CHAPTER

16

Innovation Systems in Latin America

The two building blocks required to understand the process of innovation are the company itself as a creator and administrator of knowledge, and the national innovation system as the provider of the environment and the resources necessary for this creation of knowledge.

Businesses are the focal points where people with different types of professional and technical knowledge interact and combine to achieve collective results. The capacity of businesses for learning and innovation is closely related to how knowledge is constituted, generated and used, so any analysis must incorporate conceptual categories that examine how businesses carry out this process. Knowledge-based theories of firms use the distinction between explicit and tacit knowledge proposed by the philosopher Michael Polanyi.[1]

Explicit knowledge is that which can be encoded and transmitted through verbal or written communication. It can be codified and stored in blueprints, written rules, technical procedures, equations and formulae. This type of knowledge is the subject of scientific and technical treatises.

Tacit knowledge, by contrast, is the practical know-how derived from hands-on or on-the-job experience. The skills that workers learn by doing constitute the individual component of tacit knowledge. The massive and complex weft of shared beliefs and implicit understandings of a firm's workers and managers regarding how tasks should be done constitutes its collective component.

While explicit and encoded technological knowledge can be traded between firms, tacit knowledge is accessed only by hiring people who possess it, or by merging with other organizations that have incorporated it into their practical culture. Tacit knowledge is the non-codified technological knowledge that differentiates firms. This has led analysts to conclude that tacit knowledge represents the principal source of sustainable competitive advantage in today's rapidly changing economy.[2]

The second building block of the knowledge-and-learning economy is the national innovation system, which is the set of interrelated agents, institutions and practices that constitute, perform and participate in processes of technological innovation. A country's innovation system can be delimited by looking at it as centered in the production system. The underlying claim is that what matters are the actual practices of innovation carried out by businesses. This means that while analysis of the role of formal institutions in innovation is a critical first step toward understanding a given country's innovation system, the ultimate focus must be on the innovation itself, where it is carried out, and its impact on production processes at the business level.

At first glance, it would appear that differences between innovation systems in developing and developed countries are purely quantitative. In developing countries, the number of people involved in innovation is smaller, there are fewer institutions, and they are less developed. Investment in research and development as a percentage of GDP is lower, as is the number of patents, and many firms do not have research and development (R&D) departments.

What must be understood, however, is that these quantitative differences reflect a deeper divide. Innovation systems in developing countries are, in effect, "handicapped" systems—that is, they are qualitatively

[1] For theoretical explanations of the concepts of tacit and explicit knowledge, see Lam (1998) and Melo (2001a).

[2] See Winter (1987), Hall (1993), Grant (1996) and Lam (1998).

Table 16.1 Innovation Output Measured in Patents

	European patents		U.S. patents	
	1995 (%)	1995 (base: 1990 =100)	1995 (%)	1995 (base: 1990 =100)
Western Europe	47.4	91	19.9	78
Central and Eastern Europe	0.4	101	0.1	43
Commonwealth of Independent States	0.4	113	0.1	59
North America	33.4	125	51.5	108
Latin America	0.2	204	0.2	122
Arab States	0.0	101	0.0	135
Sub-Saharan Africa	0.2	96	0.1	78
East Asia	16.6	87	27.3	108
China	0.1	152	0.2	118
India and Central Asia	0.0	103	0.0	160
Southeast Asia	0.0	165	0.0	126
Oceania	1.3	163	0.6	84
World total	100.0	na	100.0	na

Source: Barré (1998, p. 26).

different as a result of cumulative lags with respect to the developed countries. This does not mean that these systems are irreparably disabled in the sense that some human beings unfortunately are, but rather that they are at a clear disadvantage that must be acknowledged and addressed. This chapter will more explicitly describe the implications of Latin America's figuratively "handicapped" innovation systems, beginning with the question of whether the region is catching up or falling behind the world's innovative leaders.

How is Latin America doing in the technological race? The short answer supported by empirical evidence is that the region is progressing in absolute terms but falling behind in relative terms. According to *The Global Competitiveness Report* indicators described in Chapter 15, the average value of Latin America's innovation index clearly lags behind most other regions in the world. Other indicators of innovative output point in the same direction. Table 16.1 shows the relative share of 11 groups of countries and China in world innovative output, as measured by patents in both the European Patent Office (EPO) and the U.S. Patent and Trademarks Office (USPTO). Latin America's aggregate share in both patent offices was 0.2 percent in 1995.

