Science and Technology for Development:

An IDB Strategy

Inter-American Development Bank

Washington, D.C.

Sustainable Development Department
Sector Strategy and Policy Papers Series

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library

Castro, Claudio de Moura.
Science and technology ; an IDB strategy / [written by Claudio de Moura Castro, Laurence Wolff, and John Alic].

p. cm. (Sustainable Development Departement Sector strategy and policy papers series ; EDU-117)
"The science and technology strategy (GN-1013-2) was favorably considered by the Board of Directors of the Inter-American Development Bank on October 4, 2000"--t.p. verso.

1. Science--Latin America--Economic aspects. 2. Technology--Latin America--Economic aspects. 3. Inter-American Development Bank. I. Wolff, Laurence. II. Alic, John. III. Inter-American Development Bank. Sustainable Development Dept. Education Unit. IV. Series.

303.483 C457--dc21

This document was written by Claudio de Moura Castro, Laurence Wolff and John Alic. Juan José Llisterri made valuable contributions to the sections on technology. The document is based on various background papers, including *Closing the Gap,* by Román Mayorga (published by the Sustainable Development Department); *Science and Technology Program Evaluation*, *Synthesis Report*, published by the IDB's Evaluation Office and *Technology, Science and Development in Latin America and the Caribbean: Background Paper* by Claudio de Moura Castro and John Alic. This document also benefited from participants' comments during a seminar on the diffusion, assimilation and use of technology by private firms in the region, organized by the IDB in February 1998. Similarly, many international experts also contributed with their comments. They are: Román Mayorga, Carlos Abeledo, Gregorio Arévalo, Helio Barros, Guillermo Cardoza, Glenn Westley, Pedro Sáenz, Ruben Echeverría, José Guaranys, Lauritz Holm-Nielsen, Daniel Levy, Isaias Raw, Simon Schwartzman, Juan Carlos del Bello, Carlos Federico Paredes Castillo, Eduardo Sibaja Arias, Arnoldo Ventura, Eva Stal, Santiago Carrasco Toral, Sergio C. Trindade, Colin Adamson-Macedo, Victor Hugo Calahorrano and Andrés Lalanne. This document incorporates observations made by Carlos Aguirre Bastos, Fernando Chaparro, Juan Carlos del Bello, Mahabit Gupta, Ivan Lavados, Marcos Mares Guia, Carlos Bazdresch Parada, Francisco Sagasti and José Israel Vargas during a consultation meeting held in Washington, D.C., on September 21, 1998.

The science and technology strategy (GN# 1013-2) was favorably considered by the Board of Directors of the Inter-American Development Bank on October 4, 2000.

April 2001

This publication (No. EDU-117) can be obtained through:

Publications, Education Unit
Inter-American Development Bank
1300 New York Avenue, N.W.
Washington, D.C. 20577
E-mail: sds/edu@iadb.org
Fax: 202-623-1558
Web site: *www.iadb.org/sds/edu*

Foreword

This paper reviews and updates the Bank's strategy for supporting science and technology in Latin America and the Caribbean. Beginning with the fundamental importance of science and technology in the globalized economy, the paper reviews conditions in the region, the Bank's experience to date, and the challenges ahead. The IDB's current strategy for support of science and technology in the region emphasizes a strong sectoral and system-wide approach; the importance of increased support for technological development in the productive sector; continued support of scientific research but with a more focussed approach and increased linkages with technology; and strengthening of related human resource and institutional development. In addition, the Bank is placing a new emphasis on science and technology development in smaller poorer countries. On the basis of the paper, the IDB has already increased its lending for science and technology which, it is hoped, will have an important impact on economic and social development in the region.

Carlos M. Jarque
Manager
Sustainable Development Department

Contents

Summary

SCIENCE AND TECHNOLOGY IN THE WORLD ECONOMY

Economic globalization and the world technology revolution, especially in telecommunications and information technologies, define the context in which all countries will have to perform, and make technology even more important than in the past. Since technologies develop and change very quickly today, a greater command over technological innovations will be a powerful ingredient in the economic success of countries in the global market.

Technological progress leads to and results from innovations, which are broadly defined as the processes by which firms master and put into practice product designs and processes which are new to them. National innovation systems (NIS), a term now much employed in the current literature (but not always well understood), can be defined as "a network of institutions in the public and private sectors whose activities and actions initiate, import, modify and diffuse new technologies." The emphasis is on the enabling environment that fosters innovation and technical change and on the linkages between all the actors involved in innovation, both within and across nations.

SCIENCE AND TECHNOLOGY IN LATIN AMERICA AND THE CARIBBEAN

Latin America and the Caribbean need to gear up and structure their economies to succeed in the new world environment. But productivity growth in the hemisphere as a whole was less than half the world average during the 1973-1992 period. Scientific and technological productivity, in terms of publishing in reputable journals, as well as in patents, is below the region's competitors. In addition, while high-income economies typically spend 2-3 percent of GDP on research and development (R&D), investment in R&D in the 1996-1999 period ranged from 0.6 to 0.8 percent for a few countries to less than 0.1 percent for others. Finally the public sector in most countries in the region accounts for over 70 percent of R&D funding, compared to around 25 percent in some of the newly industrialized countries of Asia and less than 50 percent in most industrialized countries.

The region has made some progress over the past years. Some middle-income countries have built up capacity in scientific research, some medium- and large-size businesses in the region already know how to effectively use advanced technologies, and in several countries a network of public institutions supporting innovation is in place. But on the aggregate, society does not get adequate payoff from its investment in science research because the effort is often geared to areas which do not have the corresponding technological and productive activities, and linkages between university based research and the productive sector are inadequate. Institutional elements (e.g., transparency in decision making, priority setting, and monitoring) require improvement and the numbers and quality of researchers are still low. The majority of private firms spend too little on R&D and have little or no tradition of technological innovation or understanding of their needs. Public and private efforts in technology remain too small as compared with the potential for innovation and the needs of the countries. Agencies providing loans and grants to R&D, while they have had significant successes, are still slow to act, often overly bureaucratized, and with inadequate capacity to evaluate and assess their own efforts. The smaller, poorer countries in the region have almost no institutional S&T framework, except for a few universities, and their small and medium enterprises usually have no R&D capacity or understanding.

THE PAST ROLE OF THE IDB

The Bank has long recognized the importance of S&T and has made major contributions to strengthening country capacities. During the period 1962-1995, US$1.4 billion went to 31 operations defined as science and technology projects, with total project size (loan and counterpart) estimated at US$2.6 billion. Multiple IDB loans for S&T have gone to Brazil, Mexico, Argentina, and Colombia, and single loans were made to Venezuela, Chile, Costa Rica, Uruguay, and Ecuador. The objectives of past IDB lending for S&T were to build human and physical infrastructure, especially in universities; strengthen science funding agencies, especially by channeling funds through peer review and open competition; encourage private sector investment in R&D through technology development funds; and support individual research institutions of merit. Based on earlier drafts of this document, a new set of loans totaling US$350 million to Argentina, Guatemala, Uruguay, Panama, Venezuela and Chile were approved during the period 1998-2000.

IDB support has had positive payoffs in applied research, provision of continuity in times of financial constraints, establishment of institutions, strengthening of decision-making capacities of these institutions, and training of many researchers, teachers, and high level industrial workers. Some technology investments have had payoffs which more than justify the amount of the loans. The S&T portfolio has performed well above the Bank average in terms of project execution and disbursement. In spite of these efforts, science and technology institutions continue to be inadequate for their purposes. Efforts to improve linkages between public sector research and society have been less successful than desired. Spin-off results from IDB supported technology development funds have had little impact on the overall investments of firms in R&D.

REGIONAL PRIORITIES

Based on the above analysis, the region as a whole needs to strengthen national innovation systems and to seek to link them with the global knowledge society, as a means of ensuring economic and social progress. The critical objectives are: to get firms and other institutions to increasingly incorporate new technology into production and related processes; to increase the amounts, effectiveness, and productivity of investments in science and technology; to increase the numbers and quality of higher level human resources; to ensure closer linkages among the different components of the systems; to strengthen international cooperation in S&T; and to complement all these actions with investments in basic, secondary, and higher education and in training.

Most countries in the region will need to increase overall R&D spending as a percentage of GDP. In the middle-income countries, most of the effort should take place in the private sector. The objective, however, should not be to increase spending per se but to take a systems approach to ensure that the critical elements of national innovation systems are in place and the relationships among them are understood, and to target expenditures where an impact on long-term growth can be expected. Economic policies must emphasize creating a policy and regulatory environment promoting lively competition and ensuring stability and low inflation.

Compared with the past, technology development? increasing the diffusion and utilization of R&D in the productive sector—should be emphasized, redressing a balance that today is tilted toward scientific research, although both need to be strengthened in the future. This especially means strengthening institutions providing finance, information, technical support, services, and standards to the productive sector.

With regard to investments in research, the focus should be on building capacity in critical areas, strengthening institutions and the decision making process, and ensuring a closer match between S&T supply and demand. The region also needs to strengthen all levels of the education and training system to ensure that the labor force will be technologically literate and that the poor will benefit from the fruits of science and technology.

IDB SUPPORT FOR S&T

The Bank will seek to support the regional objectives described above. To ensure that a systems approach is followed and that policies have consensus support, the IDB will promote studies and inquiries as well as broad-based discussions of needs and opportunities. Where appropriate the Bank will undertake or support comprehensive assessments, designed to identify current and prospective bottlenecks to technology and productivity development. In its dialogue with countries, the IDB may propose a limited number of policy changes, either as conditions for loans or as part of the process of project implementation, to ensure all the pieces are in place for technological innovation.

The Bank will increase its support for technological innovation in the productive sector. This will include establishing or strengthening technology development funds (providing lines of credit as well as grants, to support improvements in products or processes which incorporate new or risky technologies not susceptible for investment through a country's normal capital markets), as well as strengthening relevant public and private institutions. It will also include increased support for centers or units that offer information, technical assistance, metrology and quality control services, particularly for small and medium businesses. It will support efforts to reinvigorate technological institutes to ensure that they are demand driven, accountable, and effective. Experience has shown that establishing and strengthening institutions of this type, including an innovation mentality among entrepreneurs, is a complex endeavor requiring a long-term commitment.

The Bank will not abandon programs where governments provide grant financing for basic and applied (pre-competitive) research as well ancillary scientific and technical services projects, but will provide more focussed support, with a particular emphasis on building capacity in critical areas, not only those related to competitiveness but also to social issues such as poverty, violence, and health care. The Bank will also seek to strengthen institutions and the decision-making process, through explicit analytical and consensus building activities, ensure a closer match between S&T supply and demand, and improve quality and cost effectiveness rather than simply increase investment amounts.

The Bank will increase its S&T lending to smaller, poorer countries as a means of helping to ensure that they can also participate in knowledge-based development in accordance with their evolving comparative advantages. For these countries the IDB will assist in identifying strategic fields, increasing the availability of information, developing pilot outreach programs, and, where appropriate, supporting or creating potential centers of excellence.

The IDB will support human resource training designed to strengthen all of the above activities, including short- and long-term training, in academic and nonacademic settings, and in-country and overseas, to upgrade the staff of research, service, financing, and sectoral institutions. The Bank's commitment to increased support of elementary, secondary, and higher education and of training will also have an important long-term impact on S&T development in the region.

The Bank will consider all projects which include technological investments as S&T projects with potential opportunities for increasing the country capabilities in the area, will ensure that concerned departments coordinate their activities in S&T, consult on a regular basis with outside advisory groups, and regularly review the impact of its investments in this area. Annex 1 provides a summary of the Bank's strategy.

Science and Technology in Today's World

This paper reviews and updates the science and technology Bank's strategy for Latin America and the Caribbean. The paper begins with a review of the role of S&T in the world economy. It then reviews conditions in the region, including the Bank's experience to date. Finally, the paper provides guidelines and recommendations for future S&T development. It should be noted that IDB policy has been evolving over the past few years and that the strategy outlined here is not a break from the past but a continuation and intensification of past trends. The recommendations in this paper apply not only to specific S&T projects but also to all projects financed by the Bank which include support for technology-related infrastructure, training, and institutional development. In other words, all projects which include technological investments should be treated as potential opportunities for increasing country capabilities in the area.

The region as a whole needs to strengthen national innovation systems and to link these with the global knowledge society, as a means of helping to ensure economic and social progress. The IDB strategy specifically seeks to assist countries to:

- diffuse and incorporate new technology into production and related processes;
- increase the level, effectiveness and productivity of investments in science and technology;
- increase the numbers and quality of higher level human resources; and
- ensure closer linkages among the different components of the NIS, including the increasingly important international links.

