CANADA

IDRC-TS26e

Science and Technology for Development

Policy Instruments to Build up an Infrastructure for the Generation of Technology

STPI Module 5

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IDRC-TS26e

Science and technology for development : STPI module 5 : policy instruments to build up an infrastructure for the generation of technology. Ottawa, Ont., IDRC, 1980. 59 p.

/IDRC publication/, /science/, /technology/, /science policy/, /institution building/, /national planning/, /development planning/, /financing/, /Argentina/, /Brazil/, /Colombia/, /Egypt/, /India/, /Korea R/, /Japan/, /Mexico/, /Peru/, /Venezuela/.

UDC: 6.008.01 ISBN: 0-88936-263-7

Microfiche edition available

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Science and Technology
for Development

STPI MODULE 5: POLICY INSTRUMENTS TO BUILD UP AN INFRASTRUCTURE FOR THE GENERATION OF TECHNOLOGY

A. Aráoz

CONTENTS

FOREWORD

This module constitutes an integral part of the Main Comparative Report of the Science and Technology Policy Instruments (STPI) project, a large research effort that examines the design and implementation of science and technology policies in 10 developing countries (Appendixes 1 and 2).

The STPI project generated a large number of reports, essays, and monographs covering a great variety of themes in science and technology for development. More than 250 documents were produced by the country teams and the Field Coordinator's Office, and this proliferation posed rather difficult problems during the comparative phase of the project. It was decided that a Main Comparative Report, covering the substantive aspects of the research work of the country teams would be published, and that several monographs treating specific subjects would complement it.

The Main Comparative Report is organized in three parts. The first consists of a short essay covering the main policy and research issues identified through the research, and the second contains the most relevant results of a comparative nature that were obtained in the project. These first two parts have been published by the International Development Research Centre in a single volume in English, Spanish, and French (109e, 109s, and 109f).

The third part of the Main Comparative Report consists of 12 modules containing material selected from the many reports produced during the STPI project. They provide the supporting material for the findings described and the assertions made in the first two parts of the Main Comparative Report.

The modules were prepared by several consultants, and given the diversity of topics covered, the IDRC staff did not consider it desirable nor possible to impose a single format or structure for their preparation. The reader will find a diversity of styles and structures in the modules and will find that the selection of texts reflects the views of the consultant who compiled the module. However, the modules were prepared in close collaboration with the Field Coordinator and were also submitted to a STPI editorial committee who ensured that they provided a representative sample of STPI material. They should be read in conjunction with the first two parts of the Main Comparative Report.

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INTRODUCTION

The increase in the supply of scientific and technological products - knowledge, services, trained personnel - requires that the science and technology policy should include both the creation of scientific and technological (S&T) capacity and its proper use.

The emphasis to be put on either aspect will depend on the stage of S&T development in the country considered. Developed countries already have an established S&T infrastructure, and it would seem that the principal role of S&T policy is to put it to work according to national needs and objectives. This type of action may be called marginal, in contrast with structural action, which would be centrally relevant in developing countries such as Senegal and Ecuador where the S&T infrastructure is still to be built. Some countries are in an intermediate stage where policy should take care of both types of action. This is the case in the countries that have participated in the STPI Project; they may be classified in two general groups:

(1) Countries with a S&T infrastructure still being developed (Brazil, Colombia, Egypt, Korea, Macedonia, Mexico, Peru, and Venezuela); here perhaps more emphasis should be placed on structural than on marginal aspects.

(2) Countries with a fairly developed S&T infrastructure, which needs consolidation rather than important structural expansion and should be oriented toward national needs (Argentina and India). The emphasis should be on marginal aspects, although structural aspects are still important.

The time horizon is longer in the structural case than in the marginal one. In countries with a weak S&T infrastructure, the greatest part of the total resources assigned to S&T would be devoted to investment, ideally in accordance with long-range needs and requirements, which usually do not clearly come out of a medium-range development plan. This plan, however, may be employed to give many useful indications for orienting the activities of an established S&T infrastructure. Policymaking in Brazil and India would exemplify such situations.

Three types of instruments are to be explored in this module, and the experiences of the countries participating in the STPI Project will be brought to bear in the analysis. They are institution building, financing, and science and technology planning. The first refers to the way in which a science and technology infrastructure, and its component institutions, are designed and developed. The second covers the use of financial instruments - principally special funds for scientific and technological development, and the national budget for scientific and technological activities - to allow for the structural and incremental growth of S&T capacity. The third considers the way in which policy objectives, resources, and activities may be woven into a coherent plan for the expansion of S&T capacity and for its proper utilization.

Each of these instrument types will have a different impact, but there is complementarity between them. S&T planning is perhaps the one that should be brought in last, when conditions exist for its successful application - conditions largely created through the action of the two other instruments - because it would not make sense to engage in a costly and time-consuming planning exercise if there is little previous development of an infrastructure and of financial mechanisms.

INSTITUTION BUILDING

The development of an institutional infrastructure for the scientific and technological system is a necessary condition for the development of science and technology in developing countries. As a former Director General of UNESCO has put it (1), "the scientifically advanced nations know well - and this is precisely the secret of their technological pre-eminence - that the social and economic benefits derived from oriented or applied research depend on the existence and efficiency of what is known as the country's "operational network" of scientific and technological research institutions."

This network of institutions is generally well developed in advanced countries, and therefore they have seldom dealt with it explicitly: planners in developed nations take the institutional structure for granted and address themselves to the problems of priorities or resource allocation.

The fact that institutional structures are more developed in advanced countries has often led to the belief that developing countries should follow a strategy of imitation in planning their institutional development. But such a strategy is likely to be inefficient and ultimately to fail (2). The reasons for this are fairly evident. First, the context and the environment in which institutions operate in a developed country are widely different from those prevailing in the developing ones, and there is no guarantee that the institutions will operate efficiently and contribute to development. Second, if they had the choice, developed countries would probably prefer in many cases to develop a different institutional structure than the ones that they presently have and that are being copied. Third, the particular social and historical conditions of the developing country may provide opportunities to develop new institutional patterns that are better suited to local conditions and that could eventually become a model for other countries, developing and developed.

In developing countries the growth and evolution of institutions in the scientific and technological system have been slow. Research organizations, universities, research councils, and service organizations have lacked financial resources and qualified manpower, and in some cases, particularly in Latin America, there has been little demand for the knowledge and services they produce.

A well-organized institutional structure, particularly at the national level, cannot be developed from scratch in a short period of time. However inadequate, there is usually a core of institutions from which to begin building and designing the organizational fabric in developing countries. They should be examined critically, and changes and additions should be considered. Once proposals are implemented, they should be left to evolve without changing them again too soon. A certain lead time is required for the institutions to stabilize after introducing major modifications, and frequent radical changes may retard the development of the institutional structure.

It is not possible to optimize an institutional design in the traditional sense. There is no set of criteria for identifying and generating optimal institutional designs, particularly for the scientific and technological system in developing countries. One possible strategy may be based on a "satisfying" approach in which minimal conditions are established for an acceptable institutional structure. To this may be added a second set of criteria based on the capability of the institutional design for adjusting to changes in the system or its environment. In this way institutions may comply with minimal standards ensuring acceptability, and they may acquire a capacity for adaptation, helping its survival in the frequently changing milieu of a developing country.

There is no standard blueprint for the institutions that an efficient S&T infrastructure should contain, but most people would agree that five different types of activities should be contemplated:

(1) R&D, in universities, government institutions (general purpose, devoted to a problem area, mission oriented), industrial research institutes, and industry-level units and laboratories.

(2) Supporting activities for R&D, such as information, computing, training, surveys of natural resources, etc.

(3) Services for the technological needs of the productive and government sectors, such as consulting, engineering, diffusion and technical information, standards, meteorology, quality control, analyses, tests, trouble shooting, etc., as well as technical advice for policymaking, regulation of technology imports, etc.

(4) Public S&T services, such as those provided by statistical offices, observatories, geographical and meteorological institutes, etc.

(5) Policymaking for science and technology.

An institution may carry out one or more of these activities. In developing countries the latter is usually the case because the size of the S&T infrastructure - measured for instance by the number of scientists and engineers - is not large enough to allow for a great deal of specialization. Additionally, there may be complementarities in having the same institute carry out several types of activity; for instance, industrial research institutes in developing countries tend to undertake testing, quality control, technical assistance, consulting, engineering, and training, in addition to R&D, and such activities may be more important at a certain time if industry requires them for its own technical development.

Certain aspects of institution building in R&D institutes, which make up the heart of the S&T infrastructure, are examined next. Institution building requires first the installation of S&T capacity; this means the creation of new institutions, and the reinforcement of existing institutions by small piecemeal additions or by major expansion. The concern here is in the creation and the major expansion cases, in which structural rather than incremental growth of the S&T infrastructure takes place. In such cases investment projects are to be formulated, engineered, and implemented in such a way that results are optimal for society.

The problem in many developing countries is still mainly structural: how to get S&T capacity installed. This has often taken place in a haphazard way, guided by intuition, pressure groups, and the imitation of S&T development patterns elsewhere. However, it is possible to introduce some rationality into this process.

Major fields in which new S&T capacity is to be installed, or existing capacity considerably reinforced, may be identified through a planning exercise that may be done concurrently with the preparation of an economic and social development plan. Long-term requirements may be compared with existing capacity to find out the areas where existing capacity should be strongly reinforced or new capacity created.

It should be remembered, however, that decisions about the creation of new scientific and technological capacity should take into account a time horizon that goes beyond that of a 5-year planning period. When capacity is installed, resources are committed for investment, in persons and physical installations, which may require up to 3 or 4 years before being completed. To this should be added a period of time, varying according to the nature of the field, during which the institution is consolidated and grows, acquiring new knowledge and experience, until it reaches a situation of maturity in which it can produce efficiently the type of outputs it was originally designed to produce. The period of installation and maturation may be long (for instance, the Metallurgical Laboratory of the Atomic Energy Commission of Argentina took about 10 years), and although in the meantime the developing institutions may provide new knowledge and services, much of its energies are tied up with its growth and the improvement of its intellectual quality.

These considerations should be made explicit to policymakers so that they do not entertain expectations that cannot be satisfied in the short run. Investment in science is not like investment in industry or in the economic infrastructure, where outputs depend principally on physical assets and equipment, and where the human resources required to run new installations are usually obtained without much difficulty from the labour market and are able to do a good job after a relatively short period of training. In science, output depends principally on the number and quality of human resources, and to a lesser extent on buildings and equipment. It takes much time to develop human resources from the usual bachelor of science level with only a general type of training into the type of researcher who will produce good results. Moreover, a collection of mediocre scientists will only produce mediocre results, so an eye must be kept on scientific excellence. Scientific institutions, being basically made up of human beings, are fragile and vulnerable, and the record shows how easily such an institution may be destroyed through the loss of its top scientists as compared with the long time it has taken to build it up.