A comparison with the shares for two economies that can be considered to have successfully caught up—South Korea with a 0.65 percent share, and Ireland with 0.14 percent—shows even more clearly that Latin America's innovative output is not catching up with that of the world leaders.[3]

It is still true, however, that the region is progressing in *absolute* terms. For instance, the number of Latin American patents in the EPO grew by 104 percent between 1990 and 1995, and the number in the USPTO rose by 22 percent. Still, the region's innovative output can be considered relatively meager, and a look at national efforts in this area shows why. Table 16.2 shows the expenditure on science and technology as a percentage of GDP for 16 Latin American nations and for Canada, Spain and the United States. With the exception of a few countries, Latin America's efforts fall short of what is needed.

Human Resources

Human resource development in the Latin American countries imposes serious constraints on their innovation systems. Table 16.3 shows the number of researchers per 1,000 people in the labor force for 15 Latin

[3] The shares for Ireland and South Korea, which are not shown in the table, are for 1996 and refer to IPO patent applications only. They are from OECD (1999).

Table 16.2 **Expenditure on Science and Technology as a Percent of GDP**

Country		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Argentina	STA	0.33	0.34	0.36	0.43	0.44	0.49	0.50	0.50	0.51	0.54
	R&D	-	-	-	-	-	-	0.42	0.42	0.42	0.47
Bolivia	STA	-	-	-	-	-	-	-	0.58	0.54	0.55
	R&D			0.37	0.39	0.39	0.37	0.33	0.32	0.29	0.29
Brazil	STA	1.23	1.20	1.04	1.20	1.35	1.26	1.29	-	-	-
	R&D	0.58	0.59	0.48	0.61	0.74	0.87	0.91	-	-	-
Chile	R&D	0.51	0.53	0.58	0.65	0.66	0.65	0.66	0.65	0.62	0.63
Colombia	STA	-	-	-	-	0.62	0.67	0.70	0.65	-	-
	R&D	-	-	-	-	0.37	0.39	0.41	0.41	-	-
Costa Rica	R&D	0.73	1.05	1.23	1.42	1.23	1.25	1.13	-	-	-
Cuba	STA	1.13	1.11	1.65	1.56	1.47	1.43	1.26	1.33	1.49	1.69
	R&D	0.72	0.65	1.13	0.93	0.82	0.77	0.61	0.70	0.87	0.83
Ecuador	STA	-	-	-	-	-	-	0.18	0.23	0.22	-
	R&D	-	-	-	-	-	0.08	0.09	0.08	0.08	-
El Salvador	STA	-	-	-	-	0.30	0.30	0.30	0.30	0.84	-
	R&D	-	-	-	-	-	-	-	-	0.08	-
Mexico	STA	0.28	0.33	0.32	0.37	0.41	0.35	0.35	0.42	0.47	0.41
	R&D	-	-	-	0.22	0.29	0.31	0.31	0.34	-	-
Nicaragua	STA	-	-	-	-	-	-	-	0.14	-	-
	R&D	-	-	-	-	-	-	-	0.13	-	-
Panama	STA	0.63	0.67	0.63	0.71	0.72	0.76	0.85	0.92	0.87	-
	R&D	0.38	0.38	0.34	0.36	0.37	0.38	0.38	0.37	0.33	-
Peru	STA	-	-	-	0.18	0.42	0.68	0.74	0.67	0.75	-
	R&D	-	-	-	-	-	-	-	0.06	-	-
Trinidad & Tobago	STA	-	-	-	-	-	-	0.33	0.36	-	-
	R&D	-	-	-	-	-	-	0.13	0.14	-	-
Uruguay	R&D	0.25	0.15	0.19	0.07	0.14	0.28	0.28	0.42	0.23	0.26
Venezuela	STA	0.37	0.39	0.49	0.47	0.39	0.48	0.29	0.33	-	-
Canada	R&D	1.45	1.51	1.56	1.60	1.65	1.62	1.57	1.59	1.61	1.50
Spain	R&D	0.85	0.87	0.91	0.91	0.85	0.85	0.87	0.86	0.89	0.90
United States	R&D	2.62	2.69	2.61	2.49	2.39	2.48	2.52	2.55	2.59	2.67

Notes: STA=scientific and technological activities. R&D=research and technology.
Source: Adapted from Red Iberoamericana de Indicadores de Ciencia y Tecnología (2000).

American countries, and for Canada, Spain and the United States. Although the stocks of human resources in science and technology in Argentina, Chile, and Cuba are relatively strong, the general picture for the region is of a gap that does not seem to be closing. However, the human resource development system is not the only culprit, as it only explains the supply side of the problem. There is also a demand side: firms have systematically de-emphasized knowledge investment and technological innovation as major tools for profit making. Generally speaking, universities in the region produce more researchers than the amount demanded by the productive system.

