4,804	European Union
1995	154	110	264	62	99	161	Latin America (Argentina, Chile, Uruguay)
	232	220	452	201	186	387	United States
	766	213	979	507	91	598	Japan
	2,258	1,163	3,241	2,081	1,855	3,936	European Union
1996	105	664	749	72	50	122	Latin America (Argentina, Chile, Colombia, Ecuador, Uruguay)
	677	374	1,051	362	192	554	United States
	736	203	939	426	51	477	Japan
	2,089	816	2,905	1,859	1,366	3,448	European Union
1997	183	307	490	108	253	361	Latin America (Argentina, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru)
	609	412	1,021	397	184	581	United States
	818	236	1,054	559	159	718	Japan
	2,062	638	2,700	1,793	639	2,432	European Union
1998	139	491	630	87	371	458	Latin America (Argentina, Chile, Colombia, Ecuador, Mexico, Paraguay, Uruguay)
	7	4	11	9	14	23	United States
	793	241	1,034	869	148	1,017	Japan
	2,001	606	2,607	1,611	565	2,176	European Union
1999	219	338	557	140	235	375	Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru)
	829	472	1,293	399	228	627	United States
	649	118	767	456	148	604	Japan
	1,899	622	2,521	1,263	511	1,774	European Union

Source: César Morales, "Situación y Perspectives de los DPI sobre la biotecnología y transgénicos", document presented at the seminar "Genetically modified organisms: their impact on Latin American agriculture" (Termas de Cauquenes, 20-22 November), 2001, on the basis of the United States Patent and Trademark Office (USPTO).

This section examines some criteria that could be used to guide the first component of this strategy. In view of the importance of ICTs for the integration of firms and individuals into global production networks, special consideration is given to policies designed to encourage the adoption, use and development of such technologies. At the same time, in view of the growing importance of the protection of intellectual property rights in global institutionality, possible ways to reconcile these rules with local technological development are analysed.

1. Reinforcing innovation systems: active strategies and policies

When national innovation systems are the core environment in which enterprises acquire and develop their technological capabilities, their strength, density and dynamism are necessary conditions for technology development and dissemination, continued increases in productivity and the maintenance of international competitiveness. Consequently, the reinforcement of national innovation systems has become one of the main objectives of systemic competitiveness policies.

Both the public sector and private enterprise must play key roles in strengthening national innovation systems. Producers of goods and services must necessarily deepen their commitment to the development of new technologies by financing and carrying out R&D activities downstream from basic and applied research phases. It is the job of the public sector, however, to ensure adequate levels of basic research. The public sector's efforts should be seen as complementary to research carried out meanwhile by the private sector and as providing an environment for the generation of externalities in this regard. The State must promote, guide and coordinate innovative activities and the formation of linkages among the scientific and technological apparatus of universities, development banks, public and private R&D laboratories, and the production sector. To that end it must operate as a central agent that selects and prepares technological projects that will be of interest to the private sector only once the initial uncertainty and problems of inappropriability of benefits have been resolved through government intervention.

Market imperfections in the innovation system, appear to be stronger and more pervasive than those of technologically advanced countries. Public policy should include measures and programmes, formulated in partnership with the private sector, to resolve market failures in the long-term financing of innovative projects, accumulation of technological capabilities, access to technological knowledge and business management and the training of skilled human resources. At the same time, public policy should contrive the means to encourage the development of institutions, synergies and strategic complementarities within the production system.

On the other hand, given their importance, efforts to strengthen the externalities, complementarities and synergies of innovation systems should be an integral part of the competitiveness and technological development strategy rather than being confined to isolated programmes. Linking horizontal, sectoral and regional innovation policies with competitiveness policies, based on this strategic vision, should be the job of a specialized agency recognized as such within the institutional order.