A first task in S&T planning is the establishment of capacity in human and physical resources in fields that are considered to be of high priority. The planning of investment in S&T may be expressed in a set of investment projects chosen from a number of candidate projects to be gradually implemented over several years, according to the possibilities of allocating resources for such a purpose. Investment projects may include new S&T units or institutions, or structural expansion of existing units.

The usual cost-benefit techniques are difficult to apply here. The benefits of producing knowledge are not easy to determine; on the other hand when an investment project in S&T is being considered it is usually not possible to define with precision the types of knowledge that will be produced when the investment matures, because this would involve knowing which research projects will be undertaken a given number of years hence. This double uncertainty would seem to preclude the use of a quantitative cost benefit approach.

To guide decisions in such a situation, the approach suggested by Aráoz and Kamenetzky may perhaps be employed (3). This is a primarily qualitative approach, which may be applied by expert committees through a sequential mechanism. It looks at two main parameters, utility and efficiency, and suggests that the priority of an investment project in S&T will depend on its usefulness for the achievement of national objectives and on the expected efficiency in carrying out its activities. The evaluation of utility in investment projects in the applied sciences (installation of new capacity or structural expansion of already-existing capacity) should consider how desirable future scientific and technological work in the specific area promises to be. Thus the projects should show relevance to national objectives, particularly those pertaining to social and economic development in the long run, and they should be installed to deal with problems in which there is an assurance that useful results may be forthcoming in the not-too-distant future; technological adventures should be discouraged and left for richer countries.

In basic science, the country should attempt to cover a large part of the scientific spectrum so that access is gained to what goes on in the scientific world and that a good level of education is imparted to young people. Normally, such a coverage of the scientific spectrum would be attained in institutions of higher education. If a survey of installed capacity in basic science shows large gaps in the coverage of that spectrum, there would be prima facie strong reasons for filling them, probably through the creation of professorships or university institutes in the missing areas (4).

If the spectrum is adequately covered, there may be a need for reinforcing capacity in basic science in a certain field if this is necessary to produce scientific inputs that are required by an applied science. Such an investment would be justified through its indirect relevance to national objectives. A good example in Argentina is basic research in plant nutrition, important for agricultural research on the use of fertilizers and other related subjects.

As regards efficiency, investment projects should be carefully designed to assure that the conditions exist for a high level of efficiency in their future activities. Among the items that should be checked the following may be mentioned: the qualifications of the person who will lead the scientific group; the optimum size and structure of this group; a good program for training the scientists who are to be incorporated; adequate buildings and equipment, taking into account that the first priority is human resources; and last but not least an annual operating budget that will permit peace of mind and smooth operation at least during the maturation period. It is not worthwhile to set up a new group or institute in science and technology if conditions are not right for good scientific productivity.

The problem is that the state of the art in the design of S&T institutions is not codified as in factory design, for example. No two S&T institutions are the same even when they deal with similar problems. Even though there are a number of rules of thumb that may be employed as guidelines, the design of such an institution is very much an art and not a science. The dangers of uncritically imitating institutions in developed countries - which may not function properly in the very different environment of a developing country - have already been mentioned. This applies both to the strictly productive areas of the institution - its laboratories, workships, information and documentation facilities, etc. - and to the management and organizational characteristics - for instance, a contract research type of institute may not be appropriate in a country where industry has absolutely no tradition of demanding R&D.

Building up S&T capacity is a gradual process that should be carefully planned many years ahead. Two observations may be made. First, the bottleneck for such an expansion lies in human resources, and this underlines the importance of good coordination between S&T policy and educational policy; it is desirable to produce able and creative scientists and engineers at home in strong academic institutions rather than to depend on training from overseas. Second, insistence on usefulness should not downplay the role of basic research. Basic research of a good level of excellence is crucial for producing competent researchers and professionals; it provides standards of quality for applied research, it supplies applied research with much-needed inputs in the form of required new knowledge or just competent advice, and it opens a window to the outer world of science. Without the latter, local scientific acitivity may fall behind, unaware of new developments that are useful for its activities, or it may research topics already explored somewhere else.

The Experience of the STPI Countries

The creation and development of S&T institutions took different forms in the various countries participating in the STPI Project, from a quasi-spontaneous process impelled by scientific groups, ministries, and interested productive units to a planned approach contemplated by national policy and included in national S&T plans.

It is only in recent years that some of the countries have planned the development of their S&T infrastructure according to their national needs, and it cannot be said that this institution-building approach has crystalized into a recognizable methodology as yet, although very interesting elements are appearing.

The two STPI countries with a fairly developed S&T infrastructure, Argentina and India, are examined first. Here, as already suggested, the main task of S&T policy and planning is to consolidate the existing capacity and put it to work according to national objectives. Institution building, however, remains important but does not occupy the central position as is the case in the other STPI countries below.

The S&T system in Argentina grew piecemeal over the years, and there have been notable efforts in several areas of endeavour - principally the military institutions, industry, agriculture, and basic research - to shape subsystems properly in those areas. An example is the network of agricultural research stations and extension agencies of the powerful National Institute of Agrarian Technology, which over a period of 15 years since its foundation (1956) was able to cover thematically and geographically most of the field assigned to it. A more interesting case - and potentially one with very interesting implications for other developing countries - is that of the National Institute of Industrial Technology (INTI), which was created a research system that operates with great flexibility and can be expanded by incorporating already-existing capacity in universities, industry, and official institutions. INTI is an autonomous state institute with its own funding (a proportion of all loans to industry) that has a number of central laboratories in physics, chemistry, materials, and other areas that cut across industrial boundaries. In addition it is empowered to associate with other sponsors - industry, universities, state agencies - to constitute research centres dedicated to a certain field of application that will benefit industrial activity. These centres are not subjected to state control, being nonprofit private institutions, but INTI is allowed to assign funds to them. Hence a vehicle has been found to build up industrial research institutions with state support yet without state red tape and excessive controls. Moreover, in several cases it has been possible to bring into a new centre the physical and human resources of universities that previously were not properly employed in R&D and other S&T activities, so that much of the recent growth of the INTI system has been achieved by incorporating already-existing S&T capacity that was not utilized properly, thereby giving it a mission and an injection of financial resources. There are more than 20 research centres in the INTI system, in addition to a dozen central laboratories, making this a large, multipurpose industrial research institute with a good degree of flexibility and with an excellent mechanism for growth and diversification.

In India, institutional development in S&T has been very important since independence but, as happened in Argentina and other countries, it has taken place according to sectoral initiatives with little overall coordination. The 1974-1979 S&T plan was mainly concerned with how to put this capacity to work according to national needs, but it includes a section regarding the programs of the major scientific agencies, which in several cases include the creation of new S&T capacity in areas whose agencies have identified. This however does not constitute a coherent program for institutional development, but rather an aggregate of what agencies feel they need; it does not attempt to evaluate and integrate these requests or to identify and design institutions needed in areas still unattended.

The Brazilian Plan mentions numerous areas where the creation of new institutions is proposed. This however is implicit in the Plan document; the very long list of new institutions has to be culled from the text, leaving the impression that such an important expansion of S&T capacity as is envisaged should perhaps be treated in a special section and eventually be subjected to a special effort of project formulation, evaluation, and implementation, with particular attention to funding aspects and to the relations with human resource development. Noteworthy among the programs for new S&T institutions in the Brazilian Plan is the one referring to "technological complexes" that would integrate research centres, engineering firms, and high-technology industries, of which the first is now being formed in Rio de Janeiro around five technological institutes and the

National Laboratory of Metrology. This notion of concentrating institutions to provide critical mass, interactions, and other favourable effects is also present in the Korean science park and science town concept, and would seem to be worthy of further study.

Peru and Korea are probably the only STPI countries where institution building has become an explicit national policy. In both cases the question has been how to create an infrastructure that would supply the pressing S&T needs of the rapidly developing economy. In Peru this has been done sectorally, perhaps with little overall coordination, and has brought into being new institutions in agriculture, industry, mining, communications, ocean resources, natural resources, etc. Whether it was better to allow each sector to have its own S&T applied capability, or whether a Korean-type solution should have been adopted with a few general-purpose but sufficiently large institutions, is a matter for debate. The same solution may not apply to entirely different countries on account of historical factors, existing areas of influence, entrenched interests, and other circumstances where strong differences are bound to exist. It would however seem that the manner of institution building in Peru - and this may be applied to many other countries - may have drawbacks in the shape of units too small, atomized efforts, difficult coordination, and duplication of certain physical resources. Time will show whether this is so. In any case, the efforts made by the National Research Council for national planning and overall coordination have largely been unsuccessful so far.

In Korea, on the other hand, institution building has produced a tightly-knit network of efficient S&T institutions - a seemingly powerful Ministry of Science and Technology, a graduate educational institute (KAIS), an information centre (KORSTIC), and four research centres (KIST, KAERI, KDI, ADD) to which five more research centres are to be added in the near future. There is a concentration in Seoul Science Park, and a new science town is envisaged, with the idea of creating the conditions for efficient and effective work in the scientific and educational institutions. It has to be recognized that the conditions under which this institution building has taken place, and is now continuing, are rather exceptional because there has been very important technical and financial support from an advanced scientific power, the U.S., and on the other hand the new institutions could immediately recruit Korean scientists and technologists who were working abroad. Such conditions are not likely be obtained in other countries that wish to expand significantly their S&T capacity, but some lessons may nonetheless be derived from the Korean experience.

ARGENTINA

Institution Building in the Field of Technological Research and Services for Industry: the National Institute of Industrial Technology(5)

The National Institute of Industrial Technology (INTI) of Argentina has developed a very interesting approach toward the building up of capacity for the provision of R&D and other S&T services to the various branches of industry in that country.

INTI was created in 1957 as a decentralized organization in the Ministry of Industry, with the mission of providing technological backing for industrial development by rendering applied research and development both on its own initiative and on request. Over the years the institution was able to grow steadily and extend its scope to a large number of industrial branches. At present INTI has in its system some 250 scientists and engineers who work in almost 20,000 square miles of reasonably well-equipped laboratories and installations.

INTI's policy has stressed the efficient use of the nation's science and technology resources to avoid underutilization of equipment, unnecessary duplication of work, and other causes of inefficiency. This has led it to sign agreements with other large scientific institutions in the country with which collaboration is carried out in a variety of ways, and with various central and provincial government institutions to extend the range of its services to the different regions of the country. But, more important, such objectives are being fostered through the association of INTI and a variety of universities, scientific institutions, and government agencies in the research centres that make up INTI's network. This is equivalent to the important task of institution building, as is seen next.