Table 16.4 shows the average number of qualified professionals employed by Colombian firms according to size and to whether they are international-caliber, national-caliber, or potential innovators. The figures are striking in that they show the low level of qualified human resources employed in most categories of Colombian firms. With such a low level of human capital utilization, the ability to innovate is bound to be seriously impaired.

Informal Innovation

Sutz (1998) reviewed the results of surveys in six Latin American countries and found a great deal of what is called "informality" in innovative processes.[4] This re-

[4] The six countries were Argentina, Chile, Colombia, Mexico, Uruguay, and Venezuela. More survey information and results can be found in CIESU (1987), CONACYT (1998), Durán et al. (1998), INDEC (1998), OCEI-CONICYT (1998), and Sutz (1998).

Table 16.3 Researchers in the Labor Force (per 1,000 population)

Country		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Argentina	HC	-	-	-	1.99	2.45	2.57	2.62	2.69	2.75	-
	FTE	-	-	-	1.47	1.77	1.90	1.95	1.85	1.84	-
Bolivia	HC	-	-	-	-	-	-	-	0.38	0.39	0.38
	FTE	-	-	-	-	-	-	-	-	0.21	0.21
Brazil	FTE	-	-	-	-	-	0.67	-	-	-	-
Chile	HC	1.20	1.24	1.25	1.18	1.21	1.26	1.30	1.32	1.37	1.35
Colombia	HC	-	-	-	-	-	-	0.45	0.46	0.47	-
Costa Rica	HC	-	-	-	-	1.22	-	1.52	-	-	-
Cuba	HC	1.23	1.32	1.32	1.27	1.21	1.13	1.13	1.13	1.21	1.20
Ecuador	HC	-	-	-	-	-	-	0.32	0.32	0.31	-
	FTE	-	-	-	-	-	0.15	0.23	0.21	0.22	-
El Salvador	HC	-	-	-	-	0.10	0.10	0.09	0.09	0.20	0.20
	FTE	-	-	-	-	0.04	0.04	0.04	0.04	0.08	0.08
Mexico	HC	-	-	-	0.55	0.68	0.74	-	-	-	-
	FTE	-	-	-	0.42	0.50	0.55	-	-	-	-
Nicaragua	HC	-	-	-	-	-	-	-	0.29	-	-
	FTE	-	-	-	-	-	-	-	0.22	-	-
Panama	HC	-	0.38	0.38	0.63	0.65	0.67	0.84	0.78	0.78	-
	FTE	-	0.10	0.19	0.29	0.30	0.31	0.31	0.31	0.43	-
Trinidad & Tobago	HC	-	-	-	-	-	-	-	0.66	-	-
Uruguay	HC	-	-	-	-	-	-	-	-	-	1.80
	FTE	-	-	-	-	-	-	-	-	-	0.59
Venezuela	HC	-	-	-	-	-	-	-	-	0.45	-
Canada	FTE	4.63	4.74	5.02	5.25	5.46	5.58	-	-	-	-
Spain	HC	4.34	4.78	5.02	5.15	-	6.31	-	6.36	-	-
	FTE	2.46	2.64	2.70	2.79	3.05	2.99	3.20	3.30	3.69	-
United States	HC	-	-	-	14.52	-	13.67	-	13.75	-	-
	FTE				7.47	-	7.31	7.77	8.17	-	-

Notes: HC=head count. FTE=full-time equivalent.
Source: Adapted from Red Iberoamericana de Indicadores de Ciencia y Tecnología (2000).

fers to innovations by companies that do not have a formal internal structure in charge of research and development. While 63.6 percent of firms in the sample said they had introduced innovations, only 15.7 percent had a formal R&D department. Another sign of informality is that management in many firms did not know how much the company was spending on research and development. In Uruguay, more than 60 percent of firms did not know how much they were spending on R&D, and in Mexico the figure was 71.4 percent. In Venezuela, only 8 percent of firms provided data about their research and development expenses.

Weak Linkages and Knowledge Flows

Linkages and hence knowledge flows between Latin American businesses and research institutions (including universities) are weak. When asked about the source of their innovative ideas, 13.4 percent of Colombian businesses surveyed attributed them to universities and 7.4 percent to public sector research institutes. However, 45 percent of firms with 50-100 employees, and which pertained to the category of international-caliber innovators, credited universities as a source of innovative ideas, while 43 percent credited the public research institutes.