A reasonable mix of horizontality and selectivity should be part of public policy in this area. This mix could be achieved through generic incentives to spending on innovation activities by private firms, such as tax deductions or preferential funding of R&D, and specific incentives, such as co-financing or subsidies for technological projects, risk-sharing programmes for designing new technologies, systems of open competition for R&D tax incentives or bids for developing sectoral technological programmes. Existing synergies and complementarities in each society and in each national scientific and technological apparatus can be taken advantage for these purposes, but a focused effort should also be made to create dynamic comparative advantages in sectors that are complementary to the current pattern of production specialization. The contemporary trend towards marketing complex products that include everything from the good or service itself to post-sales consumer relations opens up a wide range of possibilities for enriching the mix of export products, increasing national value added and incorporating local engineering effects.

Just as important as having world-class technologies in export sectors and moving towards more abundant and sophisticated regional and national production chains in fields of national excellence, or encouraging the development of dynamic comparative advantages by creating new products and production processes, is the objective of boosting the average productivity of the economy, which in Latin America and the Caribbean lags far behind developed countries' levels. The digitalization of production processes and a rapid and appropriate transition to the era of computerized production processes now appears to be an urgent task in order for the region to take advantage of the new window of opportunity offered by the world of ICTs. This is also true of biotechnologies, which can contribute to a rational and environmentally sustainable exploitation of the natural resources that underlie a substantial portion of the comparative advantages enjoyed by many of the countries in the region today.

This strategy should explicitly include the role to be played by transnational corporations (TNCs). In Latin America and the Caribbean, policies in this area have been focused simply on attracting foreign investment, without using any selectivity criteria or means of channeling it in accordance with national development priorities. Frequently, in fact, it has been seen more as a source of external financing than a means of enhancing competitiveness. Not all TNCs, however, have had the same impact on growth and technological development. There are not many cases among the countries of the region in which foreign investment policies have been integrated with a development strategy based on clearly established objectives. This contrasts with notable examples of such strategies at the global level, including those of Ireland and Singapore. In the absence of such strategies, TNCs tend to prioritize a country's static comparative advantages.

Part of the collective effort to develop technological capabilities to serve as a basis for sustained systemic competitiveness consists of significantly increasing expenditure on R&D and on technology diffusion and creating incentives for private spending in this area. There is a sharp contrast between the industrialized countries and Latin American nations in terms of the priority assigned to R&D. As a proportion of GDP, the former allocate nearly five times as much as the latter to creating new technological knowledge. This lag is a cause for concern and should gradually be corrected. The need is even clearer in view of the support systems used by the developed countries to encourage the creation of new technology-based enterprises.

In addition to increasing total R&D expenditure, the public sector should specifically provide incentives for basic disciplines associated with the sustainable exploitation of the region's natural resources. Fields such as molecular biology and biotechnology, animal and plant genetics, marine sciences, mineralogy and climatology should be given priority in this respect and should be regarded as an indispensable complement to the current pattern of productive specialization in the region.

2. Policies to speed up progress in ICTs

Some developing countries have based their ICT strategies on building a competitive industry for producing computer hardware and telephone facilities. Although this strategy yields a fast-growth economic activity and enhances technological capabilities, it does not necessarily speed up the transition to the digital age. In any case, as the Organisation for Economic Co-operation and Development (OECD) has pointed out, "The key to benefiting from ICT is to focus on policies to foster its use, rather than its production" (OECD, 2001b).

The Latin American and Caribbean countries should follow strategies aimed at using ICTs as facilitators of a broad-ranging process of economic development and systemic competitiveness. The digitalization of production is aimed at boosting productivity, mainly through cutting costs and opening up larger market niches to permit economies of scale. This involves an institutional reorganization process, which helps to bring business practices into the digital era. With the incorporation of ICTs into existing industries, competitive advantages are achieved; this is where the gap in ICT use becomes a central issue.

