

IV. INITIATIVES IN SELECTED DEVELOPING COUNTRIES

A. INDIAN TECHNOLOGY POLICIES

Since 1974, and more precisely in its first Science and Technology Plan (1974-79), India has explicitly and officially referred to technology absorption, assimilation and development of its indigenous capabilities.¹ Furthermore, the Indian government has stressed local R and D in the country's various S and T oriented agencies, mainly with the aim of avoiding technological dependence on other countries. During the 1970s and 1980s, these tendencies and the ensuing policies of self-reliance in S and T were strengthened, while little attention was paid to export-oriented technology development. Priority was given to the application of S and T to such vital areas as drinking water, dairying, immunization and telecommunications during those two decades.

Despite some achievements in the fields of agriculture, nuclear, defence and space, this S and T policy failed to address various social, environmental and technological issues. At the same time, the question of the importance and institutionalization of new technologies, particularly microelectronics, ICTs and biotechnology, was presenting a major challenge. The absorption, development and diffusion of these technologies led the government to lift various restrictions that had been hampering technology transfer. In the Eighth Five-Year Plan (1992-97), a range of technological fields, including food processing, photonic devices, energy-efficient technologies, intelligent automation, new materials and biotechnology, were targeted for support.²

In 1991, a new industrial policy was adopted which represented a departure from the country's previous stance and former policies based on self-reliance and protectionism. The importing of technology, whether in the form of capital goods or technical knowledge, and the hiring of foreign technical personnel were permitted, and foreign direct investment (FDI) was encouraged, with few restrictions. The needs of the market and those of industry dominated the new policy, which led in due course to a market-industry culture that has influenced India's overall S and T strategy. Private industry has come to assume a more important role in various technological areas such as telecommunications, IT, heavy industry, railways and energy. As a result, a less centralized, sectorally devolved S and T policy regime has developed at ministerial level. Since 1991, public scientific agencies have been required to generate 50 per cent of their budget from non-government sources. This has been accomplished through industry partnerships and the sale of technologies. Royalties collected by scientists from the commercialization of patents and the like have become acceptable to the government, as have partnerships with Indian and international companies.

India's policies for biotechnology, on the other hand, emerged from the more centralized "science push" approach of the 1980s. A Department of Biotechnology (DBT) was created by the government in the mid 1980s. DBT has been extremely active and dynamic and has adopted a forward-looking approach, especially with respect to teaching and research. Since its creation, it has established postgraduate and doctoral programmes in 35 universities, and has created or expanded six world-class laboratories in molecular biology and biotechnology since its creation. This has resulted in social and economic benefits in the form of locally produced vaccines, diagnostic tests and pharmaceuticals.

Although the development of the Indian ICT industry in recent years has been dominated by the private sector and transnational corporations (TNCs), the government has played an important catalytic role. It was the Indian government that initiated software technology parks in 1986, and gave strong leverage to software export processing zones in the early 1990s, through support from the Department of Electronics (see frame 30). A newly created Information Technology Ministry is expected both to spur industrial development and to ensure that the social benefits of ICTs are as widely realized as possible.

¹ V.V. Krishna, "Changing S and T policy cultures, phases and trends in science and technology in India," manuscript for submission to *Futuribles* (New Delhi: Centre for Studies in Science Policy, Jawahar Lal Nehru University, June 2000).

² Ashok Jain, "South Asia," in H. Moore (ed.), *UNESCO World Science Report 1998*, (Paris: UNESCO Publishing/Elsevier, 1998), pp.192-211.

Frame 30. “New Silicon Valley”: India’s Information Technology Industry

The coming of a new millennium saw the emergence of an IT industry, particularly in cities such as Bangalore, Hyderabad, Delhi, Pune, Calcutta, Ahmedabad, Mumbai and Chennai – generally described as the “new Silicon Valley”. Strictly speaking, the IT cluster in Bangalore gained initial prominence as India’s “Silicon Valley” in the 1990s. The IT software export industry started in late 1970s in the Santa Cruz Electronics Export Processing Zone (SEEPZ). The shortage of skilled human resources induced the industry to shift to Bangalore in the mid-1980s.

There are currently more than 946 IT companies in India engaged in the development and export of software. India exports US\$ 3.9 billion in IT software, and has a domestic market of US\$ 1.25 billion. The top 25 companies in 1998–99 accounted for 63 per cent of all exports. Major international players in the IT industry - such as IBM, Microsoft, Novell and Sun Systems - have set up joint collaborative ventures or fully-owned R and D centres in Indian cities and major universities such as the Indian Institutes of Technology.

The IT industry has become students’ first career choice during the past few years. There are some 1,800 publicly funded institutions producing nearly 68,000 professionals (in hardware and software, including PhDs and other postgraduates, undergraduates and diploma holders), and 2,300 recognized private training institutes, which turned out 10,000 software professionals in 1998 alone.

While the private sector has come to assume a dominant role in the recent years, the government has played a catalytic role since the mid-1980s. The government institutionalized the concept of software technology parks (STPs) as early as 1986, and the Department of Electronics has given concrete shape to export processing zones in software beginning in the early 1990s. Currently there are 17 STPs at various locations in the country. STPs provide not only the infrastructure necessary for exports but also assistance in project approval, imports, bonding, export certification and so on. For new entrants, STPs also provide access to incubation infrastructure and high-speed international gateways. Recognizing the importance of IT industry in the coming decades, the government created a Ministry of Information Technology early in 2000.

Source: Abridged from Krishna, “Changing S and T policy cultures”.

Building on India’s strong human resources in science and technology, multinational companies have begun to develop R and D centres in India, especially over the past five years. This trend has posed a challenge to existing public research institutes, including nearly 40 national laboratories with over 10,000 scientific and technical staff. They have been forced to create a more stimulating and rewarding research environment in order to keep their staff and become as productive as private sector R and D laboratories.³ Many of the new TNC research centres in India have developed links with national S and T institutions. However, the SME sector, which in India is predominantly rural, has not yet received the attention it deserves in the form of R and D institutions that address its need for modernization and hence greater competitiveness in the global market.