When the firms resorted to outsourcing of innovation, universities and public research institutions were the least employed counterparts. In Mexico, only 6 percent of firms had established cooperation agreements with universities and only 4.9 percent did so with public research institutes. Moreover, many firms declared that those agreements were irrelevant. In the Venezuelan survey, 43 percent of firms said they had signed cooperation agreements, but only 3.5 percent of them

Table 16.4 **Average Number of College Graduates and Professionals with Post-Graduate Degree in Production Departments of Colombian Firms**

Firm size (by number of employees)	Type of firm			
	International	National	Potential innovators	Do not innovate
20-49	1.1	0.8	0.3	0.3
50-99	4.4	1.6	3.0	1.0
100-199	8.6	3.5	3.1	2.3
200+	42.5	14.9	2.6	3.4
Total	17.5	4.5	1.6	0.8

Source: Sutz (1998).

were with universities and 4.5 percent with public research institutes. In Chile, 31.8 percent of firms acknowledged having benefited from innovations from universities and 16.2 percent from public research institutes. Some 25 percent of firms actually signed contracts with universities, and 14 percent signed them with public research institutes. In Uruguay, 27.2 percent of firms had cooperation agreements with public institutions (including both universities and public research institutes). Ten percent of those were with the country's main public university.

Firm-to-firm flows vary from country to country. In Colombia, 60 percent of firms reported having carried out some type of joint innovation with client firms. In Chile, that figure was 48 percent. In Uruguay, only 10.5 percent of firms had sought technological advice from other businesses, and in Venezuela that figure was only 10 percent. Regardless of whether firm-to-firm flows were high or low, it is important to point out that external interactions were not assigned a crucial role by the firms themselves. Most firms reported that the principal source of new ideas was their own personnel.

In summary, all the evidence points to limited and inadequate cooperation among businesses themselves, and between business communities and universities and research institutions. These are the core institutions of any system of innovation, yet in Latin America it is clear they are not working together as they should.

Finally, unlike most developed countries, where the dominant component of nationwide innovation efforts is the business sector, the dominant component in Latin America is the public sector. During the 1990s, over 60 percent of the region's research and development expenditures were by government, as compared to less than 30 percent by businesses. That trend is changing, however. The share of the business sector in total research and development expenditure has been increasing, while the government share has been declining.

Formal Organizations

Besides businesses themselves, the other building block for innovation is a nation's principal formal organizations, such as industrial and technological research institutes, universities, and policymaking bodies.

Research institutes face a difficult challenge in all countries of the world, as they try to balance the long-run imperative of keeping abreast with the frontiers of research with their institutional duty to satisfy short-run and concrete demands from their business-sector clientele.[5] According to Machado (1993), industrial technology institutions in the region have been unable to maintain that equilibrium. Most do not have the necessary knowledge of technological advances in their fields; nor do they seek out domestic or foreign partners that could help them in that respect. Many were found to be unaware of technological information already in the public domain, and had no experience in reverse engineering and copying, which are in great demand by small and medium-size firms.

Research programs are often determined on the basis of the researchers' personal agendas and not as a result of a study of industry needs. There is little consultation with the business sector. Of eight research institutes studied by Machado, none had ever conducted a customer satisfaction survey. There are few examples of

[5] See Alcorta and Peres (1995).

successful technology transfer from institutes to industry. In short, then, the problem is not only that the linkages between firms and research institutes are weak. It is that the linkages are weak in part because, due to their internal deficiencies, the research institutes often do not have much to offer to businesses.

The quality of universities in the region varies widely, but the number of high-quality universities is limited.[6] The average university does not put relations with the business community high on its agenda. While many universities do not have much to offer to businesses, it is also true that private sector demand for knowledge is weak both qualitatively and quantitatively.[7] Business strategies are often unconcerned about generating knowledge. This prompts them to emphasize routine consulting work in their relations with university faculty members. The region's entrenched tradition of relying on technology imports—generally but clearly not always the best technical and economic option—has led broad segments of the business community to simply discount local universities as potential technological partners. To the universities' credit, many studies report that it is the academic community that usually takes the initiative in searching for partnerships with firms. A number of universities have actively built organizational arrangements to foster university-industry relations.[8] Nonetheless, it is also true that the region's university researchers still have strong incentives to conduct their research around agendas set by their respective scientific or technical discipline in the developed countries. In most cases, it is unlikely that these agendas will be relevant to the problems faced by firms in the region.

Policymaking Bodies

In most Latin American countries, the organizational component of the innovation system is formally structured along the following lines: (i) a central government agency in charge of defining science and technology policy; (ii) a set of executing agencies; (iii) institutions (including both public and private universities) in charge of basic and applied research; (iv) institutions responsible for defining technical norms, standards, quality control and certification; (v) institutions in charge of technical and vocational education as well as short-term training of the active labor force; and (vi) financial institutions and funding agencies.