The strategy places increasing emphasis on smaller and poorer countries in the region and will benefit from increasing IDB investments in basic, secondary, and higher education and in training.

THE POWERFUL ROLE OF SCIENCE AND TECHNOLOGY IN ECONOMIC DEVELOPMENT

Technological progress drives economic growth and development, creates jobs, and leads to higher agricultural yields, improvements in human health, and higher quality goods and services at lower prices for consumers. Judicious investments in S&T have a substantial payoff in increased productivity. Most of these benefits appear as increases in productivity, wages, and living standards. Economic globalization and the world technology revolution, especially in telecommunications and information technologies, define the context in which countries of the region will have to perform, and make technology even more important than in the past. Since technologies develop and change very quickly today, a greater command over technological innovations will be a powerful ingredient in the economic success of countries in the global market. Latin America and the Caribbean need to gear up and structure their economies to succeed in this environment.

The critical importance of the process of disseminating and incorporating innovations is now better understood and considered one of the most decisive aspects of science and technology. Hence, a new view has evolved which considers that technological progress generates and results from innovations, which are broadly defined as the processes by which firms master and put into practice product designs and processes which are new to them. This concept can be generalized to innovations outside productive enterprises, including social institutions. National innovation systems, a term which is much employed in the current literature of this field (but not always understood), can be defined as "a network of institutions in the public and private sectors whose activities and actions initiate, import, modify and diffuse new technologies" (OECD). The new emphasis is on the enabling environment which fosters innovation and technical change and the linkages between all the actors involved in innovation. National innovation systems would therefore include:

- macroeconomic conditions and regulatory frameworks providing the environment for innovation in the private sector;
- national systems managing and coordinating S&T institutions;
- communications and information technology;
- the capacity to monitor and assess relevant information;
- mechanisms for linking academic institutions with society;
- scientific and technological services and mechanisms to promote and facilitate the diffusion and transfer of technology, such as metrology, norms and standards, information services, and technological consulting;
- operating conditions and procedures; R&D capacity to generate knowledge and techniques;
- programs to educate and train personnel;
- the scientific and technological know-how of the labor force; and
- financial intermediaries and resources.

This approach increasingly breaks down the difference between the idea of producers (public and university scientific research creating knowledge) and consumers of knowledge (firms and productive sector users/buyers of technology) and emphasizes the relationships between all the components in a complex system.

The idea of a systems approach to S&T policies is not new. What is new is a greater emphasis on the demand side and on the overall macroeconomic climate. Also new is the stronger evidence that efforts to develop S&T without taking into account the nexus between all parts of the system tend to fail, as happened so often in the past.

Notwithstanding this tendency for the frontiers to become blurred, differences between science and technology remain important. At the most fundamental levels, science explores nature and human society to understand it. Science includes not only the natural sciences but also social sciences—economics, sociology, psychology—as well as multidisciplinary studies of areas as disparate as the environment and education. Good scientific training also forms the basis for preparing the human resources needed to understand and adapt technology.

The core activity of technology is the creation of purposeful goods and services. Technology is broader than science, especially in its tacit dimensions. The technological enterprise remains, to a certain degree, an art and a craft, drawing on science and depending on it, but also, and not infrequently, going beyond hard scientific understanding. Nonetheless, in the new economic environment, with a rapidly expanding knowledge base and increased speed of applications, the institutional divide between technology and science is eroding, as science is increasingly used to create new products (e.g., pharmaceuticals) and technological change influences science priorities and approaches.

Recent experience indicates that whatever the policies, they need to be consistent and to remain in place for a long period. The life-cycle of S&T is long, requiring continuity year after year. Zigzags in policies (explicit or implied) tend to destroy the chances of results that reach society and the economy.

GOVERNMENT PLAYS A KEY ROLE

Public goods often merit funding by governments because lack of incentives for private funding would otherwise lead to underinvestments in technologies from which society as a whole can expect to benefit. Most fundamental research falls into this category, as well as research related to public goods such as public health and defense. If the new knowledge is available to all and cannot be protected through patenting, there are minimal incentives for private investors. A market failure resulting in underinvestment by private firms may also take place. Government intervention would thus be justified when private costs are higher than the private benefits and individual firms are unable to capture the full benefits of their investment. Empirical studies show that this is often the case (see, for example, Smith and Barfield). Even though the R&D will find its eventual applications in industry, those applications may be well in the future and hard to predict. If so, private firms have little incentive to invest, since they cannot expect to capture the returns within the time horizons of alternative investment decisions. In some cases, the firm may not be sure that it can protect and exploit the results. Economic history is full of examples of imitators becoming rich while inventors go bankrupt. Unless government helps finance the R&D (which may be conducted in the government's own laboratories, in educational institutions, or in private industry), society will not be able to reap the full measure of benefits from technological innovation. Government investments can also be justified in providing basic scientific literacy for citizens, in training teachers who will provide this literacy, and in training scientists and engineers. Research conducted in universities and technical institutes helps train creative professionals in all fields who not only learn the principles and methods of science but also take the latest knowledge with them, which is necessary to identify and adapt new technologies, when they enter the labor market.

Public expenditures for industrial R&D can be further defined in terms of path-breaking, generic, and strategic technologies, corresponding to the generalized market failure described above (see Alic, et al.). Path-breaking innovations, such as those associated with solid-state electronics or the Internet, affect large portions of the economy and can establish a new growth trajectory. They may or may not result from basic research, but share with much basic research lengthy time horizons and high uncertainty in outcomes and impacts. Generic technologies are more incremental, with benefits that are widely applicable and thus hard to protect. Examples are improved construction and manufacturing processes. Strategic technologies are those where, for one reason or another, governments perceive that a national interest is at stake.

In short, a strong public role is justified in basic scientific research and in precommercial R&D; but there is also a role to play in directly encouraging technological innovation. The key in public technology policy is to identify and then support those elements of technology which incorporate the greatest social payoffs and do not yield sufficient private returns to compensate private costs. While the case for public financing is clearly justified, the case for public provision is less compelling, since in many cases private institutions with a variety of public subsidies can provide the service more efficiently than the public sector.

It should also be noted, of course, that S&T may not solely result in economic progress. Public policies are needed to ameliorate or guard against deleterious impacts of S&T such as war or mass destruction, pollution and environmental degradation, social dislocation and unrest, technological unemployment, etc.

CRITICAL POLICIES FOR TECHNOLOGICAL INNOVATION

Successful technological innovation requires a policy focus on ensuring that all the elements of the NIS are in place and understood. This involves, *inter alia*, having a macroenvironment that encourages competition and is conducive to technological innovation, which will flourish only if the incentives and regulatory framework are right and if all the actors and stakeholders in a complex system find it profitable to innovate. It requires programs and policies which foster and respond to demand for the identification, selection, and adaptation of available technologies, including strengthening the exchange of information using rapidly evolving information and communication technologies.

Of particular importance is investment in knowledge transmission and generation at all levels of the education and training system. This is also known as building human capital. The basic skills learned in primary and secondary schools are the necessary foundation for development and an indispensable base for technology and science. Mid-level technical workers are needed with skills in many technological areas (e.g., electronics, computing, use of automatic machines), as well as in management areas (quality control, information management, inventory management, cost accounting). Higher and graduate education and training are fundamental to manage innovation. Science research is fundamental to generate and transmit new knowledge and train creative technology manpower. It has been observed that support for science does not automatically lead to technological innovation. One of the main goals of public policy in science, therefore, should be to encourage more linkages with technology.

Because the paybacks from S&T come over the long term, that is through compounded growth in productivity, a stable environment with long-term plans and funding, as well as a focus on institutional development, is required. It takes a long time to create R&D groups and little time to destroy them. High-level research institutions, as well as the private sector, cannot afford stop and go projects and delayed payments due to erratic public funding. Countries unable to isolate their S&T institutions from the oscillations, crisis, political uncertainty, and erratic budgets run the risk of paying the front-end costs of S&T without reaping lasting benefits. In this respect it is important to focus on the sustainability and delivery capacity of institutions. As one author has stated:

> *...technical advance and economic growth are seen as proceeding through the operation of a complex set of institutions: some for-profit, some private but not-for-profit, and some governmental. [These] are seen as having evolved through a complex set of processes that involve both individual and collective action. Institutional change, like technological change, must be understood as an evolutionary process.* (Nelson)

Another requirement is to take a regional and international perspective. Technology now has no country or regional boundaries. Countries will need to encourage importation of technology as well as sharing and diffusion of regional successes and lessons learned. Latin American and Caribbean countries remain too isolated from one another, they need to cooperate more. As suggested by some authors, national innovation systems should become part of international information exchange systems.

Science and Technology in Latin America and the Caribbean

THE CURRENT SITUATION: SOME PROGRESS BUT MANY DEFICIENCIES

Forty years ago, Latin American productivity, technology, and science could only be described as backward compared to the industrialized countries. There were equally wide gaps within the region. Although there has been much progress, both sets of gaps persist.

Inputs and Outputs

Because productivity growth depends almost entirely on technology, it provides an important measure of increases in technological capacity. In none of the Latin American economies for which data is available has productivity growth been comparable even to the slower growing countries included for comparison. The best-performing economies in the region over the period 1950-1992—Mexico, Colombia, and Brazil—saw their productivity levels rise by roughly 20 percent compared to the United States. Seven non-Latin American countries (Switzerland, Spain, Portugal, Taiwan, South Korea, Indonesia, and China) exhibit improvements relative to the United States ranging from 40 percent (Switzerland) to more than 300 percent (Taiwan) (see Maddison).

Comparing the hemisphere as a whole to other regions for the 1973-1992 period, productivity growth was less than half the world average. Macroeconomic difficulties certainly contributed to lagging productivity growth, but can be presumed to have done so at least in part with technology as an intervening variable. In short, low rates of growth in productivity (and hence GDP per capita) reflect low levels of S&T capability, both of which are influenced by the macroeconomic situation.

The Swiss-based Institute for Management Development has published annual rankings of international competitiveness for a number of years. The 2000 World Competitiveness Report compared 47 economies, six of them Latin American (Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela). Except for Chile, all of them fell in the lowest third of competitiveness-related S&T measures (see Roesssner et al.). Latin American countries scored low in number of patents, in R&D personnel per 1,000 people in the work force, and in spending on R&D as a share of GDP.

Although R&D measures only a fraction of the inputs to technological activity, for some kinds of activity quite a small fraction, it is the best available indicator of inputs. Here too the hemisphere compares poorly with other developing regions. High-income economies typically spend 2 to 3 percent of GDP on R&D. Several of the rapidly growing Asian economies are beginning to approach these levels—Taiwan at 1.7 percent of GDP and South Korea, 2.1 percent; Malaysia invests 0.8 percent (see NSF and *World Science Report*). Data in the region in general have been unreliable. A recent initiative, the *Programa Iberoamericana de Ciencia y Tecnologia para el Desarrollo*, has sought to develop consistent indicators for countries in the region. These show investment in R&D in the 1996-1999 period for Chile and Brazil at 0.7 to 0.8 percent, and Mexico at 0.3 percent (see www.ricyt.edu.ar on the Internet). The poorest countries invest less than 0.1 percent. In several larger, middle-income countries, public sector spending as a percentage of GDP is similar to that of some of the East Asian NICs. But the public sector in most countries in the region accounts for over 70 percent of R&D funding, while the public sector in some Asian NICs accounts for around 25 percent. Finally only 10 percent of government financing is allocated to R&D in engineering, which effectively reduces the opportunities for interaction with industry (see UNESCO, 1998, p.74).

Quantity and quality in academic science are commonly measured by publications and citations of publications. The Science Citation Index (SCI), derived by the Institute for Scientific Information from its worldwide database, calculates citations in the best scientific journals. Dutch and Swedish scientists separately publish more than all the scientists in Latin America and the Caribbean. Thirty years ago, scientific output in East Asia outside of Japan was lower than countries such as Brazil and Argentina. Currently, Taiwan's production is higher than Brazil's, South Korea contributes more than Argentina or Mexico, and Hong Kong and even Singapore, with populations of under 6 million and 3 million respectively, outstrip Chile, Venezuela, and Colombia.

There are also gaps within the region: Argentina, Brazil, Chile, Mexico, and Venezuela are relatively advanced. A second group, Colombia, Costa Rica, Uruguay, and the English-speaking Caribbean, now has significant national capacity and specialized institutions to promote S&T. Other countries fare very poorly, in some cases with a complete absence of policies, institutions, and investments in national S&T development.