Despite the introduction in 1998 of income tax relief on R and D expenditure and five-year tax holidays for commercial R and D companies, government policies have been neither sufficient nor effective in encouraging private companies to invest in R and D.⁴ This forces the government to provide a high proportion of R and D funding compared to the private sector, as indicated in appendix 3. The respective roles of the state and the private sector in S and T is still a key issue that remains to be resolved, as are the mechanisms that facilitate linkages between the two sectors.⁵ A protectionist technology policy and funding for selected fields of technology may be one option for the government, as some observers have proposed.⁶ But the current market-oriented economic policies, together with a focus on basic socioeconomic needs, particularly education and sanitation, seem likely to dominate the Indian technological development scene in the medium term. That development will be underpinned by the country’s extensive S and T infrastructure and human resource base, as well as its expanding domestic markets.

³ Krishna, “Changing S and T policy cultures”.

⁴ Ibid.

⁵ Ibid.

⁶ Rangan Banerjee, “In Search of a Technology Policy,” *IIT Update* (Bombay: IIT Bombay, December 1998), pp. 26-28.

B. TECHNOLOGY INCUBATORS IN THE PHILIPPINES

Research and development in the Philippines is conducted in public-sector institutions for the most part, and tends to be basic academic research rather than applied research leading to industrial innovation. Confronted with this situation, the government decided to establish the “Technology in Business Programme”, setting up technology business incubators (TBIs) and science and technology parks (STPs) in an effort to induce public research institutes to turn to applied research with a view to a more productive environment (see appendix 4 for a list of these TBIs and STPs).

These incubators and parks have achieved some success, according to an assessment made in 1995.⁷ In particular, start-up firms have been created with help and guidance from incubators. Moreover, both STPs and TBIs have facilitated technology transfer and have made good use of public-sector funds and resources.

However, the assessment found that two important implementation issues had been neglected: previously established rules and criteria for tenant selection were not adhered to, and monitoring was inadequate. As a result, there were substantial discrepancies between what it would theoretically have been possible to achieve through these initiatives and the realities of practice on the ground. In quite a few cases, tenants lacked a simple telephone, received poor guidance, especially with respect to management, and had little use for the available technologies. According to the assessment, the main problems encountered by TBI tenants were as follows (in order of seriousness):

- (a) Inadequate/inappropriate facilities or equipment;
- (b) Lack of time/availability of the TBI manager or staff;
- (c) Lack of equipment maintenance;
- (d) Competition with host research institute for use of equipment;
- (e) Insufficient capital.

The assessment exercise resulted in important recommendations and suggestions aimed at overcoming difficulties and obstacles to the establishment and efficient management of TBIs and STPs. These are summarized below.⁸

1. *Achievable goals and proper facilities*

More modest and achievable goals for the TBI and STP schemes are needed, taking into account the context and real-life situation of the Philippines. Examples of such goals might be: nurturing new start-up firms that are unlikely to survive in the Philippines without help and getting them off the ground, developing ways of activating and promoting underused public resources in science and technology, and disseminating achievements resulting from improvement in the technological and business environments.

The main strengths of TBIs and STPs should be recognized and disseminated, particularly with respect to the development needs of firms through the provision of a positive environment affording more fertile ground for innovation in science and technology and based on:

- (a) Credibility for new firms with new technology;
- (b) Appropriate infrastructure;
- (c) Business facilities;
- (d) Management guidance;
- (e) Technological resources;
- (f) Contacts and access to business and technology networks.

⁷ Stuart Macdonald and Richard Joseph, *Technology Business Incubators and Science and Technology Parks: Assessment Report*, Report by the Centre for Research Policy, University of Wollongong, for the Department of Science and Technology, the Philippines (Wollongong: University of Wollongong, September 1995).

⁸ Stuart Macdonald, *Technology Business Incubators and Science and Technology Parks: Draft Recommendations. Report for the National Technology Development and Transfer Plan*, Report by the Centre for Research Policy, University of Wollongong (Wollongong: University of Wollongong, October 1995).

2. Clarity of objectives

The objectives of TBIs should be made clearer and distinguished from those of STPs. This should make the selection criteria for tenants more effective and lead to better results. The distinction is dictated by the fact that an STP tenant firm is generally a larger and more complex undertaking than a TBI start-up firm, and is much more capable of looking after itself. Obviously, no incubation is needed for established firms that have proved their viability, but need to become more competitive and productive by developing more innovative products through collaboration with R and D institutions in a park. Furthermore, STP tenant firms do not need the common services and rudimentary facilities that are considered essential by TBI tenants, and their managers need none of the management guidance required by TBI start-up managers.

Given the context of the Philippines, the common and distinctive features of TBIs and STPs have been defined as follows:⁹

(a) The purpose of both TBIs and STPs in the Philippines' Technology in Business Programme is to increase the transfer of technology to local industry by locating selected private-sector ventures alongside appropriate public centres of expertise;

(b) A TBI is an establishment that provides temporary accommodation, technological assistance, business guidance and appropriate facilities to start-up small firms to enable them to select and adopt appropriate technologies that are essential for the growth of their business;

(c) An STP is a property-based development, closely associated with a research centre, which provides an environment and facilities conducive to the commercial exploitation of new technologies.

3. Selection and monitoring of tenants

As applied in the Technology in Business Programme, the criteria used for the selection of tenants have had no technological dimension, and have been more appropriate for business development schemes than for technology transfer schemes. There should be additional criteria relating to would-be tenants' need for new technologies and their capacity to assimilate those technologies. Furthermore, there has been little monitoring of the business and technological progress of sites and tenants, with resultant difficulties in the assessment of their performance by the responsible government agency.

The assessment study suggested appropriate criteria for the selection of public sector research locations and TBI and STP firm and site monitoring. These criteria are shown in frame 28.