The top tier of the organizational pyramid typically includes a central government agency empowered with policymaking authority and a technical advisory body. In three countries (Brazil, Costa Rica and Venezuela), the policy agency is at the ministry level: the Ministry of Science and Technology. In other countries, the highest authority is the Ministry of Planning or the President's Office assisted by a Science and Technology Secretariat or a National Research Council. In several countries, the advisory bodies have representation only from the ministries related to science and technology. In other countries, other sectors are represented as well, including public and private universities, the scientific community, trade organizations from the business sector, and regional science and technology entities.

Legal Frameworks, Agencies and Policies in Transition

With the advent of the structural reform process in Latin America in the late 1980s and early 1990s, agencies entered a period of transition that is still in progress. The two central features of this transition have been a policy shift toward greater emphasis on supporting technological modernization by the business sector, and major institutional and legal transformations of the formal organizational component of innovation systems.

With the reorientation of development strategies away from the import-substitution model and towards market-based development, the general direction of public policies has changed substantially. In particular, a new approach to industrial policies has emerged that focuses on finding the ways and means to improve competitiveness. The overriding concern of both entrepreneurs and policymakers has become access to external markets and ways to successfully compete in them, productivity growth, and efficient technological modernization. This new policy thrust has been felt in the area of innovation policies, where new policies are emerging as well. The central issue of innovation policy is increasingly understood to be how to help the productive sector enhance its competitiveness, and at the same time, how to respond to the long-run challenges posed by the knowledge-based economy in terms of basic scientific research.

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6 See Meyer-Stamer (1995).

7 See Sutz and Arocena (2000).

8 See Sutz and Arocena (2000).

Policies to Promote Technological Modernization

In Latin America's leading countries in terms of innovation, there is a definite preoccupation with better linking science and technology with the imperative with improve competitiveness. As a result, almost every major industrial policy statement in the post-reform period has given high priority to technological modernization as an area where government intervention is critical to enhancing the ability of the domestic private sector to compete.

The main areas of action for technology policies in the region are:

- Promoting research and development by the private firms themselves;
- Strengthening cooperation between public research institutions and private firms; and
- Creating or strengthening the informational infrastructure necessary for successful research and development by businesses.

There is considerable variation in the ways countries go about defining mid-term objectives for their technology policies. Mexico's policy defines seven areas where government efforts must be concentrated: (1) fostering technological transfer as a key factor in strengthening productive chains; (2) promoting quality norms and systems in the microenterprise and small and medium-size business sectors; (3) strengthening the basic technological capabilities of those same businesses; (4) providing basic information to businesses on such issues as voluntary standardization and regarding available technology advice and consultancy services; (5) encouraging technology transfer from the more advanced countries; (6) protecting industrial intellectual property; and (7) stepping up efforts to create a culture of technological innovation in the business sector.

Brazilian policy, by contrast, focuses on specific and selected sectors grouped into two categories (see Ministério de Ciência e Tecnologia, 1996). The first includes sectors where the country has already developed some technological capabilities, but where there is still the need to further strengthen them. This includes information technology and automation, aerospace technology (particularly satellites), nuclear technology, military technology, and agriculture. The second category consists of sectors where technological development is either absent or in an incipient stage. This includes superconductivity, special materials, optical electronics, biotechnology, application of biotechnology to agriculture, energy conservation and alternative sources of energy.

The promotion of technological research and innovation in the first category requires mobilizing a whole battery of policy instruments to encourage the firms themselves (albeit with the support of government and private non-profit institutions) to undertake technological innovation. For the second category, this effort revolves around the creation and future expansion of world-quality research centers devoted to basic and applied research. The rationale for tackling this research is based on the idea that, while it may not respond to short-term market demands, the research has significant medium- to long-term potential for both productive application by businesses and the consequent benefits for society at large.

Policy Instruments

The array of instruments used by policymakers to support scientific and technological development in leading countries of the region include: (i) grant for research projects; (ii) credit programs to strengthen the technological capabilities of industries and firms; (iii) fiscal incentives for technological innovation; (iv) programs geared to the needs of targeted industries; and (v) horizontal programs to address needs that emerge in special areas of the private sector's technological performance.

Grants are typically nonreimbursable and given to qualified projects selected by means of competitive procedures. A distinction is made between scientific research projects carried out by research institutes and university researchers, and projects aimed at technological development at the industry and company levels.

One frequently stated objective in technology policies is to foster partnerships between businesses and academic institutions for research and innovation aimed at solving technological problems faced by the former. In Brazil, there are two institutional mechanisms through which these partnerships are promoted. One is called "Technological Platforms," which are fora where the stakeholders get together to identify and address the technological obstacles faced by a particular productive sector or a specific region. The expected outcome of these meetings is the formation of partnerships between research institutes, universities and representatives of the particular productive sector (or region) to formulate cooperative research projects. These projects are eligible for funding from government agencies.