The region is also deficient with regard to the educational bases, from primary to higher education, underlying science and technology. For example, the region performs poorly on international comparisons of mathematics and science learning. The only Latin American country (Colombia) which competed in the Third International Mathematics and Science Survey of the International Association for the Evaluation of Student Achievement scored lower in eighth grade mathematics than 40 of the 41 countries participating in the survey. Only 4 percent of the students in Colombia scored in the top 50 percent of students in the world (see TIMSS).

Institutional Development

Some middle-income countries now have world-class scientific institutions; most have developed mechanisms for relatively open, transparent and competitive financing of science. In fact, science can be an enclave, less sensitive to the macroeconomic framework and associated institutions and conditions. But salaries are usually too low, physical facilities are inadequate, funds for supplies are scarce, transparency in decision-making and priority-setting requires further improvement, and science and mathematics teaching and learning at all levels of the education system is inadequate. With some exceptions, linkages between university-based research and the productive sector continue to be inadequate.

In the larger, middle-income countries of the region, some medium- and large-sized businesses already know how to effectively use advanced technologies to their own advantage. These middle-income countries are seeking to develop publicly supported extension centers and agencies for standardization, metrology and quality control and certification (such as ISO 9000), and several have established agencies providing grants and loans to support technological innovation in industry. Some specialized technology institutions provide valuable services to firms. The region also has had some real successes in R&D. For example in Argentina, a rotavirus vaccine for calves, now in commercial production, has driven the incidence of that disease from more than 40 percent to below 10 percent and reduced the death rate in afflicted calves from 5+ percent to 0.2 percent. In Brazil genetically engineered varieties of soybeans and sugar, now widely available, have already had considerable economic and social impact, and Brazilian commuter airplanes have a sizable share of the world market. Costa Rica, Chile, Colombia, Mexico, Venezuela and Uruguay report similar R&D successes in health, agriculture, computer software, petroleum, and manufacturing (see Colciencias, CONICET, Roche Rivera, Magalhaes Castro).

In short, scattered sectors or groups have mastered the full technological cycle from conception to successful implementation. The problem is that these efforts remain too small *vis-à-vis* the potential for innovation and the needs of the countries, and the majority of firms have no tradition of technological innovation or understanding of their needs. The improved macroeconomic environment in the region and increased international competition eventually will have a positive effect on innovation, since local firms must now innovate to compete with foreign firms. Nonetheless, in spite of the opening of markets to competition, the evidence of adequate private sector investments in R&D is restricted to very few areas.

While the public sector has achieved much success in providing an adequate macro-environment for innovation, much work still remains in policy areas such as regulation and intellectual property protection. Technical and information services, usually provided by government, react slowly and often ineffectively to demand, and usually do not reach small- and medium-sized enterprises. Agencies providing loans and grants to R&D, while they have had significant successes, are slow to act, often overly bureaucratized, and have inadequate capacity to evaluate and assess their own efforts.

The institutional situation in smaller, poorer countries in the region is more dire. There are a few good R&D institutions, often organized on a regional basis. But most of these countries have almost no institutional S&T framework, except for a few universities. Enterprises, large or small, have no R&D capacity or an aggressive policy to purchase it. Regulatory frameworks, intellectual property rights organizations, and information and technical services are weak or non-existent, and university based research is divorced from country conditions and needs. In fact, many research efforts take place in areas where it can neither link with existing technological capacity nor be directly useful for society. In other words, no matter how successful it could become, this scientific research has no potential to help the country. On a more basic level, primary education and training are grossly inadequate, with large numbers of primary school dropouts and functional illiterates.

IDB LENDING FOR S&T

The Bank has long recognized the importance of S&T and has made major contributions to strengthening country capacities since lending began in 1962. In 1968, the Bank's Board approved a policy for science and technology operations (OP 744) which is still in place. The policy emphasizes the need to develop capacity in science and technology. It considers academic and governmental institutions as the principal provider of S&T, while firms are viewed mainly as consumers of technological inputs. The policy lacks the "systems" approach and concern with linkages and incentives prevalent today.

IDB support to S&T, higher education, training, and agricultural research during the period 1961-1995 totaled about US$3.8 billion. Of this amount, $1.4 billion went to 31 operations defined as science and technology projects (described in Annex 2). Total project size (loan and counterpart) of these operations is estimated at US$2.6 billion. Multiple IDB loans for science and technology went to Brazil, Mexico, Argentina, and Colombia, and single loans were made to Venezuela, Chile, Costa Rica, Uruguay, and Ecuador. Brazil alone received about US$475 million in loans, followed by Mexico (US$250 million), Argentina (US$223 million) and Colombia (US$190 million). Based on earlier drafts of this strategy paper, a new set of loans totaling US$350 million was provided to Argentina, Guatemala, Uruguay, Panama, Venezuela and Chile during the period 1998-2000. Support for higher education has amounted to $0.7 billion, for technical education and job training, $0.7 billion, and for agricultural research and extension, $1 billion.

Support for science and technology can be divided into two broad periods: from the Bank's earliest operations in 1961 to 1987, and from 1988 to 1995. Bank financing in the first period (within broad lending families intended to support S&T institutions, agricultural technology and extension, and universities and technical education) focused on creating R&D capacity in research institutions and universities, generally in the public sector. Very substantial progress resulted in many countries.

In the second period, Bank funding shifted toward strengthening institutions and supporting technology as well as science in order to help countries facing international competition raise their productivity levels and become more competitive. Support for applied research and experimental development rose. The instruments of choice in this second period were competitive grants to allocate public funds among research projects, partnerships between universities and businesses, and technology development funds intended to foster innovation through loans to firms for R&D projects.

The objectives of past IDB lending for science and technology were to:

- build human and physical infrastructure, especially in universities;
- strengthen science funding agencies, especially by channeling funds through peer review and open competition;
- encourage private sector investment in R&D through technology development funds; and,
- support individual research institutions of merit, especially in agriculture.

Recent projects, starting with a 1995 loan to Colombia (Loan 875-CO), have taken a more proactive and systematic approach to encouraging technological innovation than earlier projects.

Although relatively little evaluation has been undertaken in the past, recent studies provide valuable results. At the request of the IDB's Board of Directors, the Evaluation Office (OVE) commissioned an independent review of the Bank's science and technology program which included evaluations of loans to Brazil, Chile, Colombia, Costa Rica, and Uruguay. SDS/EDU has complemented this work through case studies of technology projects in five countries which have received loans from the IDB as well as an additional review of the Brazilian technology financing agency (FINEP). The discussion below summarizes the results of these evaluations as well as other analytical work undertaken in background papers.

An Overall Positive Impact

IDB support has had positive payoffs in applied research, provision of continuity in times of financial constraints, establishment of institutions, strengthening of decision-making capacities of these institutions, and training of many researchers, teachers, and high level industrial workers. The S&T portfolio has performed well above the Bank average in terms of project execution and disbursement.

Science Research and Training

IDB-supported research and training programs have benefited some 20,000 scientists and engineers and at least 100 universities and technological institutes, including many that are now bulwarks of Latin American science and technology. IDB support has helped several middle-income countries (e.g., Brazil, Chile, and Costa Rica) to create a science infrastructure that is able to respond well to injections of funds, and the physical indicators of output have shown significant progress. IDB support has strengthened the process of open competitive funding for S&T projects. The Bank has also provided some support for regional cooperation in technology and science, for instance in the English-speaking Caribbean.

While recent IDB projects focus on critical areas, the efforts to create targeted programs does not seem to have an impact on overall practices. Indeed, many countries continue to disperse excessively their support of science research. In addition, there continue to be problems in universities with respect to lack of incentives, excessive bureaucracy, general inertia, and difficult procurement procedures. On the demand side, there has been a lack of innovative culture, inadequate venture capital, and too few technology professionals, resulting in inadequately articulated needs at the firm level.

While most project documents have stated that they sought to improve linkages between public sector research and society, the results have not pervaded the systems. Attitudes in both the universities and the business community have been slow to change, with a continued sense that research results are self-contained and that industry is a "user" of research. Most public research institutions, especially those not linked to a specific industrial sector, have been particularly ineffective in responding to real industry needs. Yet, a few linking mechanisms, not all financed by the Bank, have been shown to work well. These include: in Costa Rica, national centers, annexed to the universities, with an interdisciplinary focus on a particular sector; in Chile (FONDEF), supporting public sector research only if it could find outside matching funds; in Colombia privately owned R&D centers in agriculture, agro-industry and other areas; in Chile, a consortium for R&D cooperation among key institutions involved in forestry; and in Brazil, the parastatal EMBRAPA responsible for major increases in agricultural productivity, especially with regard to soybeans.

Technology Development Funds

IDB support to agencies such as FONTAR in Argentina, FONTEC in Chile, FINEP in Brazil, COLCIENCAS in Colombia, and FODETEC in Costa Rica has had a positive impact and there are many examples of successful loans for innovation. In Chile, FONTEC has fostered a process of "learning to innovate" in the private sector, and COLCIENCIAS in Colombia has had similar successes. Costa Rica also performed reasonably well but not at the same level as Chile. Uruguay, the least experienced country in technology of the five included in the OVE report, has less impressive impacts on private sector innovation, but still has seen improvements in attitudes and in the ability of research laboratories to interact with firms.

In Brazil, which accounts for one third of Bank loans for S&T, eighty-four percent of the projects in the FINEP/IDB portfolio were successfully completed. The economic results of just one of them (Coopersucar) more than justifies the entire recent IDB loan to FINEP. FINEP underwent a financial and institutional crisis in the late eighties and is presently emerging from a reorganization. At the time, an IDB loan with its conditions which favored the capitalization of FINEP may well have prevented it from outright elimination.

In spite of this support, many of the agencies executing technology development loans continue to suffer from excessive paperwork, long bureaucratic procedures, administrative inefficiency, and lack of procedures to follow up and evaluate the impact of their projects. Spin-off results from Bank-supported technology development funds have been inadequate, with little impact on the overall attitudes of firms to R&D. Dissemination programs have not reached their goals, perhaps because of the difficulties of a public centralized institution to respond rapidly to industry needs. Progress in strengthening intellectual property rights, including the information function, has been mixed. In contrast specific training efforts have generally been successful, in particular, the fellowship programs of several middle income countries which allowed thousands of scientists to acquire abroad post-graduate degrees.

Institution Building

Overall, while much progress has been achieved, universities, public sector research institutions, and technology funding agencies continue to have inadequate capacity for management, evaluation, and assessment of science and technology activities.

The Bank's Analytical Work

The Bank's analytical work has improved over time. Until recently it lacked a systems approach, especially with regard to linkages and to the articulation of comprehensive policies. According to the OVE report, future project analytical work would need to examine the NIS as a whole, with emphases on national, regional and international linkages, interchanges, institutional development, policy reforms, knowledge utilization, and technological needs of small and medium enterprises; and program documents also would need to have more clearly defined goals, benchmarks, and means of measuring success. Recent analytical work undertaken by the Bank to prepare projects in Colombia and Venezuela are examples of this new approach.

Agriculture

IDB support for research and extension in agriculture has followed a similar model as support for S&T projects, beginning with creating and expanding national research institutes, and then focusing on incentives, diversification of revenue bases, and increased open competition for funding. In addition the Bank has provided major support for international cooperation in agricultural R&D to over fifteen research centers in areas such as potatoes, wheat, and maize, including more than US$180 million to agricultural research through nonreimbursable technical cooperation operations and now through a Regional Fund for Agricultural Technology which will ensure continuity of these activities. A review of the Bank's efforts in this area in 1993 identified problems of design implementation and management; nonetheless the weighted average economic rate of return was better than 45 percent.

A New Strategy for Science and Technology Development in the Region

OBJECTIVES AND APPROACH

The region as a whole needs to strengthen national innovation systems and to link them with the global knowledge society, as a means of helping to ensure economic and social progress. The critical needs are: to get firms and other institutions to increasingly incorporate new technology into production and related processes; to increase the amounts, effectiveness, and productivity of investments in science and technology; to increase the numbers and quality of higher level human resources; to ensure closer linkages among the different components of the national innovation system; to increase international cooperation in S&T; and to complement all these actions with increasing investments in basic, secondary, and higher education and in training. Smaller and poorer countries in the region face particular and urgent needs to develop their S&T capacity. The Bank's strategy is to assist in all these areas.