INTI is a decentralized organization of the government; it possesses its own funds, derived from a levy on loans to industry by two large national banks. Such independent resources make it easier for the institution to prepare long-term plans than would be the case if its resources were allotted yearly in the national budget. This circumstance, however, is not enough to provide a favourable environment for scientific and technological activities, because, as is well known, government organizations have to comply with a large amount of red tape on account of budgetary and administrative procedures that have been designed for other types of activity. A solution to this problem has been found in that INTI is empowered by its charter to create research centres through agreements with other government institutions, universities, industrial associations, and private firms. The research centres are legally private, nonprofit institutions, although they are subjected to control by INTI and so they rightly belong to the official sphere. INTI may assign funds to the centres, but once this is done the funds can be disbursed by the latter without having to comply with certain cumbersome government administrative procedures. Thus, they enjoy great flexibility in the management of their resources, their personnel, etc. On the other hand, the association of industry in a specific centre provides a natural and strong link between scientific and technical activity and industrial firms, which favours the coupling of science and industry.

INTI operates a network made up of several central laboratories and more than 20 research centres. The central laboratories are engaged in research and technical assistance for industry as well as for government; they also provide support for the research centres. The latter deal with the various problems brought to them by the industrial branch they are serving, and engage in research, much of it under contract. Such an organizational setup means that single-purpose units are integrated into a multipurpose institution, at the same time preserving the close contacts of the former with industry and achieving a critical mass of personnel in various disciplines. This system shows several flexibilities that seem to make it especially suited for the tasks it faces:

(1) The private nonprofit legal status of the research centres bypasses cumbersome government administrative procedures.

(2) INTI may sign contracts with government directly (without entering into a bid) and is empowered to channel the funds from such contracts to its research centres where the work will be undertaken.

(3) New research centres may be set up very quickly by merely signing an agreement between INTI and the interested parties. Existing centres may be easily dissolved when the reason for their existence has disappeared.

(4) Temporary research centres may be set up to discharge a short-term task such as a feasibility study; once the job is done the temporary centre is dissolved. This allows INTI and other interested institutions to channel funds for such jobs in an easy way and to employ the best people during the period required.

INTI research centres have frequently been created on the basis of requests by industrial associations or a number of firms in a branch. Costs are borne partly by INTI and partly by the sponsors, INTI's share varying between 20% and 85%. Sponsors may contribute through payments in kind - equipment, materials, assignment of personnel, etc. They benefit from reduced rates in the technical assistance offered by the centre. An executive committee made up of representatives of INTI and the sponsors is responsible for the centre, but INTI reserves the right to approve the nomination of the director and staff; on the other hand the centre has to comply with the general policy guidelines of INTI in technical and administrative matters.

Some centres have been set up in association with the universities and other scientific organizations. In such cases a very interesting feature appears. The university may contribute buildings, equipment, and personnel, which in fact means that a favourable habitat is found for existing scientific groups that may now devote themselves more purposely and steadily to industrial technology activities, under INTI's umbrella. In this way INTI nucleates scientific potential that would otherwise be rather dispersed and allows it to start a useful interaction with industry. In a similar vein, INTI has set up centres by agreement with public enterprises, with the same results. Moreover, multipurpose centres in different provinces may be formed by agreement between INTI, the provincial authorities, the local university, and the local productive system, nucleating the existing capacity in men, equipment, and buildings. Funds for the operation come from INTI and the other sponsors, and the activity is guided by general INTI policies, with due consideration for local practices and needs. The interesting thing about this is that INTI is acting as an organizer and to a certain extent as a funder and policymaker for hitherto disperse, unorganized scientific activity, thus leading toward a countrywide network for research and technical services for industry that does not need the creation of new capacity but rather the organization and complementing of existing capacity. The experience is still too recent to permit an evaluation, but the prospects are promising, two such centers being now in operation.

To sum up, INTI may be considered as a system comprising central administrative and policymaking bodies and a research network made up of (a) central laboratories, (b) industrial research centres that serve various branches of industry (single-purpose research centres), and (c) multipurpose regional technology institutes. The legal and structural characteristics of this system make it an efficient vehicle for building up a S&T infrastructure at the service of industry, both through better use of existing but unstructured S&T capacity and through the creation of new S&T capacity.

INDIA

Creation of New S&T Institutions in the S&T Plan[6]

Several new S&T institutions are to be created by the major scientific agencies in the S&T Plan period.

(1) The Department of Science and Technology (DST) is designated to establish the following organizations: the National Information System for Science and Technology (NISSAT), the Science and Engineering Research Council (SERC), the Cryogenic Corporation, the National Remote Sensing Agency (NRSA), the Ocean Science and Technology Agency (OSTA), and the Regional Sophisticated Instrumentation Centres. In addition, DST is to set up a Machinery and Equipment Development Corporation, an International Technology Transfer Centre (ITTC), and an electronics component manufacturing unit.

(2) The major thrust of the R&D programs identified by the Department of Atomic Energy for implementation during the Fifth Plan is on the construction of a 100 MW thermal research reactor at Bombay and the development of a Reactor Research Centre (RRC) at Kalpakkam. The former is meant for the testing of fuel elements used in power reactors, material-testing programs and the production of radioisotopes. The facilities to be set up at the Reactor Research Centre are oriented to meet the power program requirements based on thorium in the 1980s. R&D work on advanced thermal reactors and fast breeder reactors would be initiated. The primary facility at RRC is the fast breeder test reactor supported by a radio metallurgical laboratory, a radio chemical facility, a materials development laboratory, and related facilities. Nearly 70% of the outlay of the plan is accounted for by these two projects. Of the remainder, many of the schemes consist of extensions to the existing facilities at the Bhabha Atomic Research Centre (BARC). New work is proposed to be undertaken in the fields of radio pharmaceuticals, radiation sterilization plutonium and uranium plant expansion, cobalt-handling facilities etc.

Programs at the Tata Institute of Fundamental Research (TIFR) envisage the consolidation of existing advanced research programs, the setting up of facilities like cosmic ray detecting array at Ooty, the enhancement of capabilities of the Ooty radio telescope, the construction of a new millimetre wave radio telescope, and the setting up of a computer network.

(3) In electronics, the main R&D effort has been confined largely to government agencies such as Defence, CSIR, Atomic Energy, Communication, and Indian Telephone Industries.

To take up extensive R&D work in various fields of electronic industry, a number of new laboratories in the fields of material science, microwave components and instruments, broadcast and entertainment equipment, biomedical electronic equipment, radar equipment, industrial control instruments, computer and data handling systems, and electronic components have been proposed.

(4) The Indian Council of Medical Research (ICMR) has proposed the expansion of a few institutions and the creation of some new ones; e.g. a clinical research institute for contraceptive technology, an institute for research in tuberculosis and chest diseases, a national institute of virology, an institute for research in cholera and gastroenteritis, and a cancer research institute.

BRAZIL

Creation of New S&T Institutions in the S&T Plan[7]

Brazil has a large network of S&T institutions covering many different disciplines, missions, and geographical regions. The country is interested in expanding and completing this network. The Second S&T Development Plan mentions the following instances in relation to the increase in S&T capacity for the support of industrial development (8):

(1) Subsystem of Industrial Metrology: This includes several new laboratories to operate in connection with the newly established National Institute of Metrology.

(2) Textiles: A system of laboratories will be created to verify the use of fibres and yarns in textile products, according to Law 5956/73.

(3) Electrical Conductors: A system of laboratories will be created to verify the quality of electrical conductors made or distributed in Brazil.

(4) Planning, Coordinating, and Setting Up Technological Complexes: Technological complexes are to be formed with centres for technology generation (public or private), government organizations, and engineering and high-technology industrial firms. Such complexes already exist in some cases such as air transport equipment (CTA), communications materials and components (Ministry of Communications), and petroleum and petrochemicals (PETROBRAS/PETROQUISA). Priority is to be given to the Rio Technological Complex, where five technological institutions will be set up in addition to the National Laboratory of Metrology, for a total area of some 8 million square miles.

(5) Industrial Design and Product Engineering: Activities in this field include the creation of the National Institute of Product Development and the training of specialists in industrial design and textile printing.

(6) National Network of Metallurgical Technology: This network will be set up gradually by creating specialized technological centres in accordance with the needs of industry.

(7) National Materials Centre: A National Centre in the field of materials technology is to be set up that will carry out R&D and application work in metals, polymers, ceramics, and other materials needed by industry - particularly that of electronic components - and for which domestic raw materials are available.

(8) Information System: This consists of the establishment of a system for scientific, technological, and industrial information especially oriented toward industrial needs, to be linked up with the System of Scientific and Technological Information that the National Research Council is to establish.

(9) Laboratory of Magnetic Measures: This is to be created under the Navy's jurisdiction.

(10) Centre of Mechanical Research: This is to be created for empirical and theoretical research in mechanics, including motors, mechanisms, propulsion, aerodynamics, resistance, and control; it is to come under the jurisdiction of the Army.

(11) Aeronautical Certification: A technological infrastructure - human resources, installations, equipment, standards, procedures, etc. - is to be developed for verifying the quality and reliability of products, processes, and services in the aeronautical field.

(12) Centre of Mineral Technology (CETEM): In the medium and long term, eight laboratories are to be installed for bench studies on ore dressing and extractive metallurgy. These laboratories are to work in close touch with existing or new semipilot plants.

(13) Laboratory of Minerals Research, Pará: The existing laboratory is to be expanded.

(14) Installation, or Expansion and Modernization, of Research Institutes: This consists of a program financed by the Inter American Development Bank, already underway, in which several important research institutes take part (IPT, USIMINAS, UNICAMP, UFSCAR, UnB, Rio Datacentro, IBGE, CETEM).

(15) Centre for the Study of Fertilizers: An institution is to be created to support the Brazilian fertilizer industry through research, technical services, management

advice, and personnel training. The project is now being prepared.

(16) Research in Industry: The Plan envisages strong government support for the establishment of research centres in the largest state enterprises or through industrialists' associations.

PERU

Creation of New S&T Institutions(9)

S&T activities in Peru underwent an important expansion in the late 1960s. The state reinforced the existing infrastructure in the ministries and created a set of institutions for carrying out research in various fields of knowledge and areas of application. The main new institutions were the Geophysical Institute, the Ocean Institute (IMARPE), the Office of Evaluation of Natural Resources (ONERN), the Institute of Agro-Industrial Research, the Institute of Industrial Technological Research and Technical Standards (ITINTEC), the Institute of Mining Technological Research and Training (INCITEMI), and the Institute of Communications Research and Training (INCITEL).

Important financial resources were allocated to these institutions, in many cases by way of autonomous funds. The most important one is that managed by ITINTEC, which is made up of 2% of the net income of industrial enterprises and is to be spent on R&D (and other S&T activities) in programs approved by ITINTEC. Similar funds have been established in the case of mining, communications, and fishing.

In their structure, mission, and activities these institutions respond to strategies that vary from sector to sector, and they deal with the characteristics and needs of their sector. In the case of industry, the policy of ITINTEC is to generate domestic demand for locally produced S&T inputs, particularly R&D, and to establish an internal R&D capacity in industrial enterprises. In communications and mining the central problem has been identified as that of training personnel outside the predominant foreign subsidiaries and using this personnel in R&D activities to create an independent Peruvian technical capability. In agriculture a network of experimental stations has been developed with close links to regional universities.