Frame 28. Suggested criteria for selecting and monitoring TBI and STP firms and sites in the Philippines	
Criteria for monitoring of individual firms	Criteria for monitoring of sites
<ul style="list-style-type: none"> • employment; • turnover; • site facilities used; • progress with technology transfer; • increase in skills; • technological co-operation with host; • technological co-operation with others; • network development; • impact on other firms in industry; • impact on market; • output exported. 	<ul style="list-style-type: none"> • number of tenants; • cumulative number of graduates; • total employment; • total turnover; • facilities available; • facilities used by tenants; • new technological strengths of host.

⁹ Macdonald, *Technology Business Incubators, Draft Recommendations*.

Frame 28 (continued)

Criteria for selecting TBI locations	Criteria for selecting STP locations
<ul style="list-style-type: none"> • low cost, expandable space; • infrastructure appropriate to incubating firms; • business facilities appropriate to incubating firms; • reasonable proximity to training facilities; • access to business consultancy networks; • access to commercial, legal and financial institutions, skills and expertise; • availability of qualified and reputable scientists and technologists; • scope of established links with universities and research institutes working in the same industry or field of science and technology. 	<ul style="list-style-type: none"> • business infrastructure appropriate to export oriented, rapid growth, technology-intensive companies; • business facilities appropriate to export oriented, rapid growth, technology-intensive companies; • high quality, low density accommodation in a park-like environment; • location within a reasonable distance from a university or research institute; • emphasis on activities which encourage the formation and growth of a range of new technology- or knowledge-based enterprises.
<p><i>Source: Macdonald and Joseph, Technology Business Incubators, Assessment Report.</i></p>	

4. Sectoral priorities

The Government’s policies have favoured TBI tenants in the fruit sector and the metal fabricating and marine industries, which have been deemed to have priority because of their export potential. This narrow focus on selected industrial sectors, to the practical exclusion of others, has had some negative consequences: it has eliminated promising tenants that might quite well have made useful contributions to the country’s economic development. Accordingly, it might be more appropriate to open tenancy to all sectors likely to contribute to the national economy, while giving some priority to selected sectors.

5. Promotion and integration with other initiatives

The achievements of STPs and TBIs should be more widely promoted and publicized; more resources should be made available for that purpose. At the same time, STPs and TBIs should be integrated with other Government programmes designed to attain the same ends, such as other technology transfer schemes, through an inclusive “Technology in Business” programme. By emphasizing the essential technology transfer function, such integration might be expected to result in more efficient management and less risk of conflict with other initiatives directed toward technology transfer.

6. Funding

The public sector has proceeded alone in the development of STPs in the Philippines. But this is an expensive initiative that constitutes a drain on the public purse and may not provide public benefits in the short term; even in the long term, benefits are likely to be indirect at best. The answer is collaboration between the public and private sectors, provided private firms can be persuaded to put up development funding. The most appropriate way would be to ensure that STPs provide infrastructure and facilities superior to those found elsewhere in the country. Firms would then have an incentive to locate in STPs, and would be prepared to pay for the privilege. This process should result in the private sector’s paying the lion’s share of STP development costs. Rents alone can never make an STP profitable.

7. Tenants’ management and business skills

TBI tenants are usually start-up firms with very little or no experience in managing a business. For them, management guidance is vital, and should be provided by the incubator. Without such guidance, failure rates will be high and potentially valuable technological opportunities lost. Unfortunately, this important function has usually been poorly performed, or not performed at all. Every incubator should engage an experienced manager to assist tenants in building their management structure; this type of guidance is just as important as incubation and technology transfer activities. Enterprises that are lacking in

management and business skills cannot make good use of technology transfer, and should not be regarded as prospective tenants.

Both site management and management guidance to tenants are important aspects of the operation of TBIs and STPs. Site management is a task that should always be handled by a specialist, since it requires administrative experience as well as experience in technology transfer. It is certainly not a job that scientists should try to do in their spare time. Unfortunately, the institutes hosting the tenants in these incubators and parks have usually been staffed by scientists and engineers with little or no commercial experience. Moreover, they have had little interest in business matters. A site manager's responsibilities, however, should not include management guidance, since that is an equally specialized and quite separate responsibility. Training for site managers is available from various international science park organizations.

The indirect benefits of TBI and STP schemes in the Philippines are likely to be more important than their direct benefits, since the latter will probably continue to be quite limited and modest in their effects, according to the assessment. The technology ventures that these schemes can initiate will never constitute more than a very small fraction of all firms in the Philippines. The indirect benefits are mainly the result of the stimulus provided by start-up firms that have gone through the incubation process to those that have not. Start-ups that have graduated from an incubator are visible evidence that more can be achieved when the right technological and commercial resources are combined. This in turn should encourage other firms to review their structure, methods and tools, thereby enhancing their competitiveness and productivity. Graduate firms also constitute good promotional tools for the TBI and STP schemes, and the ultimate result may be more effective links between R and D institutions and industry. One unanticipated consequence of the TBI scheme has been an exodus of scientists and engineers from public-sector academic institutions to establish or join start-up firms in TBIs. The main reason for that exodus is the much higher salaries paid by those firms, which may be up to four times those paid by the academic institutions.

One important lesson that can be drawn from the TBI experience in the Philippines is the importance of combining a well-thought-out policy framework with a reasonable implementation programme. The goals of such initiatives should be defined in the policy framework, no less than their integration with other programmes, funding and tenant and site selection criteria. The implementation programme should include the provision of good infrastructure, appropriate skills in technology and management, a performance monitoring scheme for both tenants and TBIs, and the recruitment of successful demonstrator firms.