Nearly all projects financed by the IDB have technology components, since they include technology-related infrastructure as well as training and institutional development components. This is especially the case in agriculture but also in industry, infrastructure, education and health projects. This strategy stresses the need to examine more systematically than before the technological elements in these projects, especially with regard to encouraging competition and local capacity building.

The strategy is not a break with the past but rather a continuation and intensification of recent trends and is based on the need to keep up with a changing international economic environment. The Bank will continue to support scientific research (university based or otherwise) and related human resource development. Scientific training and research can generate large positive externalities and are a main source of technological knowledge. Yet, many of the region's efforts in science never result in productivity or quality of life improvements. To redress the balance, this strategy gives greater attention to activities essential to ensure the final payoff to society of its investment in science. The Bank will, therefore, place greater emphasis on increased investment in diffusion and utilization of technology in the private sector, and on better articulation between supply and demand and among the partners and stakeholders in knowledge provision and use—researchers, firms, consumers.

There can be no single recipe for a strategy because each country is in its own developmental stage. The Bank will tailor its lending and programs to individual country needs, paying particular attention to smaller, poorer countries.

Most countries in the region will need to increase overall R&D spending as a percentage of GDP? both the middle-income countries whose public R&D spending approximates that of their competitors in other regions and the poorer economies that spend very little on R&D at present. In the middle-income countries, most of the effort should take place in the private sector. The objective of IDB support, however, will not be to increase spending *per se* but to target the expenditures where an impact on long-term growth can be expected.

Parallel to this strategy, the IDB has recently developed other strategies with implications for science and technology. The strategy on higher education emphasizes diversity, differentiation, autonomy and accountability of higher education institutions, which are critical to development of human resources necessary for S&T development. The strategy on training deals with the preparation of workers and technicians, both essential for economic growth. The strategy on capital markets examines how the Bank can help to raise the level of savings, improve the composition of savings, enhance the economic efficiency of capital markets, and promote the integration of the region's capital markets, all of which are essential for increased private sector investment in technology. A financial markets strategy proposes methods to encourage market-based institutions supporting the financial needs of individuals and firms as well as innovations in the financial markets and institutions of the region. The emphasis is on developing a variety of intermediary institutions, such as pension and mutual funds, leasing companies and investment banks, as well as information providing institutions. The information technology strategy examines alternatives for the adoption of information technology and proposes to increase financial support for information technology. A strategy on small and medium enterprises (SMEs) examines how to support the competitiveness of SMEs so that they may contribute to long-term growth and employment.

The main elements of the Bank's strategy are:

- a systems approach;
- an increased emphasis on technology;
- continued support of science research and training with increased emphasis on critical areas;
- increased support to smaller, poorer countries; and
- a parallel increase in support for education and training which will affect S&T capacity in the region directly and indirectly.

SYSTEMS APPROACH: ALL THE PIECES MUST BE IN PLACE

The current conceptual framework for technological progress requires that many elements of a complex system be in place. Its focal point is the diffusion and use of innovation by the productive sector. When considering S&T lending, the IDB will review national innovation systems and seek to ensure that the critical elements are in place and the relationships among them are understood.

National innovation systems include macroeconomic and sectoral policies; patent, copyright and trade secret systems; tax policy; technology services (metrology, standards, information services, technical assistance); industry practices and attitudes; linkages among various actors and participants in S&T; critical areas for development; comparative advantages; capital markets; venture capital; in-service and pre-service training; higher education development (particularly in science and engineering); specialized public research institutions; decision-making processes and incentives; science and mathematics in basic and secondary education, and communications and information technology. In addition, technology has no country or regional boundaries and NIS operate within the context of increasing exchanges and interdependency among different systems across national borders. Latin American and Caribbean countries remain too isolated from one another. They need to take a regional and international perspective, encourage the importation of technology, and seek to share and diffuse regional successes and lessons learned.

Where appropriate the IDB will undertake or support comprehensive NIS assessments designed to identify current and prospective bottlenecks to the development of technology and productivity. Issues in technology diffusion and utilization which could be analyzed include: legislation and enforcement of programs related to science and technology development, such as imports; technology transfers; WTO regulations with regard to services; key agents and relationships; competitiveness; business structure, characteristics and problems; sectoral issues; and enabling environment for innovation (e.g., market, economic, fiscal, and legal incentives). Issues in science which could be analyzed include: the quality and relevance of scientific work, decision-making and monitoring, and training and linkages with the productive sector. Last but not least, it is necessary to have a better understanding of why firms spend too little on R&D. Where appropriate the IDB will assist in the identification of critical areas for scientific and technological development where countries have natural competitive advantages which can be exploited (keeping in mind the risks of "picking winners" and the need for flexibility in providing such support as circumstances change).

In its support for S&T, as in all its projects, the Bank will also consider the other elements of sustainable development in the region, especially the objectives of poverty alleviation, equity, and environmental preservation. In particular, S&T can play a role in improving the productivity, participation and general quality of life of the poor and is crucial in stemming environmental degradation and destruction. At the same time, without appropriate policies, technological development can increase inequities in a region which already has large disparities in income distribution. This strategy strongly supports policy analysis in all areas which are critical to society. In addition to economic and technological themes, acute problems in the social sectors suggest the need for pragmatic research in areas such as unemployment, violence, anti-social behavior, health care, urban development and poverty in general.

Improving the Environment for Innovation

The IDB's approach with regard to economic policies which affect innovation will emphasize creating a policy and regulatory environment that promotes lively competition under a framework which encourages local initiatives. Without strong internal and external pressures to lower costs, improve quality, and keep up with new products because of strong competition, there is no compelling incentive to adopt more efficient new technology and organization.

Of fundamental importance will be the continuation of the current macroeconomic policies ensuring stability and low inflation. These policies are essential since market instability would inevitably raise the risks to firms that wish to invest in the development of innovation and technology.

The major source of technological innovations in the region comes from the importation of capital goods and their specifications, and from the technical assistance provided by foreign purchasers, providers of licenses, and external investors. Therefore, the Bank will support policies leading to increased free trade, with particular emphasis on liberalization of commerce and elimination of barriers to the importation of technology. The Bank will also identify and encourage other policies and regulations which can have a positive impact on technology, including those incorporated in tax policies (e.g., tax incentives for investment and for R&D), the exchange rate, domestic competition (anti-monopoly) policies, and development and oversight of capital markets, including risk capital.

While defending the general policies of lowering tariffs and reducing barriers to trade, two qualifications apply, on a case by case basis. First, the pace of the reductions in protection remains a critical variable, lest local industry is not given adequate time to adjust. If excessive protection stifles investment in technology—as has been the case too often—opening too fast can wipe out local industries altogether, an even worse alternative. Policies will have to avoid these opposing dangers and protection is one alternative among others. Second, and especially important for R&D activities, the infant industry argument may still apply under certain conditions. Newly innovative firms may need a temporarily protected environment to consolidate a competitive position, especially as large multinationals enter with "deep pockets." The Asian experience has taught that protection can be beneficial when there is a strong credible state and a measurable discipline in the capacity to export. Clear incentives, penalties, and strict calendars of graduation (from infancy) must be set in place and government bodies doing the enforcement must be believable in their attempt to keep to calendars and punishments. There are good reasons to encourage direct investment by foreign firms. At the same time, there is also a need to examine issues related to the possible reduction of R&D in recently privatized firms, as well as the actions of some multinationals replacing local and parastatal firms and shifting R&D back to the home office to accommodate the world wide internal efficiencies of the corporation. If the public externalities from local R&D are important it may be useful to subsidize R&D via tax incentives to compensate the firm for loss of internal efficiencies.

It must be clearly understood that the cost of technology has been steadily increasing. For example, the Brazilian chemical industry saw the cost of technology increase from 2-3 percent in the 1960s to 25 percent of total product cost in recent years. Without adequate incentives that create level ground for local firms, the increased cost of technology may give foreign firms a decisive edge in competition, driving local firms out of the market. Since inadequate capital markets is one of the frequent handicaps of local firms, technology funds—such as those often sponsored by the Bank—might be the most appropriate tool.

Firms interested in investing in R&D need to have effective protection of the results of their research and innovations to ensure that the economic return on their investment is more secure. Regulation and enforcement of intellectual property rights (IPRs) is also going to be crucial for the new international trade environment, under the Agreement on Trade-Related Aspects of Intellectual Property Rights, (TRIPS) as established by the World Trade Organization (WTO). Therefore, the Bank will support the strengthening of intellectual property rights laws and enforcement, including patents, trademarks, utility models, copyrights and trade secrets, as well as their role in disseminating valuable information to firms and scientists. The Bank's support for IPR could include institutional strengthening, international cooperation, developing information systems, and evaluating the impact of IPR legislation and enforcement.

Institutional and Sectoral Development

People make their contributions in organization settings (universities and research laboratories, private firms and government institutions) that can stimulate or stifle innovation. Vital, dynamic organizations, open to new ideas (and to the international community of technology and science) are a necessary complement to human capital improvements. Institutions that span and link the organizations in which practitioners of technology and science go about their day-to-day work create the necessary environment for innovation. These institutions range from systems of intellectual property rights to financial intermediaries to labor markets in which rewards from innovation are shared with workers at all levels.

An especially important target for rescue is the technological institutes. Many countries created such institutions to produce applied research and ended up with few applications in the productive sector. These institutions have been chronically supply driven. They do not make a deliberate effort to respond to the needs of enterprises and their survival depends exclusively on public budgets. As a result of tighter budgets they become strapped for cash. As a result of lack of accountability, overhead costs grow.

The performance of universities in scientific research is usually less than stellar, even though they are responsible for just about all national research. Their performance tends to be worse in technology development which requires a flexibility and business aggressiveness which is impeded by rigid civil service rules. In accordance with its higher education strategy, the Bank is well advised to use the leverage of its loans to promote the reform of higher education institutions.

The Bank will, therefore, pay particular attention to assessing the "delivery capacity" of executing S&T institutions, both national science and national technology funding agencies, and to institutional strengthening and reform where necessary, in some cases as pre-requisite or parallel to lending efforts. It will seek to strengthen institutional capacity for information management and evaluation of impact of S&T, which could include performance benchmarks, procedures for on-going monitoring and follow up, and developing capacities for impact analysis. The Bank will also strengthen the basis for design, implementation, management, coordination, and evaluation of S&T policies.

The Bank will support S&T in its broadest definition. For technology, this will include not only identification of improved production processes but also business management, public sector management, information and communications technology, market research, and financial management. Technological improvements will be sought not only for industry but also for agriculture, commerce, and public and private services. For science this will include not only the "hard" sciences (natural, exact, and applied) but also social science, industrial and social psychology, economics, statistics, computer science, environmental science, etc.

CONTINUED SUPPORT FOR SCIENCE RESEARCH WITH INCREASED EMPHASIS ON CRITICAL AREAS

Scientific skills are fundamental in a modern economy. Countries in the region want to ensure that they are not left behind in science and that an exclusive pursuit of technology will not handicap them in the long run, given the increasingly close connection between basic science and technology. Their concerns are justified but have to be put in the right context. Overall, scientific research in the region should be viewed under different perspectives.

First, countries need strong science teaching. Western culture and styles of reasoning borrow heavily from science and its paradigms. And teaching science requires some "teaching research," where the objective is to make science realistic and creative, giving teachers an opportunity to exercise and expand their skills. Good science teaching is a necessary input into training creative professionals who will have the capacity to adapt existing knowledge and technology, but not necessarily as a means to create new knowledge.

Secondly, a targeted effort at generating new knowledge can be justified where the output of the scientific activity will feed existing or potential technological R&D in the productive sector. In just about all countries, while the overall level of public investment in research will need to increase to keep pace with the modernization of the economy, reforms are needed to reduce excessive dispersion of resources, to strengthen incentives, decision-making, and assessment, and to increase the linkages with the productive sector.

The Bank will not withdraw its support for scientific research. However, it will increasingly support technology diffusion. With regard to science, it will focus its efforts on supporting key areas for economic and social development, strengthening institutions and the decision making process, ensuring closer matching between S&T supply and demand, increasing support to smaller and poorer countries in the region, and improving quality and cost effectiveness.

Critical Areas

IDB-financed projects will be directed toward filling gaps in skills and ensuring critical mass in strategic areas for economic and social development. In the area of science, there is no such thing as a market for scientific papers to provide cues. The idea here is to concentrate resources in fields in which there is a proximity of science to areas where there is already installed productive capacity in the country or to areas which are critical to the economic future of the country as well. A main concern will be to reduce fragmentation of efforts, which has been a particularly serious problem in almost all countries in the hemisphere but is even graver in smaller countries. Fragmentation results in lack of critical mass in any individual group. Spontaneous and individual efforts to choose areas of study results in young scientists merely following the research interests of their thesis supervisors abroad, which lack convergence and relevance in their countries of origin. In matters of technology, the criteria are more visible, since market and projections of future markets should be the predominant driving force. Business is the major stakeholder in designing such policies.