In contrast to more highly developed economies, digitalization in Latin America is not yet a decisive factor in competitiveness. This is mainly due to the lack of scale. Digitalization is not an individual process. Network models only make sense if they have a critical mass of participants, since the more members a network has, the greater the benefits of joining it. Once a critical mass is reached, network externalities accelerate the process of adaptation, thereby generating a herd effect that forces those who have been left behind to either digitize or withdraw from the market.[4]

It is necessary to apply the "joint requirements" principle in order to speed up the transition. To this end, special attention must be given to creating an awareness of digital opportunities, strengthening human resource skills, obtaining financing, adapting the regulatory environment and, certainly, facilitating access to the Internet (Hilbert, 2001).

The rapid changes in ICTs and the paradigm that is taking shape are shifting the challenges and opportunities for developing countries. The appearance and features of the Internet —as we know it today— are continuing to change at the same headlong pace that marked its initial development. The general trend is towards a convergence of all different types of ICTs into what amounts to a network of networks. The gradual integration of data services in the mobile telephony industry (2G and 3G), together with the advances in the Voice over Internet Protocol (VoIP) and the trend towards digital television or the use of digital powerline communications networking, are early and very promising attempts in the region. The convergence of ICTs is shaping a new type of Internet, which complements the functionality of the "digital nervous system" (Gates, 1999).

But the field in which the region really needs to catch up is in the widespread diffusion of digital practices, which will require a drastic reorganization of the use of human resources. The region is still very much behind in terms of the use and integration of digital practices in economic processes. Fiscal incentives could be useful in this area, together with direct State measures to encourage connectivity, in order to accelerate diffusion rates.

On the other hand, the transition to the digital era should not be thought of solely as a phenomenon related to the production of goods. The potential benefits of the digital era in areas such as e-health, e-education or e-government are immense; digitalizing education and access to pedagogic messages and content in schools (Schnettler, 2001), the dissemination of practices used in the diagnosis and treatment of illness, the expansion of distance education for medical and paramedical personnel (Rodríguez, 2001) and linking governments with their citizens (Orrego, 2001), appear among others, to be fields with inmense future possibilities.

To encourage greater equity in the transition to the information society, measures of various types will be required, both to provide affordable telecommunications services and heighten participation in computerized networks, and to promote access to computer infrastructure. Emphasis must be placed on ensuring universal access, which means, first of all, preventing the emergence of new forms of economic and social exclusion (the "domestic digital divide"), but also speeding up progress towards the critical mass necessary to make the digital organization of production profitable. The concept of digitalization is not limited to the Internet. Less costly solutions to provide alternative access must be found so that the masses of Latin America and the Caribbean can become connected. One policy that embodies this goal, which has already been implemented in a

4 Network externalities arise for a product when the utility derived by a user from the consumption of a good increases with the number of other agents that consume the same good (Arthur, 1989).

number of countries in the region, involves setting up Internet terminals in schools, community centers and public places.

A factor of particular importance for productive development, systemic competitiveness and job creation is for small and medium-sized enterprises to be sufficiently incorporated into the digital era so that they can participate in internationally competitive networks. As yet there are very few programmes to promote the mass use of computers in the management of small enterprises and the use of the Internet in their technological and commercial management Such programmes could operate through specialized associative networks that would give small and medium-sized enterprises access to information on technology, technical services, credit and markets and make available the tools that have been created to help them in these areas (ECLAC, 2000a, vol. 3, chapter 3).

In addition, in order to ensure the legal security of electronic transactions and generate a greater volume of business through this channel, the legal framework for the protection of such transactions and the consumers who acquire goods and services by this means must be improved.

Lastly, ICTs are a particularly appropriate field for regional cooperation, in particular through the creation of joint mechanisms for developing, consolidating and marketing high-technology products and services (such as software and distance learning) together with region-wide networks. Progress in some of these areas has been blocked by the total absence of regional standards and regulations to support the integration of telecommunications services. This situation is reflected, for example, in the diversity of technologies and standards used in the mobile telephony industry, which are hampering the physical integration of systems and cost reductions associated with the expansion of the regional market. These tasks should therefore be priority lines of action for regional integration processes in the immediate future.