C. MEXICAN INITIATIVES

1. *Mexican UNDP network*

The Mexican Confederation of Industrial Chambers (CONCAMIN), the Fundación para la Tránsferencia Tecnológica a las Pequeñas y Medianas Empresas (FUNTEC), the United Nations Development Programme (UNDP), and the United Nations Industrial Development Organization (UNIDO) launched the Programme of Industrial Integration (PII) in the second half of 1997. PII purports to stimulate and support up to twelve local projects to foster both SME networks and small-large firm subcontracting networks.

The first two projects, launched in the States of Chihuahua and Jalisco, focus on the latter type of networks. In Chihuahua, the private sector counterpart organization is the association of "maquiladora" firms; in Jalisco, the private sector counterpart organization is the Cámara de la Industria Electrónica. In both cases, the operating cost of the projects is shared equally between the private sector counterpart, the local government, and PII.

At the time of the UNIDO report (1999), both projects were in the process of establishing technical centres to: (a) help firms identify subcontracting opportunities; (b) co-operate with technical personnel of the larger firms on activities to upgrade the capabilities of the identified subcontractors; and (c) channel technical support and, if needed, loans to the identified subcontractors to help them meet contractor requirements.

These centres can produce significant benefits for the main contractors. They can also raise transaction costs, at least during the initial phases. Potential benefits include:

(a) Co-ordination of demand for the goods and services of the main contractors, thus allowing lower input prices and justifying higher investments by the subcontractors;

(b) Co-ordination of supply and establishment of horizontal networks among subcontractors, which is expected to bridge the gap between the large firms and their much smaller suppliers in terms of production capabilities, technology and management;

(c) Higher transaction costs may be the result of the required collective action to establish and maintain the centre, requiring consensus over the network's design and the co-ordination of the technical inputs for its management. The role of PII is precisely to decrease these costs by speeding up the decision-making process at the firm level, decrease negotiation time, facilitate the emergence of consensus, and co-ordinate agent contributions to the co-operative activity.

Importantly, the two subcontracting centres in Chihuahua and Jalisco differ from such activities in other countries in that they do not operate on the premise that the main obstacle to linking the demand and supply of subcontracting services is an information failure. Instead, the two centres concentrate primarily on technical support addressing the basic problems of capacity failure and difficulty in establishing relationships based on trust. Needless to say, the information gap is also addressed through the use of data banks on demand and supply.

An early lesson from this experience has been that large firm commitment increases significantly when, in addition to financial resources, the firms in question also contribute their own personnel to the project. This further contributes to making the programme demand-led. It also facilitates the transfer of knowledge to subcontractors.

2. Mexican knowledge networks and "Knowledge Spaces"¹⁰

(a) Background

Mexican S and T policy has gone through several permutations. As regards the relationship between academia and the private sector, there have been four identifiable stages since the 1960s.¹¹ The first, which lasted until the mid-1970s, was dominated to a large extent by the academic elite concentrated in Mexico City, particularly at the National Autonomous University of Mexico (UNAM). The National Council of Science and Technology (CONACYT), the first and basic institutional embodiment of national S and T policy, was established during this era (in 1970); it, too, initially focused its activities on academics.

The second stage, which extended into the mid-1980s, represented a model of policy co-ordination based on state authority. This stage was characterized by an expansive planning project and the creation of a host of S and T-related institutions. S and T policy activities were taken over by bureaucrats who promoted the idea of integrating supply and demand for knowledge. The first mechanisms for financing and promoting co-operation among public research centres, universities and industry were put in place. As a result of the hierarchical structure of the system and the economic crisis during this period, however, the effect was minimal. Industry, largely protected from foreign competition, continued to be uninterested in S and T, most of which was undertaken in universities.

¹⁰ This section is based on R. Casas and M. Luna, "Government, academia and the private sector in Mexico: towards a new configuration," *Science and Public Policy*, 24, 1 (1997), pp. 7-14 and R. Casas, R. de Gortari and M. J. Santos, "The building of knowledge spaces in Mexico: a regional approach to networking," *Research Policy*, 29 (2000), pp. 225-241.

¹¹ Casas and Luna, "Government, academia and the private sector".

During the late 1980s, Mexico introduced radical changes, including economic liberalization, the opening-up of its economy through the North American Free Trade Agreement (NAFTA), and State institutional reform. As part of this transformation, the government embarked on a programme for educational, scientific and technological modernization reflecting the more general market orientation. Some important features introduced at that time include the substitution of programme evaluation for planning; the integration of economic and scientific guidelines and the introduction of evaluation criteria such as competitiveness and productivity; private sector intervention in the functioning and financing of educational and research systems; and the participation of the private sector in policy making. Still, the State continued to play a very important role.

It is argued that since the mid-1990s, Mexico has entered a fourth stage in S and T where the government emphasizes the establishment of relations between the various agents, such as between the universities and industry. The private sector appears in government policy both as a rationalizing element of the education system and as a factor in its modernization. A multitude of new S and T institutions reflect the push for the “triple helix” of government-university-industry collaboration. Universities have undergone serious transformations in terms of opening up to the private sector as a source of funding and in terms of orientation of their research (which is said to have more concrete (economic) aims today than the broad advancement of knowledge). The private sector’s attitude towards public universities also seems to have changed dramatically—under increasing competitive pressure at the marketplace and government encouragement—from the earlier indifference (and political conflict) to an unprecedented willingness to cooperate.

(b) *Public research centres and knowledge networks*

The new emphasis on public-private partnerships and the accumulated capabilities in firms and universities provides opportunities in specific regions for the emergence of so-called “knowledge spaces.”¹² The term is meant to capture regional spaces with accumulated underutilized knowledge and emergent knowledge flows between actors giving rise to knowledge networks.

Traditionally, research activities in Mexico have been concentrated in universities. Industry has invested very little out of its own resources. The government has also promoted two systems of research-active public research centres (PRCs): the SEP-CONACYT system and the CINVESTAV system. SEP-CONACYT, promoted by the Ministry of Public Education and CONACYT since the 1970s, is made up of three groups: (a) the science centres, focusing on basic research; (b) the technology centres, oriented to the needs of regional industries and economic development; and (c) the social science centres. The SEP-CONACYT system receives close to one fifth of the federal S and T budget. Science and technology centres employ approximately 900 researchers.