Reducing dispersion is a difficult endeavor, fraught with dangers. Who will choose the "winners"? The region has sad memories of bureaucratic *fiat* leading to unenforced and unenforceable priorities. Wrong concentration is worse than dispersion. Even when priorities coming from above make sense, they tend to face inertia and vested interests in the *status quo*. The new priorities must have a clear and legitimate rationale, as well as some form of consensus building.

Fortunately the latest decade has been fertile in generating tools to better focus S&T efforts. The OECD has considerable experience in conducting successfully the search for what has been called the essential technologies and has built the science and technology effort around them.

Brazil has been using platforms which also start from the critical problems the country wants to solve and derive from them the S&T needs and the multiple actors needed. The technological missions played a similar role in Minas Gerais (Brazil) and were generated by means of a statewide consultation with thousands of stakeholders. Venezuela and Colombia have also undertaken similar analytical and consensus building actions to define priorities. It stands to reason that whatever the approach, it makes sense to concentrate efforts in areas where the productive sector can be served. The selection of these priorities or platforms must have a built in system for feedback and self-correction if results are not adequate.

This critical choice of concentration areas requires a good knowledge basis. Prospective studies are needed. Without good analysis it is difficult to have good policies. In all these efforts, the state has a major role to play. This is no place for a laissez-faire or a minimalist government, as is the case in many economic areas.

While the process to concentrate efforts must be a collective effort, competition would prevail within the chosen areas. Since science is the ultimate meritocracy, the Bank will support programs which especially focus on strengthening existing centers of excellence. The preferred approach will be through competitive funding. The Bank will also support strengthening or establishing individual research and training institutions when these are viewed as fundamental for S&T development in a particular country, as will especially be the case in smaller countries. In these cases funding will include incentives for productivity as well as mechanisms to assess institutional effectiveness.

While the main focus will be on supporting critical areas, the Bank will also encourage the provision of a minimum of conditions for university level teachers to keep up with their subject. Teachers and students must be familiar with research methods and principles in order to have full understanding of their subject. The objective here is science teaching rather than pushing the frontier of disciplines and the funding is for affordable experimentation rather contributing to world science. Furthermore it will always be appropriate to set aside some funds to support research proposals of very high merit, even if not related to a country's apparent comparative advantages, provided the costs are not extreme. In certain cases modest set-asides should also be provided for young researchers and for underdeveloped regions. Research of high quality will be supported whether it takes place in public or in private institutions, provided the institution agrees to use the results according to the standard practices of the area.

Linking Supply and Demand

Future IDB projects will include incentives for increased interchange and linkages with the productive sector. For some (but by no means all) research proposals, these could include requiring co-financing by the potential users of academic research; supporting conferences, publications, other information sharing activities; establishing new institutions linking science research centers with productive enterprises; directly supporting nonproprietary research in industry; exchange programs between academic and public research centers and industry; etc. The relative success of these efforts will be carefully monitored and evaluated.

Institutional Development

The Bank will seek to improve the efficiency, effectiveness, and sustainability of institutions which fund science research and training. This will include: ensuring institutional autonomy, reducing the size of bureaucracies, strengthening transparency and open peer-review based competition for funds with minimum transaction costs, improving information systems, encouraging interchange with other research funding agencies throughout the world, trying out and evaluating new funding models, establishing stronger monitoring and evaluation systems, and increasing flexibility and agility to change the nature and direction of support for research areas as circumstances change.

REDRESSING THE BALANCE: INCREASED EMPHASIS ON TECHNOLOGY

A critical issue in the region is the low level of private sector investment in R&D and the inadequate speed and effectiveness with which firms and institutions acquire, assimilate and efficiently use new technologies. The Bank's efforts to date in this area have had an impact but they have been restricted to narrow sectors. Therefore, the Bank will act more intensively and systematically than in the past to increase the diffusion and utilization of R&D in the productive sector and to encourage firms to engage in technological R&D. This will include, as noted above, efforts to improve the economic environment for innovation, as well as direct financing of technology development and strengthening the support systems necessary for technology development and diffusion, including institutions providing information, technical support, metrology services, and standards.

Technology Development Funds

In most countries, structural reforms have alleviated the climate of uncertainty prevailing in years past. But firms still have restricted access to long-term financial resources, and continue to have the perception that technological investments involve often unacceptably higher risks. As noted in recent IDB strategy papers, the modernization of the financial systems of many countries is still far from attaining the level of efficiency and specialization required by innovative businesses. In addition, risk capital funds and institutions are still very much underdeveloped in the countries of the region, to a great extent a result of overall weaknesses in capital markets.

Technology development funds providing loans and grants and managed by specialized entities can facilitate long-term credit for technological projects, and can have a positive impact in private investment in R&D and in innovation processes in firms. The Bank will therefore continue to support these funds, which would have the following characteristics and objectives: focus on areas where there are market failures in innovation diffusion and utilization (note: no single approach works in any one country and boundary problems between public and private goods must be faced); provision of a variety of instruments, depending on country and institutional conditions; emphasis on small and medium enterprises; strengthening of institutions responsible for technology financing, through developing stronger management systems and better assessment and evaluation; and emphasis on joint financial effort by industry and government. The Bank will also seek ways to establish or strengthen private sector intermediary institutions providing credit for new technologies. Recently, technology support agencies in several countries (Chile, Mexico) have reduced their lending activities (which have been shown to have inadequate demand and have led to excessively complicated administrative procedures) and increased the provision of matching grants to industry (Waissbluth). This is in accordance with OECD experience, where loans now account for only 2 percent of government support for S&T, with grants accounting for 48 percent and fiscal incentives for 39 percent. The Bank will encourage the increased provision of matching grants and fiscal incentives, which can be expected to have simplified approval and monitoring procedures compared to loans.

Strengthening Support Systems for Technology Development and Diffusion

Most firms in the region are not aware of the possibilities for innovation by using already known technologies. Technological know-how is now so diverse and specialized that only firms with a large R&D department can afford up-to-date information about technologies in their fields. Therefore, one of the NIS building blocks is the existence of an infrastructure for technology support made of a varied set of institutions providing such services. These institutes do not substitute but rather complement the normal market mechanism and play a critical role in innovation and diffusion. They can be of a varied nature (publicly owned and operated, publicly owned and privately operated, mixed ownership and privately operated, privately owned and operated) and provide a range of services (contract R&D, support and assistance in technology transfer, resolution of technical problems, information and extension services, technological brokerage between various public and private institutions, technical training, diagnosis of processes and projects, and testing laboratories). Experience suggests that it is better to orient such programs toward specific sectors (e.g., shoes, textiles), technologies (e.g., automatization, industrial design), one specific industry and its major firms (e.g., petrochemical); territorial (regional/local), and/or specialized by function (information, technology transfer, R&D, testing, training). Generic or all-purpose systems of information or dissemination are less successful.

The Bank will act to develop and support technology-support institutions. Current research shows that the best performing among these institutions are those which are independently operated (whether public or privately owned), generate a substantial part of their overall income with revenues from their customers, and have a structure of governance and management encouraging flexible responses to demand, with related incentives for their employees (see Mullin and Goldman and Ergas). The Bank will support the role of technology institutions *vis-à-vis* SMEs, which traditionally have not adequately used these services. Financial support will be provided to create the infrastructure (e.g., facilities and equipment), train personnel, launch initial activities (initial operating costs), and provide matching grants for services paid by firms. The level of subsidies will vary according to the function/activity, with, for example, support for SMEs and training being more subsidized than the use of laboratory services.

As part of increasing decentralization, and because of the importance of the local/regional environment, especially for SMEs, the Bank will also consider supporting a new role of local/regional authorities to create an appropriate business and innovation environment, through developing local/regional infrastructure (e.g., technology centers, technology parks/incubators).

Strengthening Support Systems for Metrology, Standards and Quality Control

The increasing complex organization of production, through the subcontracting of parts and components and successive phases in the chains of value, as well as the growing importance of international trade require increasingly strict compliance with international quality assurance standards. The availability of basic metrology and calibration tools and equipment, of a network of internationally accredited testing laboratories, and of product and service certification institutes is, therefore becoming increasingly important. Furthermore the commercial integration negotiations currently underway in Latin America and the Caribbean (most immediately NAFTA and Mercosur, but also ALCA and the trade agreements with the European Union) include the negotiation of technical standards.

But only a very small number of businesses in the region have incorporated standardized quality management mechanisms that are internationally acceptable. National metrology and technical standards institutes generally have a capacity less than that required to provide services to potential export firms that will be required to compete on an international scale.

The Bank will, therefore, act to support a new culture of quality and the strengthening of public and private metrology and standards institutions. The key priorities for the region are creating or strengthening a basic metrology and calibration national system appropriate for the most used processes in each country; strengthening of the standards agency and its capability to deliver services and assistance to industry associations and firms, with an emphasis on SMEs; facilitating accreditation bodies to authorize testing laboratories and certification entities; and enhancing firms' awareness and action to improve quality management and quality control, including the adoption of ISO 9.000 and 14.000. The characteristics of support in these areas will include: joint industry government collaboration on sectoral basis; in larger countries ensuring that the apex system of metrology is adequately staffed and financed in autonomous high quality institutions, public, quasi-public or private under contract with government; seeking at least partial cost recovery for metrology and standards services provided to industry; and ensuring that defining quality and standards is mainly an industry rather than government responsibility. Smaller countries, have the added problem of lack of scale for many of these activities; therefore, it becomes even more important to identify critical areas for standardization and metrology. The Bank can play a role of promoting joint efforts either among small countries or creating fair provisions for smaller countries to use the facilities of their larger neighbors.

Dealing with Enterprises

There is considerable experience in dealing with scientists and with academic institutions. Yet, when it comes to dealing with firms and entrepreneurs, there is much fumbling and ignorance. Learning how to work with the private sector and understanding the logic that leads them to invest in technology is critical. Agencies must deal not only with the stand-alone firm but with the new varieties of associations, such as strategic alliances, often including foreign partners. Dealing with multinationals and creating the incentives and conditions which will lead them to invest in R&D is a problem for more advanced countries. Small firms and the means of clustering them is another issue affecting a wider range of countries. In fact, policies to support and disseminate information to small industries requires their clustering because they cannot be individually. S&T public agencies have to learn the multiple modes of dealing with enterprises.

NEW EMPHASIS ON SMALLER, POORER COUNTRIES

The poorer countries can be expected to exploit their current comparative advantage—inexpensive low-skilled labor—through labor intensive production technologies. They may also concentrate production in a narrow base of products. However, over the long run, this approach will end in low technology, low productivity, and low income. *In the knowledge-based world, strengthening human capital and related research will be as fundamental for poorer countries as for the more advanced ones. The Bank will, therefore, increase its S&T lending to smaller, poorer countries as a means of helping to ensure that they can also participate in knowledge-based development in accordance with their evolving comparative advantages.* But increased lending to these countries does not mean that the Bank will reduce its lending to the more advanced countries.

The Bank will assist in identifying strategic fields (usually agriculture and other resource-based industries such as forestry, fishing and mining, as well as health and the environment), defining strategic regional and international alliances, planning for their development and promoting stakeholder dialogues. Coordination of agents, institutions, and policies is weaker in smaller nations, a result of lack of information on elements as diverse as international prices and sources of technical assistance and well as poor capacity to process information. Therefore, the Bank will encourage the development of groups of businessmen, scientists, engineers, and educators who would identify issues and priorities in the national innovation system, and, with the help of international experts, establish ways of improving coordination and strengthening technology development.

The smaller, poorer countries will especially benefit from electronic networking (Internet), which will enable them to benefit from regional and international institutions as well as to communicate more effectively with each other. It will therefore be important to support activities to strengthen Internet infrastructure as well as literacy. In addition, community information centers can be established to cater to needs of both business and civil society.

There is also a need to support the establishment or strengthening of regional R&D institutions, building on the success of institutions such as the Nutrition Institute for Central America and Panama, based in Guatemala; CATIE in Costa Rica; and the International Center of Tropical Agriculture, in Colombia.