Credit Programs

Government agencies that support technological modernization usually operate through trust funds, fiduciary funds, or specialized financial agencies. They provide loans to firms, consortia of firms, or consortia of firms and research institutions to carry out coordinated research and technological development that is expected to result in the invention of new products, significant improvements in existing products, better production processes, stronger infrastructure for innovation, or improved product quality. To this basic core of innovation activities eligible for credit, some financial agencies add the purchase of technological and scientific services; acquisition of scientific and technical documentation and information; consulting services; adaptation of imported products, processes or technologies to local conditions; purchase in domestic or foreign markets of product, process or service technologies; strengthening of teams devoted to technology development or adaptation; and creation, implementation and expansion of technological research centers.

Inspired by an innovation research program sponsored by the U.S. Small Business Administration, the funding agencies typically provide nonreimbursable loans to technological innovation projects of microenterprises and small enterprises.

Brazil and Mexico have a number of special credit programs to encourage technological innovation by businesses. In Brazil, a first set of credit lines is part of the Ministry of Science and Technology's Program to Support Scientific and Technological Development, funded by the World Bank. This includes two particularly interesting sub-programs: Support for Technological Sector Entities (TSEs), and Technology Management and Competitiveness.

The TSEs are non-profit organizations that provide one or more of the following services for firms from particular productive sectors: (i) product research and development; (ii) technical services; (iii) metrology, normalization and certification services; (iv) quality management; (v) training; and (vi) organization of technological information banks.

The Technology Management and Competitiveness Program supports pilot projects carried out by partnerships of firms and non-profit technical support entities. The projects must include (i) diagnosis of the current technological situation of the particular industry; (ii) training of senior management in new technology management concepts and instruments; and (iii) internal implementation at the firm level of technology management structures and mechanisms that will enable them to apply the concepts learned at the training stage.

In addition to these programs, FINEP, the Brazilian federal innovation financing agency, also offers an integral support credit line that finances all aspects of a technological innovation business plan, from the project formulation stage through the construction of civil works; the purchase and installation of machinery, equipment and technical instruments; the licensing or purchase of technology; and training, technical assistance, and initial working capital. FINEP also offers a pre-investment credit line to finance engineering consulting services, as well as credit in support of technological, environmental and product quality management.

Fiscal Incentives

Beyond the leading countries of the region, a number of other Latin American countries use fiscal incentives as a policy instrument for technology innovation. The incentives typically include (i) reduction in the corporate income tax; (ii) reduction in value-added taxes; (iii) accelerated depreciation of capital goods and equipment acquired in the context of an innovation project; and (iv) fiscal credits for expenses and additional investments in R&D. In addition, some countries grant some special incentives. Colombia allows a deduction of 125 percent of the costs of innovation projects, and gives exemptions from value-added taxes on imports of equipment and instruments for such projects by research centers, technological development entities and universities. Brazil grants an exemption from the tax on industrialized products to firms that produce information technology products, provided that the firm spends more than 5 percent of its gross sales on R&D. It also allows the deduction as operational expenses of payments of royalties and other technical assistance payments made by advanced technology firms.

Other Programs

Several countries in the region have special programs to promote technological innovation in specific sectors deemed to be strategic. Perhaps the best example is incentives given by the Brazilian government to firms in the information technology sector. Besides the above-mentioned exemption from the industrialized products tax, the government purchases information technology goods based not merely on price considerations but on the price-quality ratio of products offered in competitive bids by information technology firms. In addition, a program to support software production provides loans to companies involved in software development and buyers' credit for their commercial customers.

Finally, there is an array of programs and institutional efforts across the region in areas of product quality and design; participation in or organization of technical fairs and other events where technological innovations are disseminated; organization of pools of technological consultants; promotion and defense of industrial property; and the formal organization and completion of technology-foresight exercises with implications for policy formulation and design.

Policy Issues

The systemic issues that affect innovation in Latin America are not all directly amenable to policy intervention. Bearing this limitation in mind, the policy discussion centers around the role of government in a proactive strategy to catch up with the world's technological leaders. The assumption is that implementation of such a strategy will allow the Latin American countries to gradually transform their national innovation systems into more mature frameworks that can better assist domestic businesses in creating and applying technological knowledge to the production of higher-quality and lower-cost products

The essence of catch-up strategies is the generalized and intensive build-up of problem-solving capabilities throughout a national innovation system. The end result is that firms will be able to improve their productivity—initially by imitating and learning from the leaders and adapting products, processes and organizational technologies already developed elsewhere to local conditions; and subsequently by making steady improvements in quality, cost reduction, and incremental change.