The CINVESTAV system was created by the government in 1961 with the mandate to train researchers and develop original projects in various scientific and technological fields in order to improve the standard of living of the population and stimulate economic development. Initiated in Mexico City, these centres have decentralized to other states, and have diversified their focus to reflect the needs of the local economies. They account for approximately seven per cent of the federal S and T budget.

The Bajío region is one where knowledge capabilities have been accumulated in different institutions and where various kinds of networking have been identified. The economy of the region is diverse, comprising agriculture, livestock, agro-industry, petrochemicals, clothing and textiles, engineering, the automotive industry and electronics. The region accounts for a little more than one third of the country’s R and D activity, mainly concentrated in PRCs in the States of Queretaro and Guanajuato. Queretaro is also home to a rising number of innovative private firms, principally in electronics, machinery and equipment design, home electrical appliances and services.

¹² Casas *et al.*, “The building of knowledge spaces”.

An example of an important PRC in the Bajío region is the CINVESTAV-Irapuato PRC, created in 1981 in Guanajuato. This is the primary institution in the country for plant biotechnology, undertaking basic research with a strong orientation toward regional agricultural problems. Another example is the Centre of Research and Technological Assistance (CIATEQ), a SEP-CONACYT technological PRC, located in Queretaro. CIATEQ specializes in materials, and is one of the most important technological centres in this region. In addition to PRCs, however, technological capabilities in Bajío are accumulated in private centres. An example is the Long Distance Supervision National Centre (LDSNC), a private service centre located in Queretaro which is in charge of the long-distance network of the main Mexican telecommunications firm (TELMEX). LDSNC was created after TELMEX was privatized, and concentrates the functions of maintenance, supervision and long-distance technology acquisition for the firm.

The role of PRCs in developing “knowledge spaces” in the Bajío region is considered very important. Extensive collaborative interactions among agents and learning processes involving PRCs have been identified that lead to the creation of knowledge networks. These include:

1. Collaboration among PRCs. For example:

(a) Vertical interactions among PRCs, universities, and other institutions of higher education in the region for human resource training of relevance to local firms at both the undergraduate and graduate levels (an example is CIATEQ);

(b) Collaborative R and D activities between PRCs. For example, CINVESTAV-Irapuato collaborates with INIFAP (the National Research Institute on Agriculture, Forestry and Cattle) in developing virus-free potato plants;

(c) Provision of services and research subcontracts for other PRCs. For example, CIATEQ certifies and tests raw materials for the metal-mechanical industry and other PRCs.

2. Interactions between local and international firms. For example, LDSNC works closely with ALCATEL of France, playing a very active role in product and service maintenance, modification and improvement.

3. Knowledge flows from PRCs to firms. For example, CIATEQ has traditionally worked very closely with metal engineering and metallurgy firms in the region. This specialization has also produced offshoots in terms of collaboration with the industries producing capital goods for agriculture and the sugar milling industry.

4. Knowledge flows from PRCs to farmers’ associations. For example, extensive flows to farmers have materialized in plant biotechnology involving CINVESTAV-Irapuato (strawberries are a case in point). Farmers’ associations are beginning to play an important role in establishing interactions with PRCs and in attracting support from local governments for that purpose.

5. Networking between PRCs and multinational corporations (MNCs). Networking to transfer knowledge from a MNC to a PRC has been relatively infrequent. An example of extensive research interaction was between CINVESTAV-Irapuato and Monsanto to transfer the foreign firm’s technology for virus-free potato plants to Mexican varieties of potatoes.

6. Networking between multiple actors. There have been many examples of the two PRCs and the one private service centre collaborating with many agents. However, relationships are still dominated by bilateral collaborations and have not evolved into the adoption of interactive processes among all the agents.

All in all, important factors that sustain knowledge spaces in the Bajío region are said to include:

(a) PRCs that have accumulated knowledge in different fields and have oriented their activities towards regional problems;

- (b) Sufficiently trained entrepreneurs and technicians that understand the role of PRCs in technological solutions;
- (c) Informal networks that have made individual learning possible;
- (d) Active local governments interested in the creation of knowledge networks;
- (e) The efforts of all agents (PRCs, firms, associations and local governments) to find windows of opportunity in the national and global economies.

3. *Panama's City of Knowledge*¹³

The departure of US troops from the Panama Canal in the late 1990s meant that a number of sites became available for peaceful purposes. One such site, previously known as Fort Clayton, consisted of a large complex of well-maintained buildings surrounded by 120 wooded hectares at the tip of the Pacific entrance to the Canal and within the limits of Panama City. The Government of Panama moved swiftly on Fort Clayton. Armed with a feasibility study prepared by the Academy for Educational Development in Washington, DC, a strategic plan prepared by UNESCO, a business plan developed by the InterAmerican Development Bank, and a feasibility study for the industrial development component conducted with the technical support of the European Commission, it established what it called a "City of Knowledge" (Ciudad del Saber), which opened officially in February 2000. Comprising academic programmes, research programmes, a technology park and a Forum, the City of Knowledge is currently one of the most ambitious experiments in Central and South America, and one that is bound to be widely replicated if successful.

The City of Knowledge (the City) operates with statutes and internal by-laws and in compliance with Law No. 6 (*Official Gazette* No. 23,480, February 1998). Its mandate is worded as follows:

"The City of Knowledge is an international complex of academic, scientific, research, and technological development, industrial and cultural institutions, which converge within a context of integration of efforts with the purpose of promoting the generation, dissemination, and use of knowledge for achieving an integral human development.

Our mission is to identify and facilitate links and associations between Academic, Research, and Technological Innovation Institutions, in areas where human development can be promoted through scientific and humanistic knowledge." (www.ciudadelsaber.org.pa/en/academia/, p.1).