In 1968 the Peruvian government created the National Research Council (CONI) as an institution in charge of coordinating research efforts and exerting leadership in national S&T planning. However, CONI has not been able to carry out activities successfully and has not had a significant impact on the country's S&T development. Whether this is a result of legal and institutional shortcomings, i.e. lack of means and resources to influence behaviour, or of more general causes that would affect any institution of this type in Peru or elsewhere is a matter for further study and debate.

KOREA

Institution Building for the Promotion of Science and Technology(10)

Institution building in the last 10 years covers the Ministry of Science and Technology, nine research institutes, an educational institute, and an information centre. Of the nine research institutes, the physical research facilities of five are still to be completed. The scheduled completion date is 1981. The information centre and the Korea Atomic Energy Research Institute are included in this review because of their institutional renovation in the last 10 years.

Institution Building for the Administration of S&T: The establishment of the Ministry of Science and Technology (MOST) in 1967 marks a turning point of S&T promotion efforts in Korea. MOST has a wide range of activities - coordination and planning of S&T, manpower planning, technology development, information management, resources development, fostering research organizations, international cooperation, and atomic energy development - which it carries out through two offices (Policy and Planning Management) and three bureaux (Development and Promotion, Atomic Energy, Technical Cooperation), and through its managing of several interministerial committees. In addition, MOST holds supervisory responsibility for the National Science Museum, the National Computer Centre, and the Central Meteorological Office, and it dispatches science attachés abroad.

More recently a National Council for Science and Technology has been established. This is chaired by the Prime Minister and has as its members several Ministers as well as civilians nominated by the Prime Minister. This Council is in charge of assessing the national need for science and technology and guiding the national science and technology plan.

Establishment of Research Institutes: The creation and development of several research institutes has been a major part of the government's efforts in the last 10 years: the Korea Institute of Science and Technology (KIST), the Korea Advanced Institute of Science (KAIS), the Korea Development Institute (KDI), the Korea Atomic Energy Research Institute (KAERI), the Korea Scientific and Technological Information Centre (KORSTIC), and Hong Nung Machinery (ADD).

The establishment of another set of institutes has been under way since 1972. Five research institutes and an educational institute are scheduled to be located in the Science Town near Daejon, which is expected to be completed in 1981.

The Korea Institute of Science and Technology (KIST) was established to help develop industry by carrying out research and development programs and providing the technical services needed by industry. KIST is responsible for:

(1) Research, investigation, and examination, with respect to science and technology and engineering economics, and the dissemination of the results.

(2) Cooperation with universities and other research organizations and professional societies in and out of Korea.

(3) Contracts for research and technical services or for such services performed by other organizations in and out of Korea.

(4) Other supplementary activities to accomplish the objectives of the institute.

Since its establishment in February 1966, KIST has undertaken more than 600 contracted research projects worth approximately $8 million. Its staff, totaling about 250, has participated in government science and technology policymaking and has carried out industrial technology research. Although its main customers are government agencies and big industries, medium industries are now beginning to pay attention to the role of KIST.

The preparatory work for the establishment of KIST dates back to 1961, when the Ministry of Education studied the feasibility of establishing a research institute. This was not implemented because of the excessive investment required. Other studies were carried out and finally President Park presented a proposal at the 1965 meeting with President Johnson. It was agreed to study this proposal under a joint-venture program. A team from the U.S. was sent to Korea and set forth the following principles:

(1) The institute should be based on secure financial support derived from the Korean government and private industrial sources as well as from the U.S. government.

(2) The institute should be an independent, nonprofit organization that would provide the requisite latitude for dedicated professional leadership and for flexibility in staffing as well as a budget sufficient to attract and retain the best Korean scientists and engineers.

(3) The institute should interact closely with Korean industries and should improve their efficiency and the utilization of Korean resources. It should provide a foundation for new industrial activities.

Following the guiding principles, the team recommended the establishment of an institute for industrial technology and applied science in Korea with U.S. cooperation and support. Another study was conducted by the Battelle Memorial Institute (BMI) to delineate the feasibility, corporate framework, scope, operation, and organization of the new institute. The total investment was estimated at $12 million in 5 years.

Upon completion of the preparatory work in 1966, KIST was established as an integrated applied research institute in Korea, its autonomy and independent founding being overseen by a special law.

After its inception KIST undertook a technoeconomic survey of Korean industries, with the cooperation of BMI. This survey was designed to analyze the status and the research needs of a large number of branches of industry. From the results of the survey the scope of KIST's research activities was determined. The following fields were emphasized for the inside research activities:

(1) Problems related to metallurgical materials.

(2) Intensive development of the iron-and-steel-making, electronics, mechanical, and petrochemical industries.

(3) Food production and food technology.

Further refinement was required to establish the following fields of research: the material, mechanical, electronics, chemical, and food industries. In addition, the following fields were placed within the scope of research by the institute: industrial economics, construction, computers, technical information, material testing, and chemical analysis. Following the setting up of these fields of action, it was possible to establish research personnel, equipment, and facilities. The recruitment program served to repatriate Korean scientists and engineers residing abroad. It was fortunate that there was a large reservoir of qualified Korean scientists and engineers abroad. Steps were taken to assure that the research staff would have a good research environment, adequate and modern research equipment, and reasonable salaries, relocation expenses, and housing.

Staff training was undertaken as soon as the principal researchers were recruited. The Battelle Memorial Research Institute, which has experience and tradition in the field of contract research, was selected as a training ground for senior researchers. Thirty-four persons were trained at BMI in the 1966-1970 period.

In 1971 an educational institute was added to Seoul Science Park. Having had about a year of preparatory work for its establishment, the Korea Advanced Institute of Science (KAIS) was formally founded to produce capable scientists and engineers. Faculty members of KAIS are expected to assume educational duties as well as basic research. KAIS is intended not only to meet the growing demand for applied scientists and engineers but to fill the fragmented and weak nature of the existing education in graduate engineering. Equipped with highly trained and competent faculties, it plays a leading role in active research and practical engineering education, which have been rare among existing educational institutions.

To allocate the government budget and receive foreign aid, the government found it necessary to enact a law for the establishment of KAIS. This was accomplished in 1970 a few months after a study on a new graduate school of applied science and technology was ordered by President Park.

As was the case in the preparatory planning of KIST, a foreign study team was brought in to look into the status of Korean higher education and to aid in planning the future of KAIS. Emphasis was placed on continuing interplay between KAIS, the government, industry, and educational institutions to help the economy achieve its strength in international commerce.

KAIS possesses a number of features unprecedented in educational institutes. (1) KAIS is exempt from the existing rigid educational law and regulation of public employees, thus giving it the freedom to pursue autonomy and financial stability. (2) KAIS has an endowment fund provided by the government. (3) KAIS has recruited highly qualified Korean-born faculty members from abroad. (4) KAIS students receive generous financial support and are exempt from military duty. (5) KAIS has an independent self-perpetuating board of trustees that exercises full responsibility for it.

As of 1975, seven academic departments consisting of basic science, electrical engineering and electronics, mechanical engineering, and biological science formed the backbone of KAIS. In addition to regular academic courses for masters and doctorate degrees in science, KAIS conducts special programs and short courses for plant engineers and researchers. Judging from the initial academic programs of the seven departments, KAIS responds to industrial needs for engineers in manufacturing sectors of the economy.

The government has granted approximately 2.2 billion won for land, buildings, and housing for the faculty and students. The U.S. government has also provided a long-term development loan of $6 million through USAID for the initial procurement of teaching and research equipment and library materials and to provide a technical assistance program.

The Korean government is financing an operational budget to cover the full cost of the KAIS operation.

The establishment of the Korean Atomic Energy Research Institute (KAERI) dates back to 1956. Both U.S. aid and funds from the Korean government were provided for the establishment of KAERI. Through this research institute, over 200 engineers and researchers were trained and supplied to the academic and industrial communities of the country. Because of organizational and operational restrictions inherent in government organizations, KAERI found it necessary to reform the organization to a nonprofit and independent research institute with a self-perpetuating board of trustees, along the lines of successful research institutes in Korea and abroad, and the administrative functions of the Office of Atomic Energy were transferred to the newly established Bureau of Atomic Energy at MOST.

KAERI focuses its research activities on energy and development, environmental protection and control, nuclear power technology, nuclear fuel technology, the use of radiation and radioisotopes, and life sciences and basic sciences (physics, chemistry, and biology). Because it is engaged in basic research, it has to rely on government grants for most of its operational budget.

The establishment of an economic research institute was contemplated during the Second Five-Year Economic Development Plan. After a few years of preparatory study, a law was enacted in 1970 for the foundation of the Korean Development Institute (KDI).

It was deemed necessary to have an economic research organization to conduct studies on economic policies and make recommendations to government. This kind of research activity is unsuitable for a private organization. KDI, therefore, has to resort to government grants to support its operational cost. To maintain qualified researchers and to continue research work, it is required to have a permanent organization to perform these functions; KDI has to maintain an amenable research environment that is different from a college or a government organization. It also has to maintain impartiality and objectivity in assessing policy formulated by the government departments.

KDI divides its field of research into financing, industrial policy, trade and economic growth, manpower and social welfare, international politics, and statistics and computation.

U.S. aid and the Korean government granted 1.3 billion won to KDI for an endowment fund. Additional U.S. funds of 1.75 million won were supplied to provide books, a computer, and printing facilities. Since the institute does not carry out contract research for industry, operating expenses are covered by the returns on the endowment fund and by government grants.

The Korean Scientific and Technical Information Centre (KORSTIC) specializes in information collection and retrieval for scientific and industrial communities. KORSTIC was preceded by the Korea Scientific Documentation Centre which was established with UNESCO assistance in 1962. The Documentation Centre was part of an earlier project to promote science and technology during the First Five-Year Economic Development Plan.

To Expand its activities, operational support was shared by the Ministry of Education from 1964 to 1967. The supervisory agency of government was later turned over from the Ministry of Education to the Ministry of Science and Technology in 1967. KORSTIC performs the following functions:

(1) Collection of technical information from domestic and international sources.
(2) Classification, arrangement, and storage of collected information.
(3) Dissemination of technical information at regular intervals and supply of information upon request.
(4) Survey and study on the promotion of science and technology.
(5) Technical consulting for small- and medium-scale industries.

Hong Nung Machinery (ADD) is another research institute in Seoul Science Park. This organization is engaged in defence research. The need for more strategic technologies has increased as the Korean economy rapidly expanded. A single comprehensive research institute cannot meet this increasing need, and the Korean government has therefore launched an ambitious plan to establish a new Science Town in Dae Duk near the city of Taejon. Five new research institutes and a technical college are planned to open there and 12 existing research institutions are scheduled to be relocated.