With regard to technology development, the poorer countries are characterized by a large number of very small enterprises that chose their technologies with little knowledge of the wide range of available alternatives. It will be important to establish or support outreach programs of training in elements such as quality and inventory control and simple productivity enhancing investments, as well as a program of mini- and micro-loans for improved productivity. Transparency in decision making, including international participation, will be important because of the small size of the technology community. The

IDB will also support identification of technologies from elsewhere which are appropriate as well as developing local capacity and linkages with larger countries in service areas such as metrology and standards. Technology centers could be linked with larger, more complete centers in the region or abroad, in part through networking. One possibility is that of developing "virtual centers" acting as brokers between sources of technology and companies seeking technology. The IDB will also support pilot or experimental efforts to establish technology development funds.

Choice of technology is very critical, particularly under conditions of high unemployment and underemployment. Labor-saving technologies are a two-edged sword, making the country more competitive but increasing unemployment. Yet, there are many intriguing combinations of modern and traditional technologies (e.g., the use of satellites for surveying the Peruvian mountains and deciding where it is worth recuperating the centuries-old terracing). And, of course, genetic engineering can be used to develop better strains of traditional crops.

In smaller countries, there are often one or just a few higher quality institutions. Therefore it will be important to emphasize outside assessments of research productivity and relevance of these institutions, often through international referees and review committees. In some cases, new applied research institutions will need to be created. The IDB policies favor the support of a few selected research institutions, provided they address critical problems of the country and are designed (or redesigned) in such a way to ensure good governance, the right incentives to respond to real demand and financial sustainability. Experience shows that well engineered partnerships with foreign institutions increases changes of survival and efficiency.

University-based research will usually be considered as a necessary input for strengthened undergraduate teaching. The IDB will also support efforts to bring back scientists and engineers working abroad (not necessarily on a permanent basis) and to establish international twinning arrangements with researchers from other countries. It will also provide grants to local individual researchers of merit in priority fields. When critical mass is lacking joint ventures with outside groups is preferable to the creation of local research groups or laboratories. Finally, in these poorer countries, the IDB is paying particular attention to human resource development, especially building up basic education so that all citizens are literate and numerate, strengthening the quality of teaching of science and mathematics at all levels, stressing problem solving and higher order skills, and strengthening technically oriented higher education institutional capacity.

HUMAN RESOURCE DEVELOPMENT

A workforce with good basic skills (reading, writing, arithmetic) provides a foundation for continuing development, and a workforce rich in higher level skills (technical skills, engineering, science, management) provides a source of leadership, linkages and capacity to adapt technology. Strengthening the base of the education system will ensure not only that the labor force will be technologically literate but also that the poor will benefit from the fruits of science and technology. However, the educational level in the region is still far below that required by the technological challenge in a globalized economy. Businessmen and women, particularly in SMEs, are limited in their ability to understand the far-reaching nature of the implications of technical change, to design innovation strategies that are appropriate for their specific environment, and to efficiently manage the acquisition of new equipment and other intangible investments. Technical personnel, in turn, are unable to incorporate innovations into the work process nor to adapt processes of more technically advanced international firms. Skilled and semi-skilled workers lack flexibility and basic mathematics and communications skills.

The IDB is expanding its lending and support for all levels of the education and training system which will affect S&T directly and indirectly.

Basic and Secondary Education

Among the elements of the IDB strategy for strengthening of the quality and relevance of pre-university education (grades 1 to 12), which are particularly relevant to science and technology are: strengthening systems to assess student learning, especially in math and science; raising standards; upgrading teacher knowledge and pedagogy; providing teaching/learning equipment and materials, including computers, to schools; strengthening distance education as a means of improving quality; and increasing involvement of parents, communities and businesses in school affairs.

Higher Education

The elements of the Bank's support for higher education which have an impact on S&T include support for increased diversity and differentiation of public and private higher education institutions; increased institutional autonomy and accountability; improved higher education management and stronger incentives for quality; development of post-secondary courses in technology lasting two to three years; increased interconnectivity among institutions and library resources; undergraduate and graduate training scientific and in technical fields, and in areas such as business administration; and strengthening the teaching of subjects such as mathematics, physics, microelectronics, information technologies and computer science. Among the various areas, undergraduate engineering education needs profound reforms which could be the object of future Bank loans.

Training

The Bank prepared a strategy document for training, which emphasizes strengthening middle manpower and technicians essential for improved productivity, especially at the post–secondary level, and reforming national vocational training and apprenticeship programs to improve cost effectiveness and responsiveness to demand, including increased participation of firms or industry associations in the design of curricula and resource allocation of national labor training entities (SENA, SENATI, etc.). With regard to S&T, the IDB will support training programs which impact directly on innovation, such as: continuing education programs in innovation management for business executives; specialized technical training programs conducted either by provider firms themselves, more technologically advanced clients, R&D centers or technological institutions operating at the sectoral level; training abroad or international experts lecturing on critical new technologies; and programs of job training designed for intermediate-level technical personnel and skilled and semi-skilled workers which can be implemented by national labor training services or equivalent institutions.

Graduate Study

IDB support for scholarships and subsidized loans for graduate and post-graduate study both within country and overseas will focus on critical fields with identified shortages. To be avoided are open-ended programs to send promising researchers abroad for furthers studies, since this may lead to brain drain or to the dispersion of efforts so often observed. Graduate and post-graduate study will be linked with the process of strengthening centers of excellence and providing minimum critical mass. Institutions providing such funds will be strengthened, with an increased emphasis on mixed grant/loans. As mentioned, efforts will be made to link nationals working abroad with in-country based researchers as well to twin research and funding institutions.

IDB Instruments for Support of Science and Technology

The Bank has analytical, policy, and financial instruments at its disposal for the support of science and technology in the region.

POLICY ANALYSIS AND DIALOGUE

Since consensus must be based on a shared understanding of how a country's S&T system functions, its strengths, weaknesses, and potential, the IDB will undertake studies and inquiries as needed to inform the process of discussion and decision. It will support national and international workshops of stakeholders and actors, similar to the one held in February 1998 in Washington on "Diffusion, Assimilation and Use of Technology by Private Firms in Latin America and the Caribbean." To ensure that policies have consensus support and to prevent one side capturing the decision-making process, the IDB will use its political legitimacy to promote broad-based country analysis and discussion of needs and opportunities. As part of this process, the IDB will provide examples of best practice from the region and the world, and will support improved capacity for monitoring and impact evaluation of S&T efforts

Good governance and correct incentives will be standing conditions for loans. The policymaker's toolbox encompasses a broad variety of modes of intervention? some financial, others regulatory and/or legislative, while some technological policies are integral parts of industrial or agricultural policies. Annex 1 provides a schematic view of some of these possible policies.

FINANCIAL INSTRUMENTS

This section discusses more narrowly some of the conditions and processes leading to IDB loans in support of S&T, which can include support for technology development funds, research, technology diffusion, human resource development, institutional development, and policy analysis. As is always the case, the nature and extent of this support is defined as part of overall discussions and dialogue between the Bank and government authorities on the role of the IDB in assisting country development objectives. Past experience suggests that as important as the amount of funding is the flexibility to use it. Research groups are often funded by multiple agencies each imposing its rules and rigidities. This leads researchers to creative accounting and inefficiency.

The Bank will increase its efforts to support technological innovation in the productive sector. It will continue to support technology development funds. These are lines of credit or grants to support improvements in products or processes that incorporate new or risky technologies not susceptible for investment through capital markets. The justification, focus and objectives of such funds have been described above. Eligible activities for financing will include R&D, training, and scientific and technological services. As noted earlier, accumulating experience shows that there are strong limits to what can be done through lending mechanisms. IDB operations will therefore encourage the expansion of matching grants and fiscal incentives for funding science and technology.

As part of the support of technology development funds, intermediary institutions managing and providing such loans will be strengthened, through training, technical assistance, and provision of software and information processing services. The focus will be on ensuring that these institutions have open decision making processes, timely awards of loans and grants, adequate monitoring, and systematic evaluation of results.

In many cases, lending is an inappropriate R&D funding tool, particularly when risks are very high or start-up firms cannot show the requisite collateral to borrow. In such cases, co-financing and matching grants turn out to be far more efficient. The Bank has a good record in such programs and there are good reasons to use them more often, as an alternative to loans.

Experience has shown the critical importance of policies which encourage firms and the government to purchase technology (a procedure widely used by the military with considerable success) in developed and developing countries. These procurement practices (which amount to twice as many dollars than direct support in OECD countries) boosted the initial production of semiconductors in the United States and allowed the Brazilian Embraer to get started in the production of commuter airplanes.

The Bank will expand its support of a variety of technology diffusion efforts by centers or units which offer both information and technical assistance, particularly for small and medium businesses. These agencies could be located in chambers of commerce, sectoral associations, technology institutes or universities. IDB financial support will include infrastructure (e.g., facilities and equipment), training of personnel, start-up costs, and matching grants for services paid by firms. Normally the private sector will co-finance many of these activities. The level of government/Bank subsidies will vary according to the function/activity, with, for example, support for SMEs and training being more subsidized than the use of laboratory services. Project proposals will have to confirm that procedures are in place to identify and quickly respond to demand for information and for services.

The Bank will not abandon its support of programs which finance, on a grant basis, basic and applied (pre-competitive) research as well ancillary scientific and technical services projects, but its support will be focused, especially on key areas for economic and social development. National scientific funding institutions normally manage and oversee research programs financed by the Bank. The IDB will fund programs where institutional governance and incentives are appropriate, or alternatively, where funding is part of the effort to strengthen governance. Project support normally covers incremental salaries, equipment, operating costs, training, communication and dissemination of research results, and (if agreed with the country) overhead. Of particular importance will be the strengthening and establishment of electronic communications (Internet). The Bank will normally review the capacity of the financing institution for transparent peer-based decision making, monitoring, and evaluation and, where necessary will support strengthening of the institution's capacity to manage such programs through training, technical assistance, and software and hardware provision. The rules and regulations for award, financing, monitoring and evaluation of projects, as well as the process and results of definition of high priority areas, will need to be acceptable to the IDB before agreeing on financing

Where appropriate, the Bank will support infrastructure, equipment, training and other needs of new or existing institutions considered critical to technological development. The criteria necessary for this type of support are as follows: the investment in the particular institution is shown to be indispensable for the country's S&T development (research, graduate training, or S&T services); the effective demand for the services is clearly defined; the institution has in place adequate capacity for management and self-evaluation or strengthening such capacity is included in the loan; financing of recurrent costs generated by the investment is ensured; and criteria for measuring success in meeting the institution's mission is agreed upon.

The Bank will support human resource training designed to strengthen all of the above activities. This could include short- and long-term training, in academic and nonacademic settings, taking place in the home country as well as overseas, to upgrade the staff of research, service, financing, and sectoral institutions. Programs of this type will usually emphasize linkages with the long-term plans and goals of specific centers, agencies and institutions. In some cases, free-standing projects for graduate training in-country and overseas will be considered. The institution managing such programs will have to demonstrate its capacity for sound decision making and management of fellowships and scholarships, including repatriation of overseas students and repayment of loans. Training support will be provided on the basis of a range of instruments including loans and conditional grants to recipients, with the extent of the grant element dependent on the future activities and institutional affiliation of the recipient. Where the candidate is from a for-profit company, full repayment by the candidate and/or firm would be expected.

The Bank will also expand its support for professional and business associations in science and technology, publications, conferences, and popularization of science and technology. Such support will especially be designed to encourage linkages between researchers and practitioners working in related fields. Support could include book publication, journals, web-pages, conferences, virtual seminars and training, science awards, and science museums. The Bank will also support research, consensus building, dialogues, and study tours on a wide variety of issues related to national innovation systems.

Internationalization pushes Latin America to collaborate with other countries and, in particular, to join forces with neighbors in matters of science and technology. Yet, the present financial tools of the Bank severely limit the possibilities of supporting these initiatives. Therefore, the IDB will consider the development of new financial instruments and approaches. Among those to be considered are regional and multilateral programs in S&T and venture capital funds in coordination with the Inter-American Investment Corporation.

IMPLEMENTING AND MONITORING THE S&T STRATEGY

It is not appropriate to define explicit regional goals for increased country or regional investment in R&D, because of different country conditions, uncertainty in the data, and also because the emphasis should be on efficiency and effectiveness rather than gross investments. Nonetheless, in coordination with other agencies and programs, the Bank will monitor country by country progress, including productivity indicators; gross amounts, percentage of GDP, and private sector investment in R&D; the numbers of scientific and technical personnel; patents; etc. Of particular importance will be the extent of increased private sector investment in R&D.