The synergies between universities, domestic and international industry and research institutes located in and around the complex are regarded as the dynamo powering the anticipated engine of growth for the local economy. Panama's strategic geographic location, unusually rich natural diversity and multifaceted cultural heritage are considered some of the strong selling points of the City. Not to be underestimated, the City offers ultra-modern telecommunication and computer infrastructure, modern working installations, convenient access to an international airport with frequent connections to most destinations, comfortable living conditions, close proximity to Panama City, and a location between the Panama Canal and a natural park.

(a) *Academic programmes*

The City envisages six priority areas under which the academic and research programmes for development will be integrated. These areas have been selected on the basis of Panama's heritage, the potential derived from its geographic location, and the availability of opportunities for knowledge development through various forms of interaction. The priority areas are:

¹³ This section is based on secondary information from the Web site www.ciudadelsaber.org.pa. There has been no effort to validate this information.

- (a) International business and trade;
- (b) Information technology and educational communication;
- (c) Tropical biological and ecological studies;
- (d) Intercultural and artistic studies;
- (e) Engineering and environmental design;
- (f) Strategic studies for development.

Several local institutions have already been brought together to offer a broad range of academic programmes. These include the University of Panama, the Gorgas Memorial Institute for Health Studies, the Smithsonian Tropical Research Institute, Santa Maria La Antigua University, and the Technological University of Panama. Further agreements and associations with local and foreign institutions of excellence interested in affiliating with the City of Knowledge would be welcome, as they would contribute to the further strengthening of these areas of priority.

An important strategic objective is to build interinstitutional and interdisciplinary projects through clusters of two types:

(a) Clusters that concentrate activities in an area, while cutting across the four basic components of the City of Knowledge (education, research, technological park and forum). Local as well as foreign institutions with complementary strengths can participate in an articulated effort;

(b) Clusters that establish links of an interdisciplinary and intersectoral nature—i.e., activity in two or more priority areas—while also cutting across the four basic components of the City of Knowledge (education, research, technological park and forum).

For example, a group of institutions can set up a cluster to generate and transmit knowledge in matters related to the use of tropical biodiversity. A more complex cluster could also combine aspects of health and tropical medicine. Collaboration between universities, research institutes, and industry in a cluster would make it possible to cut across the different components of the City of Knowledge.

The City currently offers rental space for offices, laboratories and other infrastructure for the academic programmes established there. It also offers maintenance and security services. Central library facilities, information and documentation, auditorium and computer services are planned for the near future.

(b) *International Technopark*

The International Technopark of Panama (ITP), a full member of the International Association of Science Parks, aims at linking research and technology organizations with industry to raise the competitiveness of the programmes and companies involved. More specifically, the following objectives were outlined for ITP:

(a) “To offer suitable conditions for the scientific and technological development of national and international companies, with regional vocations;

(b) To offer suitable buildings for non-polluting activities, related with the new technologies and its Research and Development;

(c) To carry out a joint collaboration and work between the National Secretariat of Science and Technology (SENACYT in Spanish), the University, industry and research, promoting the creation of new companies and the transformation of existing companies by the application of modern techniques.”¹⁴

ITP became operational in December 1999 on a 20-hectare site. An additional 40 hectares has been planned. It provides a wide array of services and infrastructure of excellent quality. The Technopark does not specialize in any particular technology and industry sector. It purports to attract both production and service-related activities by high-technology firms. Companies interested in locating in the park must, at a minimum, comply with the following conditions:

¹⁴ www.ciudadelsaber.org.pa/en/technopark/, p1.

- (a) They must not pursue polluting activities;
- (b) At least five per cent of their annual gross sales must be devoted to R and D;
- (c) At least five per cent of their personnel must be technically qualified.

ITP's advantages are considered to include its geographical position—both locally, facing the Miraflores Locks of the Panama Canal (the first locks in the Pacific Ocean side) and bordering a national park, and internationally—convenient access to Panama's International Banking Centre, the dollarization of the Panamanian economy and the country's biodiversity. ITP participants also enjoy tax-free operations, special immigration status for affiliated personnel and their families, and the availability of facilities for lease at competitive rates.

A notable feature of ITP is its close communication with non-profit institutions like the University of Panama, the Smithsonian Tropical Research Institute and the Gorgas Memorial Laboratory for Health Studies, and with research centres that are keenly interested in applied research, working in collaboration with the private sector. ITP also has strong links to the European Union, expediting the participation of companies in the various European R and D programmes.

ITP is developing two activity clusters: a biological cluster and a communications cluster. The biological cluster draws on Panama's remarkable biodiversity, which features 13 distinct life zones with a great variety of flora and fauna, high mountains with cloud forests, rain forests, dry savanna, long coastlines, coral reefs and deep oceanic water. The communications cluster has two lines of action—information technology and multimodal transportation—which draw on the country's geographical position and the nodes that converge in its territory.

Information technology plays a key role in the development of ITP. As a result of its unique global position, Panama is becoming attractive to worldwide data communications businesses. International undersea fibre optic cables converge on the Isthmus—Pan American, Global Crossing, Maya, Project Oxygen, Arcos and others. A number of multinationals, including Xerox, Citigroup, and OMNES Schlumberger, have joined Panama's IT cluster, which also includes companies specializing in software, telecommunications, e-commerce, electronic libraries and video conferencing.

Panama reckons that it has a competitive advantage for multimodal transportation on the strength of its interoceanic canal, international transport with the longest airstrip in the Latin American region (open to international aviation 365 days a year), and an 80-kilometre distance between the Atlantic and Pacific Oceans that is very favourable for the transfer of cargo by truck, train or ship. In addition, Panama has been active in the international commercial maritime transportation industry for a very long time. This industry has undergone significant changes in terms of technology and administration that open up promising opportunities in the area of maritime support services. The multimodal transportation cluster aims at attracting companies and other organizations that:

- (a) Are able to develop and implement new concepts and technologies for linking the different elements of the transportation system to improve the overall efficiency of the system;
- (b) Specialize in transportation logistics using technologies such as Global Positioning System (GPS), Electronic Data Interchange (EDI), logistic automation and the like;
- (c) Specialize in providing a wide range of value-added services, including transportation routing and sourcing, transportation management services, storage and transportation of dangerous goods, tracing and freight auditing services, carrier payments clearinghouse and so on.