Two of the five research institutes, the Shipbuilding Research Institute and the Ocean Research and Development Institute, were founded in 1972. The remaining three research institutes will cover the areas of mechanical engineering, petroleum, and electronic communication.

The total cost of the new institutions will be about $62 million. Once established, the Science Town will have a population of 50,000 in an area of 5,720 acres.

The institutions will share facilities such as a library, a computer centre, workshops, and testing laboratories. It is hoped that many major industrial firms will take part in the Science Town project and open their research shops in the same area.

Instruments of Institution Building: Law is the major instrument of institution building. The enactment of a law for a specific institute is instrumental in securing government funds. The following laws easily identify the respective institutes.

(1) Government Organization Law
(2) Regulation of Ministry of Science and Technology
(3) Korea Scientific and Technical Information Centre Promotion Law (May 19, 1969)
(4) Korea Institute of Science and Technology Promotion Law (December, 1967)
(5) Korea Advanced Institute of Science Law (August 7, 1970)
(6) Korea Atomic Energy Research Institute Law (January 15, 1973)
(7) Korea Development Institute (December 31, 1970).

New research institutes established in the last decade owe their existence to the understanding and forward-looking strategy of the government. A remarkably keen awareness and perception by government leaders toward science and technology contributed to building a sizable research infrastructure in a comparatively short period. Efficient government actions were taken to draw up laws, help the institutions created, build physical facilities, and recruit research personnel. Furthermore, the government provided an endowment fund for financial stability and autonomy of research.

In spite of the large government investment for building up the research institutes, the government turned control and management over to the institutes. This kind of arrangement is rare in the government organization. However, it was done for the sake of creating an environment favourable to research. In this context, the government has laid an irrevocable precedent to secure the autonomy and stability of a research institute.

It is quite evident that the administrative branch of the government has taken the initiative in promoting a research institution. It was quite successful in persuading lawmakers to favour the enactment of promotion laws for individual institutions and to allocate a large portion of the budget for building up research institutions.

It has been a common practice to draw upon foreign experts and financial aid. During the preparatory work, foreign consultants in research and management shared their experiences with Korean counterparts. A series of reports and recommendations made by the foreign consultants enriched and helped new institutes and set them in the right direction. In addition to the advisory task, foreign aid played the role of expediting the local commitment of funds.

Impact of Institution Building: The impact of institution building could be both positive and negative. It seems that the positive impact may predominate:

(1) In the case of MOST, the fact that a science and technology planning body is incorporated in the government at the ministerial level may mean that science and technology planning can command as much weight as other areas of planning such as the Economic Development Plan. It is thus expected that science and technology promotion programs can be treated in the same way as any other programs. It is also expected that MOST effectively manages interministerial coordination with respect to pertinent plans and programs related to science and technology.

(2) The establishment of research institutes paved the way to gain momentum in the expansion of Korean research activities. The increase in qualified researchers in the last decade alone amounts to over 1,000. Lack of research equipment and facilities used to be a problem for researchers, but this is no longer the case for researchers who are engaged at the new research institutes.

(3) Large numbers of Korean students went abroad for a better education. An attempt was made to draw back Korean-born engineers and scientists residing abroad. The repatriation program was accepted by both the government and the individual research institutes, and it was very successful. Repatriation means the dual advantage of technology importation and of quickly satisfying the need for researchers in an appropriate field of research. The large number of employment opportunities provided at research institutes has had a reversing effect against the outflow of scientists and engineers abroad.

(4) The program of new institution building for research not only expanded the research capabilities in Korea but also avoided undue competition or duplication of research activities by designating an institute to pursue a specific field of research. By doing so, an orderly division and specialization of research activities at the national level can easily be achieved.

(5) The physical proximity of research institutes and supporting organizations renders further advantages. A better utilization of common equipment, research material, and technical information is accomplished by institutes in Seoul Science Park. It is becoming a common practice to make a pool of researchers in the Science Park available when needed by a multidisciplinary project.

(6) Conventional research institutes and colleges that are not included in the government development program may suffer from a loss of qualified engineers and researchers. Imbalances between the new research institute under the government program and the conventional research organization may have an ever-worsening impact on the conventional research organization.

SCIENCE AND TECHNOLOGY PLANNING

Introduction

S&T planning attempts to tackle in a comprehensive fashion the building up of an S&T infrastructure in human resources and institutions, the optimal use of existing S&T capabilities, and the increase in the efficiency of S&T activities. This requires that priorities be specified in accordance with the development style and national needs, and the programs defined and carried out to attend them.

The S&T planning experience of developed countries is only partially relevant for S&T planning in developing countries. In the former, planning is done principally to orient the use of installed S&T capacity in an environment that is ready and willing to apply new results (and where foreign technology imports are not an overwhelming influence on technical progress) so that it usually becomes the planning of R&D. In developing countries, S&T planning goes far beyond that and should also be concerned with building up a human resource base, creating and developing scientific institutions (industrial research units, information systems, consulting and engineering firms, etc.), and providing favourable conditions for R&D activity. The task in developing countries is therefore more complex and has to be done in a context of technological dependence, mistrust of locally generated knowledge, a scientific community oriented mostly to world science and not enough to internal needs, and a general scarcity of resources. It is clear that developing countries will have to find their own solutions in this field.

The nature of S&T planning will vary according to the stage of development. If the country has already established an infrastructure of S&T institutions, resources, and activities, the problem is mainly that of reorienting and using effectively the existing capacity. Where that capacity does not exist, the planning process acquires a rather different character and should emphasize the training of human resources, the creation and development of institutions, the acquisition of physical facilities, the expansion of higher education, and the creation of policy mechanisms to promote science and technology.

The process of S&T planning has usually required an organizational structure consisting of a coordinating group with an executive secretariat, assisted by a number of technical committees made up of researchers, planners, and users of the results of S&T activities. The committees may be vertical, dealing with a particular sector, problem area, or discipline, or horizontal, cutting across these divisions and dealing with issues such as human resources, information, and policy instruments (11). Among the horizontal committees, some correspond roughly to the structure of public administration and others deal with special problem areas (energy, water resources, etc.) and with basic science, usually subdivided by discipline. The structure may involve several hundred participants. In fact, the implementation of the plan is helped if those in charge of carrying it out have been involved in all phases of the planning process.

The committees may be given a high degree of autonomy to define strategies, priorities, resource allocation, and even specific projects from the beginning, limiting the role of the central group to one of assembling their proposals. In such a case the plan may easily consist of a collection of projects defined after hard bargaining among committee members. Another approach would give the committees, under strong central guidance, the task of first defining a strategy for the sector, problem area, or discipline of their competence and outlining areas of concentration and general priorities. After revision and integration of committee programs, specific research projects may be defined.

S&T planning is not devoid of risks. It may be regarded merely as a technocratic exercise, unless it is backed by political will, funds, and an implementation scheme; even then the plan may be rejected by those who did not participate in its formulation. S&T planning is a young and rapidly evolving field, where experience is not abundant and conceptual approaches are still tentative. Perhaps developing countries should approach S&T planning cautiously, building up political support, consensus, and goodwill through a series of partial planning efforts in sectors where success is more likely, and gradually extending the scope to other sectors.

Issues in S&T Planning

Two main concerns emerge out of the experience of the STPI countries. The first is related to the problem of integrating technology considerations into development planning. Initially this may be considered as a by-product of economic planning exercises, and the analyses of the Brazilian and Argentinian cases show that the role attributed to S&T in the economic plans is largely implicit and somewhat marginal.

The second concern is related to the planning of science and technology activities on their own, in some cases as a horizontal sector in economic development planning and, more frequently, as a separate planning exercise, with specific purposes and a longer time horizon. India, Venezuela, Mexico, and Brazil have produced comprehensive S&T plans, whereas Egypt and Colombia have limited such activities to certain sectors or problem areas.

These two approaches - the introduction of technology considerations into development planning, and the planning of S&T activities - may be integrated in a coherent way, as the Korean example shows regarding the attempt to interface development planning and S&T planning.

The experience of the STPI countries, and the discussions at a special seminar on S&T planning held in May 1975, suggest a number of issues, which are summarized below (12):

Decision Tools: S&T planning needs a mechanism for plan formulation and a methodology to guide decisions about the allocation of resources at different levels (global, sectoral, branch, program, project) and for different purposes (investment vs. current expenditure, R&D vs. other S&T activities, etc.).

Quantitative analytical methods, such as those employed in economic planning, are only partially useful. It may be suggested that attention should be focused on formalized approaches that involve logical procedures and employ formal nonquantitative methods. Formalized approaches should not oversimplify the problem, but rather provide a framework for sequential decision-making, without reducing the inherent complexity of S&T phenomena. They may incorporate many different elements, such as the analysis of development styles and long-term trends, technological forecasting, relevance trees, boundary methods, Delphic techniques, matrix analyses, and, in general, formalized rules of thumb.

The Context of S&T Planning: S&T planning faces many obstacles in developing countries because of unfavourable structures, contrasting interests, adverse effects of existing policies, etc. Under these circumstances planning becomes a political process rather than a technical one, and it is important to attain a consensus among interested groups. A wide participatory mechanism for plan formulation becomes necessary, and a measure of gradualism is convenient to gain allies, learn the business of planning, and produce demonstration effects that will open the way to wider and more complex planning attempts.

The Approach to S&T Planning: This should ideally combine two strands, one that starts at the top and formulates programs to be undertaken by S&T institutions, and another that proceeds empirically, integrating into a plan what the institutions are doing, but with some reorientation plus a number of new programs. Once again, this calls for a participatory mechanism in plan formulation.

The Information Base for S&T Planning: The formulation of a S&T plan requires a vast amount of information. A good part of it may come from existing statistical systems (education, economics), from special surveys (for instance, of the S&T system), and from ad hoc studies. This information is particularly useful for the preparation of a policy frame and of rough guidelines for the planning exercise. But a large part of the information needed in the actual formulation and in the detailed design of programs and activities can only be elicited from the many persons and institutions in government, science, technology, and production who have the specific knowledge and the relevant experience. Hence the mechanism used to organize their participation is of utmost importance, and purely technocratic planning exercises prepared by a few persons in a science ministry or council are not satisfactory.

Institutional Aspects of S&T Planning: S&T planning should pay particular attention to the creation, reinforcement, and good functioning of institutions that perform S&T activities, taking into account that it is not enough to create an institution: it becomes necessary to continue supporting it during the time it develops, until it acquires maturity.

On the other hand, institutions concerned with S&T policy and planning should be integrated into some sort of a "system", possibly under the leadership of the S&T planning agency or some other top-level organization, if planning is to be coherent and draw a wide consensus.

Implementation of the S&T Plan: Among the principal mechanisms for plan implementation, the central fund and the national S&T budget may be mentioned. Attention should also be paid to the monitoring of S&T activities within the productive sector - including those that take place in connection with technology imports - and to the periodic review and reformulation of the S&T plan.