While the imitation of already established technologies prevails in the initial phase, the emphasis in a second phase based on more developed innovative capabilities shifts to higher value-added production, continuous improvement, and the generation of new products. At this point, there may be a number of particular firms or sectors that are considered to be internationally competitive, and hence to have "caught up" with the leaders. There may even be firms and sectors that are on the leading edge. To the extent that that is the case, the catch-up strategy may then no longer apply, and these sectors and strategies may even shift to more aggressive strategies to forge ahead of the competition.

Where there are national innovation systems whose backbone is a myriad of competing private firms that use decentralized decisionmaking and respond to market signals, the government has a multiple role. First, it must assume a leadership role. Second, it has a rule-setting function in the exercise of which it must create a general policy environment conducive to private investment in technological innovation. Third, it must perform a planning function. Fourth, it has a fundamental role to play in human resource development. Fifth, it must be responsible for promotion functions. Sixth, it cannot escape undertaking productive functions within an otherwise predominantly private innovation system. And, seventh, it has to discharge a regulatory function.[9]

The importance of government leadership is based on the notion that the task of catching up with the advanced countries in terms of innovation is an enormous endeavor. The most reasonable way of conceiving it is as a national project whose completion requires mobilization of a vast amount of societal energies. It stands to reason that state institutions and the political leadership elected to guide them play a role in guiding this overall effort.

A prime example of such a leadership role is that of the United States. The government of today's innovative country par excellence has consistently led the national innovation effort. Government-supported basic research initiates and supports technological advances, and the government has encouraged large-scale univer-

[9] Here we draw on the taxonomy of government functions devised by Celso de Macedo (2000).

sity research. It has channeled the innovation efforts of industrial firms via procurement and development contracts (Freeman, undated). Among the innovation systems of the developed countries, the United States is unique in that the federal government has financed an exceptionally large proportion of total R&D carried out by the business sector.

The remaining six functions are specifications of the leading role of government, and some of them overlap. The planning function calls attention to government's power and responsibility to lead the way in defining, through participatory decision processes, clear strategic objectives. An appropriate instrument for this is the formulation of multi-annual plans that establish measurable mid-term objectives, the policy measures and policy actions to reach them, and the required budgetary expenditures. The planning function also includes the selection of strategic research areas where efforts must be concentrated to accelerate the catch-up process.

The government plays a key role in human resource development, both in terms of devising long-term strategies for human capital formation and ensuring high levels of investment in education systems. The promotion function requires the use of financial instruments, fiscal instruments and the government's coordination role to stimulate innovation and technological upgrading by the business sector. The productive function is required because a certain number of the institutions generating innovation are in the public sector. This subset includes public universities and research institutes, as well as state enterprises in countries where these have not been privatized. These public entities are major players in the innovation system, and the government's responsibility is to manage them in such a way as to maximize their contribution.

The regulation function is related to the government's responsibility to set overall rules for all the agents in the system. The most relevant rules are in four areas: (i) industrial and intellectual property rights; (ii) market competition; (iii) technical standards, metrology, and quality standards and accreditation; and (iv) safety, health and environmental protection.

Quite naturally, a host of political economy and policy issues emerge in connection with all the enumerated functions. Prominent among them are issues having to do with the institutional prerequisites for efficient implementation of technology policies, and policies aimed at providing public goods.

Paraphrasing Lipsey (1999), one could argue that the ideas supporting the view that government intervention is necessary to promote technological innovation are both powerful and dangerous. They are powerful because they shed light on a key ingredient of economic development and they open new and promising avenues for public policy. But they are dangerous as well because, by allowing for the possibility of selective intervention or context-specific policies, they could end up being applied in the wrong institutional contexts, opening a Pandora's box of rent-seeking behavior and related abuses.

Technology policy is a complex matter. Effective policy design and implementation require a considerable degree of institutional development, good governance, and substantial administrative capabilities. Here, the spirit of Lipsey's advice on context-specific policies is wholly opposite, even when applied to the broader issue of subsidies and similar interventions to promote technological innovation: "Such policies should be avoided unless a country's political constitution, political practice, and administrative competence are all such as to reduce to acceptable levels the risk that the policies will be subverted for purposes other than those for which they were intended" (Lipsey, 1999, p. 26).

Policies Aimed at Providing Public Goods

There are a number of aspects to policies aimed at providing public goods that are relevant to the innovative practices of businesses. The discussion here will be limited to policies that support the diffusion of technologies and the promotion of innovation clusters.