Finally, in April 2000 ITP initiated an incubator for technology-based firms within its premises, housed in a building with approximately 2,000 square metres of floor space. The incubator is governed by a Board of Directors with members from the private sector. An Executive Director and an administrative assistant currently run it. The full-service incubator offers:

- (a) Facilitation (tutoring) and training to insure the proper formation of a company;

- (b) Assistance in preparing the feasibility study and business plan, and the location of business opportunities and markets;
- (c) Assistance in the creation, legal constitution and experimental launching of a company;
- (d) Assistance in contacting and obtaining finance;
- (e) Facilities for the installation of the company for two years of incubation;
- (f) Reasonable rent, maintenance facilities and security of the installations;
- (g) Convenient access to administrative services and other office services, including secretary, photocopy, organization of events, visas, labour permits, legal incorporation of companies and so on;
- (h) Access to R and D through ITP companies and other organizations;
- (i) Consultancy in business administration, marketing strategy design, legal advice and the like;
- (j) Use of the broad amenities of ITP.

Companies leaving the incubator may choose to locate in the Technopark. A large number of companies and other organizations have already set up operations in the park, including some well-known multinationals as well as local firms. It is reported that additional applications from companies such as 3M, Autodesk, Bayer, Volkswagen, Novell, Oracle, Xerox, and several less well-known companies are currently pending. The incubator currently reports nine project applications, a relatively large number for a brand-new operation.

4. Chilean "Development Projects"¹⁵

(a) Background

Chile has two bodies charged with advising the President on S and T policy matters and with promoting S and T: the National Commission for Scientific and Technological Research (CONICYT), established by law in 1968 and operating under a Decree (Ministry of Education, 1971), and the Presidential Advisory Commission on Scientific Matters, created in 1995. The second body's mandate is limited to science, and consequently it is outside the scope of this paper.

CONICYT has been the main body for advising on and implementing S and T policies. It has carried out the latter function through its management of the major funding tools for scientific and technological research in the country, FONDECYT, FONDEF and FONTEC. FONDECYT was created in 1982 and focuses on science. FONDEF was launched in 1991, as a result of close collaboration between the government and the Inter-American Development Bank, in recognition of the increasing importance of research to the economy and society and of the diverse kinds of research that must be supported through differential instruments. FONTEC's objectives are to increase the quantity and quality of R and D and

¹⁵ This section is based on the following:

- J. Humphrey and H. Schmitz, *Principles for Promoting Clusters and Networks of SMEs*, Paper No. 1, Small and Medium Enterprises Branch, United Nations Industrial Development Organization (Vienna: UNIDO, 1995).
- J. Levitsky, *Support Systems for SMEs in Developing Countries: a Review*, Paper No. 2, Small and Medium Enterprises Branch, United Nations Industrial Development Organization (Vienna: UNIDO, 1996).
- J.R. Mullin, R.M. Adam, J.E. Halliwell and L.P. Milligan, *Science, Technology, and Innovation in Chile* (Ottawa: International Development Research Centre, 2000).
- P. Perez-Adelman, "Learning, adjustment and economic development: transforming firms, the State and associations in Chile," *World Development*, 28, 1 (2000), pp. 41-55.

scientific services with a significant impact on the productive sector; to facilitate the transfer of knowledge and know-how to the productive sector through collaborative activities between R and D performers and business; and to increase the concentration of R and D activities in areas of high priority to the national (economic) interest. A third fund, FONDAP, was added in 1997. This programme fosters long-range research in areas (a) that are important for national development and (b) in which there is a critical mass of high-quality researchers.

While it is administered by CONICYT, FONDEF also falls under the policy umbrella of Programme Innovación Tecnológica (PIT) of the Economics Ministry. Following the rapid growth of the Chilean economy in the early 1990s, and in order to stimulate a transition to the next phase of economic development (innovation-led development), PIT identified five priority areas:

- (a) Promotion of technological innovation;
- (b) Modernization of SMEs;
- (c) Development of clean production methods;
- (d) Development of national infrastructure and communication policy;
- (e) Promotion of competitiveness in a global environment regulated by the WTO.

An Executive Secretariat in PIT co-ordinates six funds supporting R and D:

- (a) National Fund for Technological and Production Development (Fondo Nacional de Desarrollo Tecnológico y Productivo, FONTEC);
- (b) Fund for Development through Science and Technology (Fondo de Fomento al Desarrollo Científico y Tecnológico, FONDEF);
- (c) Fund for Economic Development and Innovation (Fondo de Desarrollo e Innovación, FDI);
- (d) Foundation for Agricultural Innovation (Fundación para la Innovación Agraria, FIA);
- (e) Mineral Resources Research Fund (Fondo de Investigaciones Mineras, FIM);
- (f) Fisheries Research Fund (Fondo de Investigaciones Pesquera, FIP).

FDI was created in 1995 to provide a competitive mechanism for dispersing funds to the five CORFO¹⁶ institutes—CIREN, IFOP, INFOR, INTEC, and INN—when the baseline government funding for those institutes was withdrawn. Since 1996, the institutes have bid competitively for funds in exchange for services to the public or private sector. They have always focused on traditional activities, including forestry, fishing, aquaculture and agriculture. These activities still define the focus of FDI.

The experience of CORFO best represents the move during the 1990s toward more active S and T strategies to promote the international competitiveness of strategic sectors by facilitating the adoption of new technologies, reorganizing enterprises and increasing productivity. Until 1973, CORFO engaged in programmes aiming at enhancing the technological capabilities of both public and private enterprises. The military government sharply curtailed its activities, but since the resumption of democratic rule in 1990, however, CORFO's role has been reinvigorated.