Human Resources Planning Aspects: The main issue here is how fast the stock of qualified scientists and engineers can grow, because this would put an upper limit on the expansion of S&T activities. There is little information on this matter, but it would seem that very few countries have been able to double their stock in a period of less than 10 years, which is equivalent to about 7% growth per annum. In the short run, growth can be faster because human resources can be redeployed and personnel can be imported, but in the long run, expansion will depend on the output of the educational system, and this must be looked into if realistic and attainable targets are to be established.

Special attention should be given to the attitudes and behaviour of scientists and researchers who may find it difficult to switch from activities oriented toward the international scientific community to those oriented toward the solution of national problems.

Diffusion of Science Throughout Society: If science and technology are to become a true part of the development effort, a receptive audience should be created in various societal groups - government, entrepreneurs, labour unions, students, intellectuals, and the general public. Diffusion campaigns and science education would be the principal instruments. In addition, the subjects of science policy and technology management should be introduced in scientific and technical undergraduate courses, particularly in engineering, business management, and government administration, because graduates in these disciplines may later become important customers of local S&T activities.

The Experience of the STPI Countries

ARGENTINA

The Technological Content of the Three-Year Plan, 1974-77

If a general conclusion may be reached concerning the technological content of the Three-Year Plan, it would be that the implicit technology policy content arising from the desired aims, and even more from the objectives, is richer and more complete than the explicit technological content of specific policies and measures proposed for this area.

The mere proposal to obtain a high rate of growth and to modify patterns of consumption without changing the basic features of the capitalist system implies the need for a creative effort of hitherto unknown proportions; it would also require the modification of one of the central variables of a capitalist system - technology - in such form that the balance thereof remains steady.

However, it is doubtful whether the goals of redistribution of income, full employment, regional balance, the fostering of national capital, and the reconversion of the small and medium-size firm can be made compatible with the chosen pattern of growth based on a large flow of investments in sectors referred to as basic, and the doubling of the volume of exports, together with a substantial increase in the productivity of factors.

Experience shows that efforts to achieve speedy capitalization as a means of attaining a high rate of growth in a short period of time are apt to condition the structure of production for many years. But if economic growth is a short-term economic necessity, it is necessary to provide the mechanisms for a progressive change at the same time that speedy capitalization is attempted in order that proposals of structural changes may be fulfilled. And one of the basic mechanisms for this is the scientific and technological creative ability (and therefore the ability to decide), which, while allowing the greater dependence arising from the process of capitalization to be progressively reduced, ensures that future capital stocks will progressively include national technology.

Paradoxically, processes such as are proposed in the Plan may provide the financial and institutional bases for the attainment of this ability, because the large flow of investments allows the inclusion of provisions concerning scientific and technological creation without greatly affecting the total investment conduct. Furthermore, political aspiration to attain this goal does exist.

It must, however, be stated that the concrete proposals contained in the Plan concerning the implementation of a scientific and technological policy leading to the attainment of the global objectives are clearly insufficient.

The most notable lack is that of precise sectoral definitions concerning the scientific and technological needs to be fulfilled during the course of the Plan, both the existing ones and those which may arise from the investment process. The Plan also fails to propose specific changes in the nature of the generation of scientific knowledge: guidelines for the organization of institutions, standards for the allocation of resources, relationships with potential users, etc. These will, apparently, not be taken into account in view of the lack of a specific science and technology plan.

Perhaps one of the principal reasons for the very marginal role of the scientific and technological factor in the development model proposed in the Plan lies in the planning process itself. Technology is introduced from the outside almost as if it were a "patch" inserted in the process.

This would show that the technological implications of global aims are ignored, precisely because of the failure to carry out the necessary basic studies. Briefly, the planning process consists of defining the way to achieve a balanced growth, based on a preexistent input-output matrix and starting from determined general restrictions of a political nature (desirable external debt, level of employment, distribution of income, etc.), which do not include the technological needs that may be implicit in global and sectoral alternatives.

The Argentinian Three-Year Plan does not escape this general rule., although in this case ambitious proposals are included concerning science and technology.

Reference must be made to the role that the Plan ascribes to the state as one of the main elements for the attainment of the proposed changes. This position implies that the state has the technical capacity to search for technological alternatives, to interact with its environment, or even to develop original technological answers to the problems posed by an accelerated process of growth. This is not the case in Argentina, where - with very few exceptions - the state has proven its very limited possibilities, despite the huge amount of resources it manages. But the most crucial point, which can now be observed in perspective, is the belief, shared by the national bourgeoisie, that there was a possibility of reorienting the activities of the state to use its power as a tool for political ends. For this purpose the Corporation of State Enterprises was created as one of the main instruments to implement the Plan in this sense.

Once the national bourgeoisie had lost its political power in early 1975, not only did the Corporation practically disappear, but all the measures taken concerning the technological behaviour of the state enterprises vanished and the latter returned to their traditional passive and dependent behaviour.

BRAZIL

Science and Technology in Brazilian Development Plans, 1956-73

The following plans are examined:

- The Target Program, 1956-60
- The Three-Year Plan, 1963-65
- The Program of Economic Action, 1964-66 (PAEG)
- The Strategic Development Program, 1968-70 (PED)
- The Targets and Bases for Government Action, 1970-71
- The First National Development Plan, 1972-74 (I-PND)

References are also made to the Basic Plan for S&T Development (PBDCT), 1973-76.

A distinction is made between two types of S&T policy. Two alternative objectives may be considered, if technological dependence is taken as the criterion of differentiation:

(1) A policy of response: to answer the technological needs of the productive system by speeding up the incorporation and diffusion of innovations within the system, but indifferent to the option between domestic production and the importation of technology;

(2) A policy of relative autonomy: to reduce the utilization of technology from abroad through the enlargement of the national capacity for the creation, adaptation, or incorporation of technical knowledge.

The Target Program and the PAEG, although not presenting an explicit policy of science and technology, contain implicit answers to the technological needs corresponding to the respective stages in the process of industrialization, besides proposing diffuse measures and initiatives in the field of science and technology. This would be a policy of response, aimed at assuring the supply of technology required by the productive system on the basis of the contribution of foreign know-how. Such a policy corresponded to the proposition of opening the economy to foreign countries and of deepening the links that connected the country to the world economic centres.

The Three-Year Plan similarly does not include an explicit S&T policy. Although its economic strategy showed the need for a vigorous and autonomous S&T policy, it proposed actions that were insufficient for defining an alternative scheme to replace the foreign sources of technology and thus support the changes intended in the form in which the country is inserted into the world economic system.

The Strategic Development Program (PED) for the first time defined an explicit policy for science and technology, presenting also a program of action that, in its basic aspects, reappeared in the following plans - Targets and Bases for Government Action and the First National Development Plan. The policy proposed in those plans can be characterized as a policy of autonomy, because it included among its objectives the country's qualification for the adaptation and creation of technology to reduce the dependence on foreign sources of know-how.

In the case of the PED, such an orientation aimed at the development of technologies more adjusted to the country's endowment of productive factors to assure a larger labour absorption. This directive was articulated in the preoccupation expressed in the PED with the creation of a mass market as a means of assuring self-sustained growth. It should be observed, however, that this preoccupation was absent from the economic policy effectively implemented in the period, and that the evolution of the Brazilian economy reflects the failure of this policy of enlargement of the domestic market by the incorporation of strata with less purchasing power.

The same preoccupation was also left aside by the scientific and technological policy proposed in the I-PND (and expressed in detail in the PBDCT), which, while also aimed at lowering the dependence on foreign know-how, linked this directive to the objectives of strengthening Brazilian industry's competitive power and strengthening the national enterprise. But the increase in Brazilian industry's competitive power did not justify by itself the directive of promoting the country's greater qualification for the creation and adaptation of technology, because the technical knowledge that should be incorporated continuously by the productive system to reach that aim could be supplied by foreign sources, either through the participation of foreign enterprises or through the mere importation of technology. In this sense, that directive only appears as a necessity when linked to the proposition of strengthening the national enterprises and assuring their participation in the process of economic growth in Brazil.

Despite the government initiative of supporting the national enterprises, the strengthening of such enterprises was not the dominant preoccupation of the economic policy of the period; it was directed above all to the maintenance of a high growth rate. In the same way, the solutions to the technological problems linked to the growth process that were implicit in the chief instruments and measures of economic policy aimed above all at assuring the flow of transfer of technology, thus characterizing it as a policy of response.

The evolution of the Brazilian economy in recent years shows that the measures of support to the national enterprises were in a certain way counteracted by the greater dynamism of the multinational enterprises in a context in which the most important incentives offered to the private sector - the subsidy for capital formation in industry and the encouragement of exports - benefited national and foreign enterprises equally. On the other hand, the position of the national enterprises was effectively strengthened in those sectors in which government action took specific forms and mobilized more concrete instruments.

From this viewpoint, it should be stressed that, although the adoption of an adequate policy of science and technology is one of the factors that makes a certain pattern of economic growth feasible, government action in the sphere of science and technology is not by itself capable of determining this pattern. And this is so because the efficiency of a scientific and technological policy depends on its degree of convergence with the natural evolution of the economic system and/or with the economic policy in force, as well as on the support it receives from the other policy measures and instruments.

COLOMBIA

The S&T Planning Experience

The following general observations can be made on S&T planning in Colombia:

(1) The explicit government policies on S&T development at a global level have been basically limited to the creation of various institutions concerned with the planning of S&T development or some specific aspect of it. This effort has not been translated into a national policy or a national development plan explicitly formulated in this field. Despite the institutional framework that has been created, no operational mechanism through which such a policy (or plan) may be formulated or implemented has been clearly defined.

(2) At the sectoral level important government research centres exist to which funds are allocated directly through their respective ministries. The fact that these institutes invest considerable amounts of money in research in their fields implies that they are formulating and implementing a policy with respect to research in each sector. That is to say, a series of sectoral policies of research exist in Colombia, at least in those sectors where there are important research centres. The level at which structuring and formalizing such policies takes place may vary from case to case. Moreover, these policies are usually not explicitly formulated. It would be interesting to analyze in greater detail the level of formulization of the sectoral policies and the proof that was used in their formulation.

(3) As a consequence of the previous point, two complementary aspects should be mentioned:

When formulating an S&T policy at a national or global level, account must be taken of the fact that most research activities of the public sector are carried out in research centres at a sectoral level, according to the policies established by each institution. The existence of these sectoral policies cannot be ignored, although in most cases they have not been explicitly formulated but are resultant policies that emerge from the allocation of funds to ongoing research projects, among other things. This raises the problem of the relationship and coordination between those institutions responsible for formulating a S&T policy at the national level and the large research centres at the sectoral level. Furthermore, it implies that research priorities defined at the national or central level will have to follow a gradual path of successive approximations through which the priorities defined by the research centres themselves are gradually made more consistent with the priorities defined by the policy-formulating institutions.