While nearly all future Bank-financed projects will have S&T components, projects specifically seeking to develop S&T will continue to be an important element of the IDB portfolio. The number of countries with this type of project is expected to increase as the Bank takes a more proactive role toward assisting the smaller and poorer countries in the region. In view of the long lead time for institutional development and attitude change, as well as the need for continuity in funding, the Bank will seek to provide continuous support (e.g., sequential projects) over a long-term period (e.g., at least ten years). Future projects will have strong monitoring and evaluation components to assist in determining the cost-effectiveness of investments, including spin-offs and attitude changes. On a timely basis, the Bank will undertake regional reviews of overall progress, policy reform, and the impact of in its own investments and interventions similar to the recent OVE report. The IDB will ensure that concerned departments and divisions responsible for macroeconomics, finance, private sector development, environment and education coordinate their activities in science and technology, and will consult on a regular basis with outside advisory groups. The Bank will also ensure that it is adequately staffed with personnel who understand the issues of this area. With regard to the current Bank policy on science and technology (OP744), as it does not conflict with the current strategy, it will remain in force. Because of the cross-sectoral nature of science and technology as well as its importance, the Bank will re-establish a focal point to represent the Bank, coordinate its own efforts, and provide support to operational units.

References

Alic, John A., Lewis M. Branscomb, Harvey Brooks, Ashton B. Carter, and Gerald L. Epstein. 1992. *Beyond Spinoff: Military and Commercial Technologies in a Changing World* . Boston: Harvard Business School Press.

Arregui, P. 1988. Indicadores comparativos de los resultados de la investigación científica y tecnológica en América Latina. In *Progreso económico y social en América Latina. Informe 1988*. Washington, D.C.: Inter-American Development Bank.

Castro, Claudio de Moura, and John Alic. 1997. Technology, Science and Development in Latin America and the Caribbean. Unpublished background paper. Washington, D.C.: Inter-American Development Bank.

COLCIENCIAS. 1994. *Diez casos exitosos de innovación tecnológica*. Bogota.

Cook, C. and Sagasti, F. 1987. La ciencia y la tecnología durante el decenio de los ochenta. *Comercio Exterior,* Vol 37, No. 12.

CORFO. 1995. *Cien proyectos innovadores*. Santiago.

Dahlman, Carl, and Claudio Frischtak. 1993. National Systems Supporting Technical Advance in Industry: The Brazilian Experience. In *National Innovation Systems: A Comparative Analysis,* ed. R. R. Nelson. New York: Oxford University Press.

Evaluation Office (OVE). 1998. *Science and Technology Program Evaluation, Synthesis Report*. Washington, D.C.: Inter-American Development Bank.

Fundación Centro de Biosíntesis de Argentina. 1996. Exposición de diez casos existosos de I&D realizados en Argentina por centros e institutos del CONICET. Buenos Aires.

Gibbs, W. 1995. Lost Science in the Third World. *Scientific American, A*ugust.

Goldman, Melvin and Henry Ergas. 1997. Technology Institutions and Policies. World Bank Technical Paper No. 383. Washington, D.C: The World Bank.

Inter-American Development Bank. 1997. Proyectos de innovación tecnológica a nivel de empresas privadas en Uruguay, 1997. M*i*meo.

____________. 1998. *Progreso económico y social en América Latina. Informe 1988.* Washington, D.C.. Inter-American Development Bank.

Maddison, Angus. 1995. *Monitoring the World Economy, 1820-1992.* Paris: OECD.

Magalhaes Castro, M.H., and Eva Stal. 1998. *Trinta anos de FINEP: Banco ou mecenas, fomento ou balcão?* Technical Papers Series of the Sustainable Development Department (Education Unit), N° EDU-107. Washington, D.C.: Inter-American Development Bank.

Magalhaes, Castro, M.H. 1996. Estudos de Caso em Desenvolvimento Tecnologico: A Experienca da FINEP (1967-1995). Mimeo. Inter-American Development Bank.

Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS), Boston College, Chestnut Hill, Mass. 1996.

Mayorga, Román. 1997. *Closing the Gap*. Social Programs Division, N° SOC97-101. Washington, D.C.: Inter-American Development Bank.

Mullin, James. 1998. Technology Centers and the Needs of SME's: a Survey of International Experiences. Paper prepared for the IDB Seminar on Diffusion, Assimilation and Use of Technology by Private Firms, February 9 and 10, 1998, Washington D.C.

National Science Foundation. 1995. *Asia's New High-Tech Competitors*, NSF 95-309. Arlington, VA.

Nelson, Richard R. 1996. *The Sources of Economic Growth.* Cambridge, MA: Harvard University Press.

OECD, Working Group on Innovation Policy. 1997. National Systems of Innovation: Background Report. Paris.

Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo. 1997. *Indicadores de ciencia y tecnología, 1990-1996.* Buenos Aires: OAS and CYTED.

Roessner, J. David, Allan J. Porter, Nils Newman, and David Cauffiel. 1995. Implementation and Further Analysis of Indicators of Technology-Based Competitiveness: Executive Summary. Technology Policy and Assessment Center, Georgia Institute of Technology, Atlanta, GA. March.

Sercovich, F. C. and S. Teitel. 1984. Exports of Technology by Newly Industrializing Countries: Latin America. *World Development*, Vol. 12, No. 5/6.

Smith and Barfield, eds, *Technology, R&D, and the Economy*, especially Edwin Mansfield. Contributions of New Technology to the Economy, pp. 114-139.

Teitel, S. 1985. Indicadores científico-tecnológicos: La América Latina, países industrializados y otros paises en vías de desarrollo. *El Trimestro Economico,* Vol. LII (1), No. 25.

UNESCO. 1996. *World Science Report 1996.* Paris.

________. 1998. *World Science Report 1998.* Paris.

Waissbluth, Mario. 1998 El financiamento gubernmental a la innovación. *Comercio exterior*. Mexico.

Annexes

Annex 1
Summary of IDB Science and Technology Strategy

S&T PROBLEMS IN COUNTRIES OF LAC	OBJECTIVES	TYPICAL TOOLS
I. SYSTEMS APPROACH		
Absence or weakness of national innovations systems (NIS)	**Coordinate public policy and create incentives for system-wide collaboration among NIS stakeholders**	• Stakeholders dialogues • Policy studies and identification of key linkages • Loan conditionalities and requirements
II. INCREASED EMPHASIS ON TECHNOLOGY		
Imbalances between S&T supply and demand	**Ensure a closer matching of S&T supply and demand**	• Technology development funds for enterprises • Support for joint R&D projects and exchange of personnel between universities and users • Linkage requirements in funds that support supply • Public sector procurement and regulatory policies
Low productivity due to lack of technological diffusion	**Promote the dissemination of existing technologies which are appropriate for the conditions of each country**	• Support for S&T services, especially those of information and extension • Adaptation of foreign technologies • Development of sectoral technological centers • Middle level technical training and professional up-dating
Little competitiveness due to insufficient technological innovation	**Encourage firms to engage in Research and Development (R&D)**	• Technology development funds for enterprises • Risk or venture capital funds • Fiscal incentives • Intellectual property rights
III. CONTINUED SUPPORT OF SCIENCE RESEARCH WITH GREATER CONCENTRATION IN CRITICAL AREAS		
Scarce capacity for high quality research Dispersion of capacity and little linkage between R&D and development needs	**Escalate and refocus national research efforts, with more effective use of resources**	• Funds for peer review based competitions of research projects • Block grants and discretionary project financing in some cases • Selective strengthening of institutional infrastructure
IV. PROACTIVE SUPPORT TO SMALLER, POORER COUNTRIES		
Concentration of S&T progress in a few countries	**Greater support to smaller, poorer countries**	• Technical cooperation to identify critical needs and develop specific national and subregional strategies • Assistance in stakeholders dialogues • Financing of comprehensive national programs of S&T
Little collaboration among countries of the region	**More international cooperation in S&T**	• Regional technical cooperation projects • Support for cooperation among countries through components of national programs

S&T PROBLEMS IN COUNTRIES OF LAC	OBJECTIVES	TYPICAL TOOLS
V. PARALLEL INCREASE IN SUPPORT FOR EDUCATION AND TRAINING		
Weak base of qualified human resources	**Remedy shortages of qualified human resources and strengthen the baseof education and training**	• Funds for high level training of human resources • Strengthening of research and post-graduate programs in universities • Middle-level technical training and pr o-fessional up-dating • Programs to improve mathematics and science teaching at the elementary and secondary levels

Annex 2
IDB Projects in Science and Technology, 1962-2000
(hundreds of US$)

LOAN No.	DATE	AMOUNT	OBJECTIVES	ACTI
33/IF-ME	4/62	400	A loan intended to contribute to financing the acquisition of technological and laboratory equipment for research.	
91/SF-AR	4/66	1 000	Support of a training and research program in modern metallurgy, including (i) courses for university graduates from Argentina and other Bank member countries; (ii) postgraduate thesis work; and (iii) training courses for industry personnel.	1. Completion of office, worksho 2. Acquisition and installation of
361/SF-BR 250/OC-BR	6/73	25 800 6 200	Strengthening of eight research and development centers in Brazil, chosen under the Federal Government's Science and Technology Program.	Installation of new equipment, cons strengthening of staff.
498/SF-BR 327/OC-BR	12/76	20 000 40 000	Improve domestic capacity to absorb new technologies, promoting technology transfer to Brazilian-owned industries.	1. Loans to subsidize small or me firms for research and develop operation and training. 2. Strengthening of the research a
329/OC-ME	1/77	20 000	Preparation of senior-level staff to serve as support for the country's scientific and technical infrastructure, in priority fields.	Scholarships and loans for masters graduate courses, in country and ab
335/OC-BR	7/77	20 000	Transfer and absorption of technology for the construction and operation of ethylene production plants and engineering services needed for CEPMAP, which will be the primary supplier of raw materials for second-generation companies in the III Petrochemical Center.	Training of personnel; transfer of te experimental units on a group scale technical advisory assistance to stre ties; preparation of basic engineerin nologies; detail engineering.
348/OC-AR	2/79	66 000	Strengthening scientific and technological research at new development poles within the country; improving and expanding the real research capacity applied to production processes, in accordance with the characteristics of each regional center, in the following sectors: (i) agriculture (ii) industry, (iii) fisheries, (iv) physical infrastructure, (v) navigation and transportation, and (vi) earth sciences.	Construction or expansion of nine r physical infrastructure, equipment a CET and INCYTH can carry out th
360/OC-ME	11/79	40 000	Training of senior level staff to support the country's scientific and technical infrastructure in field that are of high priority to Mexico's development.	Scholarships and loans for master's and technical training courses in the

LOAN No.	DATE	AMOUNT	OBJECTIVES	ACTI
403/OC-ME	4/81	50 000	Strengthen the scientific and technological base needed to create and adapt the technology in accordance with the country's resources.	Expansion and strengthening of res ments to address the priority activit ment Plan. Encourage Mexican con services generated within the count and experience of technological res
427/OC-BR 696/SF-BR	10/82	50 000	Promote and finance social, scientific and technological pre-investment studies, in accordance with sectoral and regional targets and priorities set forth in the national development plans.	1. Loans to public or private entit 2. Loans to public companies or p ELETROBRÁS, to engage con
109/IC-CO 110/IC-CO	11/82	50 000	Increase the volume of scientific and technological research in Colombia and promote significant improvement in the quality of such activities.	Create 20 programs and post-gradu eas. Finance research projects in pr development. Strengthen the physi Colombian university system in ord ity research in priority academic are
435/OC-BR 715/SF-BR	3/83	18 000 4 500	Increase the quality and quantity of agricultural research carried out by the universities in the Northeast, Brazil, with a view to resolving typical problems of the northeastern tropical semi-arid region. Field-test and adapt production technologies appropriate for low-income farmers in the semi-arid tropics.	Undertake specific research on prod the region's problems. Test and ada priate for the conditions facing sma the semi-arid tropics.
515/OC-AR	12/86	61 000	Contribute to Argentina's scientific and technological development through greater availability of knowledge, as a result of research studies, the equipping of research laboratories, the training of highly qualified human resources and dissemination among the user community of knowledge that has been developed.	Some 1,100 research project to be u universities and specialized institut national research laboratories, in sp sources training in post-graduate sc this country and in selected countri tivities (seminars, studies, interactio to promote the dissemination of res formation with the country's goods
544/OC-CR	2/88	22 100	Contribute to Costa Rica's economic and social development, by strengthening the major institutions dedicated to scientific and technological research and extension activities.	A fund for financing experimental r infrastructure of research and servic for system users. Expansion of the r and technological services at public
588/OC-CO	12/89	35 700 4 300	a) strengthen Colombia's capacity to engage in scientific and technological research an apply the results for practical development purposes; b) link knowledge- and technology-generating centers more closely to potential users; c) increase the innovation capacity of the production sector in order to improve productivity and increase the levels of product quality and competitiveness; and	1. Finance research projects and s 2. Train human resources through dates nominated for research a 3. Disclosure and dissemination o nology.