3. Policies on intellectual property rights

The countries of the region should develop their policies in two basic directions (Abarza and Katz, 2002): first, towards *the valuation of national and regional capabilities and assets.* Just as the industrialized countries had clear objectives at the time they negotiated the TRIPs Agreement, the Latin American and Caribbean countries should set clear targets in this area and design a strategy to meet them. Until now, they have simply acted in the expectation of gaining easier access to FDI and developed-country markets, but they have disregarded the possibility of developing their own resources. A priority task with respect to the development of substantive rights is therefore for these countries to take stock and become aware of the importance of the intellectual, genetic and cultural assets they must defend and to determine possible ways of conserving and protecting them.

The second direction is the *renegotiation of the principles and purposes of the TRIPs Agreement.* In this context, it should be clearly understood that respect for intellectual property rights must be compatible with meeting the basic needs of the entire population and with minimal standards of equity in the international diffusion of technical progress that will facilitate the technological upgrading of developing countries. This means, among other things, finding ways to safeguard opportunities for developing technological improvements through reverse engineering and “learning by doing”.

It is important to grasp, moreover, that the two legal elements that protect intellectual property in a country —that is, international treaties on the one hand, and the national patent and trademark law, on the other— do not necessarily use the same interpretations or provisions with regard to what can be patented, the duration of patent rights, the principle of territoriality on which patents are issued, the question as to whether or not imports of the patented product are protected, the rules governing the expiration of a patent for “lack of use”, compulsory licensing if the patent is not being used, the treatment of nationals or foreigners, and the significance of what has come to be called “exhaustion of patent rights” (Abarza and Katz, 2002). In other words, conflicts between these two juridical elements have always existed, and it is up to each nation’s judiciary system to decide how to deal with this issue. This clearly gives a considerable degree of freedom to developing countries in establishing and promoting their technology policies.

A number of possible areas of adjustment or normative development should be mentioned (see also the discussion of this topic in chapter 4 of this book). One of them derives from the statement by the WTO ad hoc group that was set up in response to the recent conflict between Canada and the European Union. On the basis of the principles and purposes of articles 7 and 8, this ad hoc group recognized that some adjustments need to be made to the first paragraph of article 28, which sets forth the rights conferred upon a patent holder, and has thereby opened the way for a new round of negotiations on these issues. The same ad hoc group has also noted that one of the possible exceptions under article 30 of the TRIPs Agreement would make it possible to use a patented product to conduct scientific experiments during the period covered by the patent, even without the consent of the patent holder. This statement is based on the fact that the purpose of patent legislation is also to facilitate the spread and advance of scientific knowledge rather than solely to protect the patent holder.

The topic of the exhaustion of patent rights opens up a promising opportunity for developing countries. National and regional policy makers in Latin America should re-evaluate, on the basis of sufficient knowledge and information, the most effective or available means for promoting the local development of technology, selecting new plant or animal species, etc. Both reverse engineering and licensing can provide possibilities for local firms to develop their own technologies in the future. This should be sufficient grounds for claiming the exhaustion of a patent in those cases where the development of local technological capabilities could be hindered by the use of foreign patents for the sole purpose of marketing and importing high-technology goods.

Compulsory licensing clearly represents another way in which TRIPs should be made more flexible, as demonstrated by the recent international debate surrounding the pharmaceutical industry.

It seems reasonable to have intellectual property legislation to protect the works of the human intellect. This system should, however, meet three additional requirements: (a) it should grant differential treatment to intellectual property in respect of merit goods such as health, education and basic nutrition; (b) it should provide the less developed countries with effective mechanisms to protect their intellectual, genetic and cultural assets; and (c) it should promote technological development and learning in the developing countries.