The rationale for emphasizing technology diffusion is straightforward. For countries whose main task is catching up, learning from the leaders through imitation and adaptation is the most effective form of internal innovation. Based on lessons learned from international experience, technology diffusion programs should (i) be customer-focused and demand-driven; (ii) comprehensively cover different types of technologies, firms and sectors, and include the transfer of both off-the-shelf and existing technologies as well as more highly sophisticated technologies if there is a demand for them; (iii) provide different kinds of expertise and services, including training and networking; (iv) develop strong linkages with all technology-related service providers and promote networks among providers and users; (v) go beyond technical problem-solving and address the managerial and organizational modifications required for firms to adapt to technical change; and (vi) have sufficient resources, linkages and leverage points to work with large numbers of firms over time.

An innovation cluster is an agglomeration in a given geographical location of firms that belong to the same or related lines of business. There are many types of clusters, and a number of different cluster typologies can be found in the literature. For the purposes of this chapter, all typologies recognize the existence of innovative or innovation clusters.

Innovation clusters center around knowledge-intensive activities and have the capacity to undertake technology innovations, design new products and processes, and bring them quickly to the markets (UNCTAD, 1998). The flows of knowledge are particularly frequent and intense among firms belonging to innovation clusters.

Innovation clusters are mainly found in industrialized countries. There are, however, a number of such clusters in the developing world. On the basis of the findings of Bortagaray and Tiffin (2000), at least 31 clusters can be identified in Latin America that meet the requirements of the UNCTAD definition. It is noteworthy that some of these clusters are in high technology industries such as microelectronics (Campinas), telecommunications (Campinas, Curitiba), computer science and informatics (Campinas, São Leopoldo, Monterrey) software (Curitiba, Espírito Santo, Porto Real, Porto, Rio de Janeiro, San José), automation engineering (Espírito Santo), biotechnology (Belo Horizonte, Havana), electronics (Santa Rita de Sapucaí, Cuernavaca, Guadalajara), and aeronautics (São José dos Campos).

The geographical distribution of these innovation clusters indicates that Brazil is the leading country with 22, followed by Mexico with six, Argentina with two, and Cuba, Costa Rica and Uruguay with one each.

The factors underlying successful innovation clusters in the developed world are a frontier research topic. In the case of Latin America, much work is a fortiori still needed to shed light on the requirements for success. This means that policy and best-practice lessons are still far from settled.

Policy experience with innovation clusters in Latin America is limited but does suggest certain recommendations. According to Quandt (1999), the first attempt was Brazil's creation of 13 "technological innovation nuclei" in selected universities and research centers in 1982. This was followed by establishment of the Program for the Implementation of Science Parks in 1984. Since 1993, many public and private entities have become involved in promoting incubators and science parks. In 1999, there were 15 regions classified as emerging high technology centers, seven science parks, and about 60 incubators housing nearly 500 firms.

Mexico started to create business incubators in 1990 and by 1999 there were 15 in operation. Most are supported by the National Council for Science and Technology (CONACYT) and the Association of Incubators and Technological Parks. Some of the efforts are led by universities, others by research and development centers. Two are led by the private sector.

In Argentina, the Polo Tecnológico Constituyentes, organized around the main public institutes, aims to develop enterprise incubation processes. But according to Bortagaray and Tiffin (2000), the emphasis is more on supply-driven technology transfer out of the large government laboratories than on demand-driven cluster formation.

Consensus among the practitioners involved with innovation clusters suggests several recommendations.

First, policymakers should let the private sector take the lead in developing these centers. Government support should be provided on the basis of a prior and irreversible commitment by the private sector to contribute substantial resources. Policymakers should make sure that the critical mass of enterprises and skills can be marshaled by private entrepreneurs before committing public resources to the support of a particular innovation cluster initiative.

Second, government support should address critical issues of seed financing and venture capital. In addition, tax incentives and credit lines from the development banks for working and fixed capital for the firms belonging to the clusters are appropriate forms of government support. Third, the role of subnational and local governments is decisive. And finally, the principle of decreasing government support as a particular cluster matures must be strictly observed.

Conclusions

In today's global economy, where knowledge-driven innovation has become a decisive factor in the competitiveness of both nations and businesses, Latin America's poor performance in the area of innovation is particularly troubling. This chapter has addressed the issues involved in upgrading the region's technological capabilities by introducing a basic analytical framework to help understand the practices and institutions involved in technological modernization in Latin America. Some of the features of the national innovation systems in the region are not encouraging: their innovation output is low, linkages between the different actors and institutions weak, and knowledge flows limited. Taking into account that these characteristics are not always amenable to direct policy intervention, the policy discussion centered around the role of government in a proactive strategy to catch up with the world's technological leaders. The assumption is that implementation of such a strategy will enable the Latin American countries to gradually transform their national innovation systems into more mature frameworks that can better support efforts by domestic business communities to create and apply technological knowledge to the production of higher-quality and lower-cost products.

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