LOAN No.	DATE	AMOUNT	OBJECTIVES	ACTI
			d) improve the processes of planning, coordination, execution and evaluation of scientific and technological activities.	
604/OC-VE	12/90	47 000	Contribute to Venezuela's economic and social development, by strengthening the country's ability to assimilate, adapt, generate and employ modern science and technology, in useful forms consistent with its physical assets and cultural heritage.	1. Research projects (R&D) and s projects in the program's priori 2. Create and implement a shared 3. Complete two projects for stre logical infrastructure. 4. Training of technicians in basi essential for the program's pric 5. Establishment of a technology
620/OC-BR	3/91	100 000	Contribute to the development and execution of Brazil's new science and technology policy, providing funding to address the most pressing problems facing the financing of Brazil's scientific and technological activities.	1. Grant non-reimbursable financ projects, or for scientific and t non-profit universities and rese 2. Grant reimbursable or shared-r opment projects by national pr 3. Implement the pilot phase of a technological information and
646/OC-UR	11/91	35 000	Contribute to strengthening Uruguay's scientific and technological capacity so that it can become one of the pillars of the country's economic and social development.	1. Experimental research and dev technological services by publi priority areas. 2. Finance projects by national pr sen by themselves. 3. Facilitate the efficient operatio College of the University of th 4. Expand and modernize the "Cl Institute (IIBCE). 5. Train specialized personnel in areas, in accordance with prov 6. Strengthen the institutional fra tion of the National Science an
672/OC-CH	1/92	94 000	Contribute to Chile's economic and social development by applying financial instruments which, when complemented by the other policy measures established by the government, internally strengthen the various actors and participants in the national science and technology system.	FONDECYT is diverted at the cou research projects without regard fo primarily on the basis of quality. F technological universities and instit strengthen the capacity of such inst ority for the country's economic de ogy development projects by priva for special loans for that purpose.

LOAN No.	DATE	AMOUNT	OBJECTIVES	ACTI
804/OC-ME	12/93	150 000	Contribute to increasing Mexico's scientific and technological capacity, as well as to expanding and improving the strengthening of human resources in such areas in order to address its economic and social development needs.	Direct financing of micro- and smal pre-commercial and pre-production vestment plan addresses the need tc availability of equipment to moderr shops, libraries and computer cente search plans of the Autonomous Ur entific and technological discipline
802/OC-AR	12/93	95 000	Contribute to developing the efficiency and competitiveness of Argentina's production processes.	1. Financing to private companies and development (R&D) proje competitiveness on domestic a 2. Subsidies to the Technology L 23,877 and to public and priva gage in technology linking pro projects, the results of which n socioeconomic activities.
874/OC-EC	8/95	24 000	Contribute to strengthening Ecuador's scientific and technological capacity so that it can become one of the linch pins of its economic and social development.	1. Complete approximately 50 ex ment (R&D) projects and scier ects. 2. Execute eight science and tech 3. Create and implement a financ projects, involving innovation sector. 4. Post-graduate programs in Ecu 5. Strengthen the National Scienc and the technical, operating an (FUNDACYT).
875/OC-CO	8/95	100 000	Contribute to strengthening the Colombia's science and technology capacity and to increasing the companies´competitives and productivity, in the context of sustainable development..	1. Post-graduate programs in Ecu 2. Strengthen the National Scienc and the technical, operating an (FUNDACYT).
880/OC-BR	9/95	160 000	Contribute to improving and developing Brazil's scientific and technological capacity and to increasing company competitiveness and productivity, through technological modernization.	1. Reimbursable financing to priv modernization. 2. Financing through non-reimbur velopment projects submitted l and private research institutes.
1201/OC-AR	9/99	140.0	Help enterprises, mainly small and medium ones, to initiate import, alter or adapt technologies to increase their efficiency and competitiveness.	1. Incentive mechanisms for inno cluding grants as well as credit 2. Strengthening scientific and te cluding thematic and geograph 3. Support for strengthening S&T

LOAN No.	DATE	AMOUNT	OBJECTIVES	ACTI
1207/OC-GU	10/99	10.7	Enhance the productivity and competitiveness of small- and medium-size enterprises.	1. Matching grants for technologi sion of a technology informati 2. Expanding the policy framewo
1220/OC-VE	11/99	100.0	Strengthen the national innovation system through improving competitiveness of productive sectors, promoting innovation; fostering cooperation between academic and other sectors, and disseminating and popularizing science and technology.	Financing for R&D projects, traini search, strengthening R&D centers innovation in the production, social nating information, and strengtheni
1273/OC-PN	11/00	10.0	Support for science, technology and innovation center of excellence in Panama.	Strengthen the City of Knowledge oping a science and technology par in the design and implementation o development of a market plan, and mation technology facilities.
1286/OC-CH	11/00	60.0	To increase the competitiveness of the Chilean economy by supporting technological innovation within the entrepreneurial sectors, including identifying key areas for investment, introducing information technologies, promoting biotechnology, improving environmental performance in production processes, and encouraging adaptation of quality management systems.	Financing of R&D and technology ening infrastructure and institutions mation.
1293/OC-UR	12/00	30.0	Help mobilize the country's innovative capacity through boosting the competitiveness of small- and medium-sized enterprises.	Support for innovation in Uruguay plication of science and technology

Annex 3
R&D Indicators
Gross Domestic Expenditure on R&D (GERD)
(millions of US$)

Country	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**19**
Bolivia	–	–	21	23	24	24	24	[illegible]
Brazil	2,801	2,834	2,321	3,072	4,657	5,360	5,484	
Canada	7,575	7,995	8,491	9,210	10,118	11,051	11,059	11,7
Colombia		–		–	259	318	351	3
Costa Rica	41.5	58.0	82.8	107.0	102.3	114.9	108.1	
Cuba	137	111	169	118	106	101	87	1
Chile	155	184	249	287	339	423	455	4
Ecuador	–	–	–	–	–	14	16	
Mexico	–	–	–	887	1,235	886	1,030	1,3
Panama	20	22		26	28	30	31	[illegible]
Portugal	502	–	705	–	–	756	–	9
Spain	3,889	4,343	4,694	4,764	4,530	4,802	5,169	5,4
United States	152,039	168,863	165,211	165,442	168,854	183,232	196,540	211,5

Source: *Indicadores de ciencia y tecnología*, Red Iberoamericana de Indicadores de Ciencia y Tecnología, Buenos Aires, 2000 (www

GERD as a Percentage of GDP (%)

Country	1990	1991	1992	1993	1994	1995	1996	1997
Bolivia	–	–	0.37	0.39	0.39	0,37	0.33	0.3[illegible]
Brazil	0.46	0.46	0.38	0.48	0.69	0.76	0.76	–
Canada	1.45	1.51	1.56	1.60	1.65	1.62	1.57	1.5[illegible]
Colombia	–	–	–	–	0.37	0.39	0.41	0.4[illegible]
Costa Rica	0.73	1.05	1.23	1.42	1.23	1.25	1.13	–
Cuba	0.72	0.65	1.13	0.93	0.82	0.77	0.61	0.7[illegible]
Chile	0.51	0.53	0.58	0.65	0.66	0.65	0.66	0.6[illegible]
Ecuador	–	–	–	–	–	0.08	0.09	0.0[illegible]
Mexico	–	–	–	0.22	0.29	0.31	0.31	0.3[illegible]
Panama	0.38	0.38	0.34	0.36	0.37	0.38	0.38	0.3[illegible]
Portugal	0.54	–	0.66	–	–	0.56	–	0.6[illegible]
Spain	0.85	0.87	0.91	0.91	0.85	0.85	0.87	0.8[illegible]
United States	2.62	2.69	2.61	2.49	2.39	2.48	2.52	2.5[illegible]

Expenditure on R&D by Sector (%)
GERD by Source of Fund

Country	Sector	1990	1991	1992	1993	1994	1995	1996
Brazil	Government	71.5	70.9	69.5	69.4	67.3	59.1	57.2
	Private Companies	23.9	24.5	24.7	26.2	29.7	38.2	40.0
	Higher Education	4.7	4.6	5.7	4.4	3.0	2.7	2.8
	Nonprofit Private*	-	-	-	-	-	-	-
	Foreign	-	-	-	-	-	-	-
Canada	Government	36.2	35.5	35.0	33.3	30.2	28.3	27.2
	Private Companies	40.2	40.0	41.2	43.3	45.3	46.5	46.6
	Higher Education	11.5	11.9	11.8	10.7	10.0	10.5	10.1
	Nonprofit Private*	2.5	2.7	2.3	2.6	2.6	2.5	3.0
	Foreign	9.6	9.9	9.7	10.1	11.9	12.2	13.1
Colombia	Government	-	-	-	-	77.0	74.0	73.0
	Private Companies	-	-	-	-	8.2	10.0	11.3
	Higher Education	-	-	-	-	8.3	11.8	12.0
	Nonprofit Private*	-	-	-	-	6.5	4.2	3.7
	Foreign	-	-	-	-	-	-	-
Costa Rica	Government	33.1	52.0	58.8	64.7	55.7	49.8	53.4
	Private Companies	11.9	7.6	8.2	8.0	11.1	20.2	17.4
	Higher Education	19.4	14.6	12.1	9.9	15.4	13.9	14.8
	Nonprofit Private*	0.9	0.6	2.1	2.2	3.1	3.3	4.5
	Foreign	34.7	25.1	18.8	15.2	14.8	12.8	9.9
Chile	Government	67.0	67.9	58.7	64.2	69.2	71.2	69.5
	Private Companies	15.7	15.1	22.6	18.6	14.1	12.2	16.6
	Higher Education	10.9	9.1	10.9	8.9	9.4	9.7	7.5
	Nonprofit Private*	-	-	-	-	-	-	-
	Foreign	5.5	7.9	7.8	8.3	7.3	6.8	6.4
Ecuador	Government	-	-	-	-	-	39.8	79.7
	Private Companies	-	-	-	-	-	32.5	-
	Higher Education	-	-	-	-	-	-	-
	Nonprofit Private*	-	-	-	-	-	4.9	0.4
	Foreign	-	-	-	-	-	22.9	19.9
Spain	Government	45.0	45.7	50.2	51.6	52.4	48.0	48.0
	Private Companies	47.4	48.1	43.7	41.0	40.3	44.5	45.5
	Higher Education	-	-	-	-	-	-	-
	Nonprofit Private*	0.8	0.6	0.6	1.0	1.0	0.8	1.0
	Foreign	6.8	5.6	5.5	6.4	6.3	6.7	5.5

Country	Sector	1990	1991	1992	1993	1994	1995	1996
United States	Government	41.5	38.7	37.8	37.5	37.0	35.5	33.3
	Private Companies	54.8	57.5	58.4	58.4	58.8	60.6	62.9
	Higher Education	2.1	2.1	2.2	2.2	2.3	2.3	2.2
	Nonprofit Private*	1.6	1.6	1.7	1.8	1.8	1.7	1.6
	Foreign	-	-	-	-	-	-	-
Mexico	Government	-	-	-	73.4	63.6	66.2	66.8
	Private Companies	-	-	-	14.3	19.0	17.6	19.4
	Higher Education	-	-	-	8.9	7.7	8.4	8.1
	Nonprofit Private*	-	-	-	1.2	0.6	1.1	2.2
	Foreign	-	-	-	2.3	9.1	6.7	3.5
Panama	Government	-	35.4	39.7	41.5	44.2	45.5	42.2
	Private Companies	-	0.5	0.4	0.5	0.6	0.5	2.2
	Higher Education	-	0.4	0.5	1.0	1.0	0.9	1.0
	Nonprofit Private*	-	0.9	1.0	1.2	1.1	1.1	1.8
	Foreign	-	62.8	58.4	56.0	53.1	52.0	52.8
Portugal	Government	62.0	-	59.0	-	-	65.3	-
	Private Companies	27.0	-	20.0	-	-	19.5	-
	Higher Education	1.0	-	1.0	-	-	1.2	-
	Nonprofit Private*	6.0	-	5.0	-	-	2.1	-
	Foreign	5.0	-	15.0	-	-	11.9	-

*Nonprofit Private Organizations.