As mentioned before, the allocation of funds to these research centres is made directly through the budgets of each sector or ministry, not through any coordinating mechanism that allocates public financial resources to technological research and development activities. This dispersion of the government's procedure in the allocation of funds to research activities represents an obstacle to the formulation and implementation of a truly integrated national S&T policy. Therefore, it is suggested that a coordinating body be created at the national level to advise the government on the allocation and distribution of these funds. This could be done through the creation of a National Budget for Science and Technology, in which the different appropriations to these activities in the various sectoral budgets could be clearly contemplated and analyzed. Probably this could involve the establishment of an interinstitutional body composed of various ministries, the National Planning Department, and others. This body would have to establish close relationships with those responsible for structuring the National Budget for S&T.

(4) Two groups of institutions in Columbia reflect, in the initial phase of their activities, two different views on the nature of scientific and technological development.

COLCIENCIAS made an initial effort in relation to S&T development that was oriented toward strengthening the internal infrastructure in this field; it limited itself to a large extent to the scientific view. As it became conscious of the complexity of the process, COLCIENCIAS expanded its activities, becoming one of the first advocates of the integrated view with respect to scientific and technological development. However, as an isolated institution, it is limited in its possibilities of formulating and applying an approach of this magnitude.

On the other hand, the second group of institutions has tended to limit its activities to those economic problems related to the commercialization of technology (following the economic view). Many of these institutions were created basically to attempt to solve problems created by foreign commerce, foreign investment, the balance of payments, and the scarcity of foreign currency. Since their scope was limited to these purely economic matters, these institutions did not deal directly with the problem of a national technological policy. As they have become more aware of the importance of the multiple aspects of technological development, these aspects have gained a greater importance in the functioning of these institutions.

(5) The difference between the two groups of institutions is reflected in their position in the administration framework. Whereas COLCIENCIAS has the principal ties with the National Council for Science and Technology (CONCYT), the organizations of the second group are more directly associated with the National Council for Economic and Social Policies (CONPES), the highest planning institution in Colombia. Since CONCYT has only had two meetings since it was created, it is difficult to judge the effectiveness of the division between these two national councils. However, the following general observations can be made:

CONPES is responsible for developing general economic policy, or implicit policies. These may well be more important than the explicit policies in determining the scientific technological development of the country.

In a similar manner, CONPES intervenes in specific decisions on important sectoral projects. It is precisely through these projects that science and technology are integrated in the economic development process, and that the principal technological decisions orienting national development in this field are taken.

If one accepts the integrated view of scientific and technological development, it is necessary to achieve a greater degree of interrelation between scientific and technological planning, on the one hand, and economic development planning on the other. Taking into consideration these observations, two alternatives arise. The first is to encourage greater participation by the institutions of the second group in CONCYT and a greater coordination of the latter with CONPES, for the purpose of integrating the S&T planning system. The second alternative is to reevaluate the rationality of the parallel existence of these two national councils.

(6) In the previous sections the complexity of the S&T development process has been analyzed, along with the multiplicity of institutions that have to do with the formulation and implementation of a national policy in this field. This responsibility is obviously too complex to be assumed by any single institution. On the contrary, one must think in terms of the structuring and coordination of an institutional network made up by the principal organizations that take part in making the basic decisions that orient the scientific and technological development of the country. At pointed out above, such an institutional network has gradually been emerging in Colombia, given the fact that several of the institutions involved participate in committees of an interinstitutional nature (e.g., Royalties Committee) or as a consequence of initiatives for interinstitutional meetings and projects that have often arisen through personal and informal contacts between the people who work in the various organizations. The function of this informal network can be carried out at the level of personal relations or small joint projects between various institutions and can be of vital importance in the progressive integration of the S&T planning system. This factor may even be more important than the simple bureaucratic administrative definition of a planning system in this field. The main weakness of these informal networks is their vulnerability to personnel turnover.

EGYPT

The Experience in Science and Technology Planning

A number of policymaking bodies for S&T have been created over the last 25 years in Egypt: the National Research Council, 1948; the Science Council, 1956; the Ministry of Scientific Research, 1961; the Council for Promotion of Scientific Research, 1964; the Council for Scientific Research (superseding the Ministry), 1965; the Ministry again, 1968; the Academy of Scientific Research and Technology, 1971; and again the Ministry of Scientific Research and Atomic Energy, 1975, although in principle the Academy structure was being kept for planning and coordination at a national level.

The effectiveness of these national policymaking bodies has been deeply hampered by the many changes that took place, the instability of policy, the inadequacy of the infrastructure, qualified personnel, and physical resources, the shortage of funds, the lack of evaluation and follow-up practices, the dominance of the university ideology (which stamped most of the research activity with academic attitudes rather than catering to the needs of the development plans), the isolation of the scientific community, the separation between the sectors of research and socioeconomic planning, and the shortage of managerial capabilities.

Two major attempts at S&T planning have taken place in Egypt and will be briefly reviewed.

The Science Council Effort (1958-60): The general atmosphere that prevailed in the country after 1956 (post-Suez war) led to the acceptance of the idea of planning in science in 1958, although with great pains and opposition. However, the Science Council finally adopted a 5-year plan for scientific research (1960-1964), which coincided with the first plan for national development. It was guided by three main principles:

(a) Surveying and assessing the potentialities of existing resources;
(b) Recruiting human resources for present and future development;
(c) Drawing up effective programs for immediate and long-term needs, mainly depending on the state projects for national development.

Work started in 1958 and was divided into six areas: mathematical and physical sciences; chemistry and chemical industry; geology and mining; engineering and engineering industries; agricultural and biological sciences; and medical sciences.

The technical secretariat of the Science Council prepared detailed reports based on available data concerning personnel, institutions, laboratories, and topics of current research. It also prepared reports on various agricultural and industrial projects in the state development plan, indicating topics of research studies (or scientific content) associated with these projects.

One hundred and seventeen topics with a bearing on the national economy and on scientific progress were selected. A total of 170 experts were commissioned to write detailed reports that reviewed ongoing work, institutions, human and physical resources, world trends, relevant foreign institutions, etc. After coordination of the various reports, 58 planning conferences were held, attended by about 3000 scientists, and recommendations were drafted regarding funds, research topics, graduate training, foreign experts, etc.

The total budgetary estimates for the science plan amounted to £E19,673,250 (at the official rate then of 1 = $2.35). About £E8.5 million were finally approved in addition to about £E3 million for a scholarship training program.

The plan called for action of a broad scope and envisaged the reform and strengthening of the scientific infrastructure through its material support for existing laboratories and qualified personnel, and for their expansion. But it was too broad, too ambitious, with a definite although initially unintended bias toward basic research, and it overlooked the practical procedures of handling urgent problems of production and services. The Science Council lacked executive powers, which widened the gap between planning on the one hand and implementation and follow-up on the other. The experiment did not live long; in January 1963 a reorganization of the science structure (that started with the establishment of a ministry in 1961) involved new policy trends.

The Academy Effort (1972): Within its responsibility of formulating, financing, and following up research projects related to national problems, the Academy entrusted its 14 specialized Research Councils - where the research and the production communities were represented - with the task of identifying some major problems facing the national socioeconomic plans, where research efforts could be applied to find some practical solutions. Several criteria were discussed for identification and priority decisions, and proposals were received from government ministries, production and service organizations, research institutes, and individual scientists. All were studied at length by the Councils, and two main types of problems were distinguished: those that had to do with the country in general and with its economic development, and those related to a particular sector.

About 70 main research projects were finally endorsed, for 3-5-year periods; £E1.8 million were allocated and spent in 1974, and £E1.2 million were earmarked in 1975. Each project was the subject of a contract between the Academy and the main research organization in charge. Progress reports were to be regularly submitted and reviewed, but implementation was free of red tape. Additions to the projects were under study by the specialized Councils, their conferences, and the Academy governing council.

Thus a program of research was worked out mainly as a practical plan of action aimed at solving important problems related to development; but at the same time the Academy approved the allocation of about 20% of the funds to strengthen the science base.

Research institutes were asked to reorient their programs, and for those under construction, cooperation was sought between the Academy and the user sector, aiming at joint ventures.

Other actions by the Academy related to the study of scientific potential; information and documentation; improvement in the status of the research community; better scientific relations internationally; and the establishment of a science policy studies unit.

Within the short life of the Academy (3 years), some very positive features can be observed: ample participation in the preparation of programs, the establishment of linkages between the research community and the applied sectors, recognition of the social function of science, and recognition of the principle of planning coordination as a function of the national science policy and as a subject to be studied in itself.

Final Remarks

The integration between planning in scientific and other planning activities at the national level is still far from being reached. A crucial issue is the relation between scientific research and the application of modern technology. One of the prevailing trends of thought is that the orientation toward applied research might be the solution. This is true in the case of advanced countries, where science has deep roots and traditions, and where industry, as other sectors, has grown in the presence of science and in most cases is based on its achievements. Yet in developing countries the case is different. It may be necessary to reverse the pyramid of this concept. It may even be argued that many industrial plants have been introduced, but not industry.

To industrialize a developing country, technology has to be imported in almost all cases. It would seem that the only way to introduce technology into the country and build up indigenous scientific and technological capabilities is to ensure the full participation of local scientists, engineers, economists, etc., in the process of importing that technology from its outset. Participation should start from the preliminary plans, feasibility studies, choice of technologies, contractual bargaining, adaptation techniques, design, construction, experimentation, operations, etc. Then, after acquiring such intensive training and experience, research activities can be developed inside the particular plant, and outside it in the concerned research institutes, whereby it would start from adaptive and developmental work and later pass on to applied and oriented basic areas. This is the real challenge facing not only the main policymaking body of the country, but the government and the nation as a whole, to implant technological capabilities and reduce technological dependence.

INDIA

Formulation of the Science and Technology Plan

The National Committee on Science and Technology (NCST) was set up in 1971, and one of its major mandates was the preparation of a Science and Technology Plan. Previous government mechanisms for science and technology did not have such a mandate, but they did set up a number of committees and working groups for many scientific and technical areas, involving a number of working scientists, technologists, and industrial interests.

To formulate the Plan, NCST adopted a combination of the sectoral approach and an overview of the nation's total scientific and technological effort. The Plan was structured in terms of 24 socioeconomic sectors with a view to studying each sector critically and evolving suitable programs of research, development, and design, and S&T inputs more broadly, which would enable target dates to be met. Work on each sector was coordinated by a Panel of NCST members, which in turn set up a number of Planning Groups/ Task Forces. The Planning Group has been the basic instrument for formulating the Plan. To aid the Planning Groups in tasks, a generalized project profile was designed.