A new role for CORFO has been to promote and facilitate firm reorganization. In that capacity, CORFO launched the Proyectos de Fomento (PROFOs), a new, experimental activity (see the following section for more details) in the early 1990s. Administered by a CORFO subsidiary, the Technical Cooperation Service (SERCOTEC), PROFOs fall within the purview of the National Support Programme for SMEs (Programa Nacional de Apoyo a la Mediana y Pequeña Empresa), aiming at the modernization of those enterprises.

¹⁶ Development Corporation (Corporación de Fomento).

(b) *Development Projects*

The evolution of SERCOTEC has naturally followed that of CORFO. It has been active since the 1950s in providing a nationwide support system for SMEs, combining credit programmes (directly for very small firms and indirectly through banks for larger SMEs), technical consultation, management training, and marketing and export assistance. It reached its peak in the early 1970s, and then went out of favour with the military regime. More recently, SERCOTEC has once again become very active in supporting SMEs, essentially by providing traditional extension services to individual businesses and by supporting business associations.

Activities with associations are aimed at promoting collaboration between firms. Such activities reportedly include the orchestration of co-operative buying (raw materials and other inputs) and selling operations, credit and savings co-operatives, clearinghouses for subcontracting relations, export committees, design centres, incubators and industrial parks. Development Projects (Proyectos de Fomento, PROFOs) fall within this category of SERCOTEC activities.

The PROFO programme is aimed at creating small networks of firms. Its objectives are to create inter-firm co-operation, to increase the acceptance of other services provided by SERCOTEC, and to create focal points in local economies that will stimulate development. These objectives rest on a series of premises, including:

- (a) The biggest problem for SMEs is not size per se but isolation;
- (b) SERCOTEC services do not reach far enough; acceptance must be increased;
- (c) Dynamic clusters of firms can have a positive impact on their localities;
- (d) Public-private partnerships are important for development.

A PROFO is formed by a group of firms in the same sector and geographical vicinity, producing similar or complementary products, and aiming at enhancing their competitiveness. The group is relatively small, typically ranging between 10 and 30. SERCOTEC promotes PROFOs for the domestic market, whereas the Association of Small Export Manufacturers (ASEXMA) promotes PROFOs of exporting SMEs along similar lines. Any group of firms may, in theory, apply for a PROFO. However, they must convince CORFO that there is a basis for collaboration with clear short- to medium-term goals.

CORFO commits to finance up to 70 per cent of the PROFO's operating costs for three years, with the member firms picking up the balance. A group manager is hired to help firms articulate a workplan for putting into effect a programme for modernization and technology upgrade. A common commercial strategy is prepared and implemented. Other PROFO activities include product exhibitions, hiring of consultants, seminars, management training and, occasionally, setting up a common services centre. The understanding is that, in the case of consensus, member firms of a PROFO will continue to work together beyond the initial (subsidized) three-year period through a common technology transfer centre, a common marketing company, and/or other joint operations.

There are three stages of PROFO development:

(a) A preparatory stage involves work by CORFO to identify candidate firms in a vicinity and establish its credibility with them. SME owners around the world are not easily convinced that public intervention can have positive results for them; skepticism must be overcome with personal contacts and problem-solving;

(b) A second stage of consolidation initiates the PROFO-building process. A group manager is hired whose immediate tasks include the improvement of delivery and take-up of further support services from CORFO subsidiaries. This becomes easier now, since joining forces enables PROFO member firms to project a larger image to attract the attention of service providers in such areas as finance, training and the like. A second task includes improving relations between the participating firms through common functions. A third task of the manager is to build the image of the group and promote its activities. Semi-annual

progress appraisals focus on success in areas such as product design, process improvement, human resource management and so on;

(c) A final stage follows the termination of the government subsidy. The goal of each PROFO is to prove itself self-sustaining after the initial three-year period. In that time period, PROFO member firms must be able to prove (primarily to themselves) that together they have been able to improve their competitiveness and performance and must be willing to shoulder all responsibility for funding the group (or the group will dissolve).

During the second half of the 1990s, the PROFO programme reported many successes. In fact, early results exceeded SERCOTEC's expectations, encouraging the agency to expand the programme to include export PROFOs. Perez-Adelman¹⁷ uses an example from the footwear sector to demonstrate the processes that can be generated by these groups. In the early 1990s, the footwear sector was feeling the pressure of a liberalized trade regime, appreciating exchange rates and rising wages. The gains that had been achieved in the late 1980s on the basis of competitive prices due to a depreciating exchange rate seemed unsustainable. The old strategy of depending on suppliers to cut costs while relying on outdated production techniques was clearly proving unsuccessful. Not only were footwear firms losing foreign markets, they were losing market share in a growing domestic market as well.

Under these conditions, a footwear PROFO was organized in 1993, initially aiming at locating new customers in foreign markets. Government funds were initially used to finance trips abroad. Only gradually, as members were unsuccessful either in capturing foreign markets or in increasing domestic market share did they come to see the PROFO as a resource that they could use to upgrade their productive capabilities. With some additional government assistance, they began to reorganize and set up a new organization, the Technical Footwear Institute, which focuses on assisting the internal reorganization of firms by making available information about new plant layouts, design technology and quality control management practices.

The basic idea behind PROFOs is to facilitate SME modernization based on the initiative and responsibility of the firms themselves, with only initial financial help from the government. The State provides general goals and relies on decentralized authority and private initiative to achieve those goals. The goals may include lowering production costs, increasing yield, increasing quality, adopting new technology, diversifying products, and obtaining internationally recognized certifications (such as ISO). Through the sharing of goals and experiences and the evaluation of management strategies and organization, collective learning processes are generated. The hope is that these will initiate emergent dynamic clustering situations.

¹⁷ Perez-Adelman, "Learning, adjustment and economic development."