The process of formulating the S&T Plan that was adopted has been both democratic and interactive. It has directly involved over 2000 scientists, technologists, economists, administrators, and others and has led to a grass-roots formulation of the scientific and technological work that the country is capable of undertaking. Furthermore, by involving individuals covering the entire innovation chain, even in the definition of scientific and technological projects, it was possible to follow a systems approach in the development of the Science and Technology Plan. This has meant, for example, that the first step of identifying a process or product technology led in turn to the spelling out of the technological skills covering the entire spectrum of engineering design capability, material know-how, and production techniques that may be critical to the fabrication and manufacture of the equipment and machinery needed to commercialize that technology. Similarly, emphasis on agriculture brought into focus not only nonindustrial resources like land and water, but also matters relating to fertilizer, pesticides, post-harvest technology, and climatic control.

The Approach to the Science and Technology Plan: In January 1973, NCST issued a document that reflected its current thinking on the complex issues facing it in the preparation of a science and technology plan, and that enunciated the policy framework that it would follow in its deliberations. The rationale for issuing this approach paper at that time was:

(1) To indicate very clearly that the science and technology policies must function as an integral part of the country's socioeconomic plans, and that indeed they would have to derive their mandate from the national plans.

(2) To ensure that all the scientific and technological activities in the country, including defence, atomic energy, etc., would come within the purview of the science and technology plan under preparation.

(3) To develop a progressive consensus on the policy framework for science and

technology planning. For example, to indicate to both the scientists and the politicians that science and technology planning is more than a collection of R&D project proposals and that the extent and pace at which science and technology can contribute to national development depends, in a large measure, on the policies evolved and the actions taken outside the scientific and technological system.

(4) To generate discussions and debate among scientists and technologists, to elicit their active participation in the preparation and implementation of the Plan; to make explicit to managers and administrators the interdependence of the science and technology system and socioeconomic decision-making; to create a consensus among journalists and politicians and create an environment conducive to implementation of the Plan.

To generate a greater consensus various seminars were organized all over the country, where the science and technology approach paper was discussed by scientists, technologists, and economists. There were in all seven seminars held in different parts of the country. After generating the consensus and the formulation of science and technology plans, the final Plan was presented to the Cabinet in August 1973.

The Science and Technology Plan: The Science and Technology Plan indicated the strategy being followed by the planners, and the details of the Plan for the 24 sectors. Each of the sectoral plans was detailed in terms of specific projects to be carried out by specified organizations and agencies. The objectives of the strategic features are detailed in the S&T Plan.

It is also important to realize that much of the extent and pace at which science and technology can contribute to national development depends upon the policies evolved and the actions taken outside the science and technology system. Its maximum utilization for achieving the socioeconomic objectives would thus require not only investments and changes in the scientific and technological system but also suitable adjustments in fiscal policies, lending policies of public financial institutions, foreign exchange allocation policies, industrial regulatory and import policies, and policies toward foreign investment. The following considerations, as pointed out in the Fifth Plan, are relevant for operational purposes:

"The import of technology does not necessarily have to be linked with the availability of aids or credits. Secondly, institutional arrangements have to be built up quickly for evaluating alternative types and sources of technology and for the selection of imported technology in areas where indigenous technology and expertise do not exist. And thirdly, the domestic scientific and technical effort must be committed not only to the operation of technology through research and development but also through learning, adapting, improving, and then displacing, imported technology."

There must be simultaneously a national commitment to increase substantially the total expenditure invested in science and technology so that by the end of the Fifth Plan period approximately 1% of the GNP is made available on a continuing basis for investments in S&T. The Plan has attempted to reorder financial allocations among the various sectors to be more in tune with declared national objectives. In this it may not always have completely succeeded but it has avoided advocating investments at subcritical levels. But the directions to be followed for matching the allocation of resources committed to the national scientific and technological efforts with the enunciated national socio-economic objective have been clearly and explicitly stated in the Science and Technology Plan. It will be the task in the days ahead to move the science and technology system even closer to the priorities inherent in the national socioeconomic plans. This science and technology planning exercise has been the first attempt of its kind in India. The formulation of the Science and Technology Plan, however, is only the first step in the effective utilization of science and technology for development. While it charts a blue-print for the future, it is only in its effective implementation that its success will lie.

The Problem of Implementation: The Science and Technology Plan was prepared in very close collaboration with the administrative ministries concerned as well as the Planning Commission. Once it had been submitted to the Cabinet and accepted, it was left to the ministries to implement the Five-Year Plan through asking for allocations for the concerned programs in their annual budget allocations. However, the resources available, even for completing the projects at hand, were scarce and any additional investments that were requested for the Science and Technology Plan were pared considerably. It was at this stage that NCST, having obtained an overall picture of the resources being allocated to the different sectors, and having decided that these reallocations of resources were quite at variance with the projected Science and Technology Plan, sought an intervention from the political leadership. The case was presented to the Standing Council of Ministries that, to avoid long-term deleterious efforts, it was necessary to ensure that adequate resources were made available and that the relative allocations among sectors should be done in a scientific and consistent manner. As a result it was decided that an annual S&T plan would be drawn up by the National Committee on Science and Technology keeping in view the financial restraints and selecting areas for investment.

It is this Plan that is now under implementation, and NCST is now examining methods of monitoring it.

KOREA

Interfacing of Science and Technology Planning with the Economic Development Plan

The emergence of science and technology planning has posed the question of how it is integrated into the Economic Development Plan. Such integration is considered inevitable, because industrial production requires technological inputs in addition to labour and raw materials. Modern production systems require labour that bears a specific skill, capital that contains varying degrees of scientific and technical knowledge, and raw materials that rely on preprocessing by related suppliers.

S&T planning is intended to influence the productive capacity of an economy through the promotion of science and technology. When resources for S&T activities are scarce, it becomes necessary to set priorities.

Since the establishment of the Science and Technology Ministry in Korea, S&T policy has aimed at fostering the country's technical capacity and directing the activities toward national goals. There has been an effort to identify specific industrial needs for technology and to supply technologies through research institutions in the country. However, this has not assured an adequate supply of technology for a product-based need.

It is traditional for the formulation of science and technology policy to lag behind that of economic development. This lapse seems to have caused underachievement in the Economic Development Plan due to lack of technical input. It is partially due to the lack of analysis and of translation of economic development into specific technology needs. It has also been recognized that the timing of science and technology planning can provide a better integration of the Science and Technology Plan into economic development planning through more appropriate timing.

Framework of the Interfacing: The general framework of the interfacing is depicted in the following diagram:

Goals of Economic
Development Plan

Sectoral Production Plan

S&T Planning Group	Economic Planning Group

Technology constraints
Technology alternatives
Resource requirement for
technology development and
scientific activities

The first interaction is initiated by feeding information about the Economic Development Plan to a science and technology planning group, which in turn reviews the information, generates its own information, and feeds it back to an economic development planning group. This exchange of information between the two groups can be repeated to perfect a workable plan.

In the administrative structure of the government, the economic planning authority is distinguishable from the authority on science and technology planning. The economic planning group is traditionally composed of economists, mathematicians, statisticians, and planners in various disciplines. The science and technology planning group, by and large, consists of the scientists and engineers within the administration. The S&T planning activity is less extensive than the economic planning activities. Science and technology planning can be independent from economic planning by virtue of its own unique function. In view of the consequences of science and technology planning and the resources required for research activities, it seems necessary to coordinate the two groups of planners to merge the contents of planning into an integrated unit.

For the preparation of the Fourth Five-Year Economic Development Plan, the Economic Planning Board formed 22 sectoral planning groups, which were expected to draw up preliminary plans in each sector and submit them to the overall coordinating group.

The formation of these sectoral groups reflects the existing ministerial organization, thus making the top planners at the ministries participate in the planning. Additional planners are expected to arrive from research organizations, trade associations, and academic communities. An intense involvement of S&T planners is expected in the sectors of heavy and chemical industries, light industries, transportation, natural resources, energy, and employment and manpower.

Science and technology planning may be extended beyond these six planning sectors. For practical reasons, the involvement of science and technology planners is to be contained in the sectors predominantly oriented toward hardware technology. At least in the six planning sectors, interaction between economic planners and science and technology planners is assured for the coming Economic Development Plan.

All sectoral planners are to be versed in the goals of the Economic Development Plan: development of agricultural and energy resources; enhancement of domestic earnings in export; a proper structure for the development of heavy and chemical industries; development of the science and management of business and manpower; development of land resources and maximum expansion of employment opportunities; price stabilization, improvement of taxation, and amelioration of banking; dispersion of population and industries to nonurban areas; enhancement of investment for social development; improvement of working conditions; expansion of the housing, welfare, cultural, and social security systems; and improvement of efficiency in development administration.

As described above, the participation of science and technology planners in the sectoral groups assures the integration of S&T planning into the Economic Development Plan. At this stage of planning, the science and technology planning group is subgrouped into metals, shipbuilding, textiles, machinery, electronics, petrochemicals, and energy. At the working level each subgroup is expected to break down the assigned branches into a project to be evaluated in terms of technological constraints, technological alternatives, and the required resources for the development and importation of technology. The economist in each planning sector must supply a feasible output of the industrial sector to the science and technology planners. The feasible output in the plan period should also be based on the overall growth, investment, resources, employment, and other discernable economic variables.

When the output of the industrial sector is given, science and technology planners are able to review technical requirements to meet the output:

(a) Current capacity of production (capital goods and labour)
(b) Current requirement of raw materials
(c) Technical requirement of skilled labour
(d) Investment requirement for a new product
(e) Investment requirement for additional capacity
(f) Extent of technology importation
(g) Supply plan for domestic technology
(h) Alternatives of better product mix.

The output requirements in each industrial sector are critical information for the science and technology group. This output requirement can be a tentative figure until the technical feasibility is ascertained. Finally, a feasible output in each sector can be adjusted across the other sectors of industries by the coordinating group.

As a tool for the systematic treatment of S&T requirements, a product-technology matrix is being employed. The matrix was prepared in 1969; it is subdivided into 16 industrial sectors with about 100 products each, and vertically into about 70 technologies. Each cell identifies the required technology inputs to produce a product, and qualifies it as major, minor, or not available in the country. Monetary values employed are those of the equipment or productive facilities that contain the technology. An index may be obtained for a certain technology (e.g., cold rolling), which shows not only the value of the technical element but also the total effect on other products. This tool, however, lacks the dynamic possibility of expanding the horizon of S&T because it is limited to existing knowledge, so that a supplementary methodology is needed for such aspects, as would be the case if the problem of energy technology for the future were being considered.

MEXICO

The National Indicative Science and Technology Plan

In recent times Mexico's scientific and in particular technological dependency upon the outside world has increased instead of diminishing. Isolated attempts to rectify the situation by promoting R&D activities in the universities and in the public sector were not accompanied by the elaboration of a national policy on science and technology until very recently, when the National Council for Science and Technology (CONACYT) was set up at the beginning of the 1970s. In close cooperation with the scientific community, leading universities, and representatives of the public and private sectors, CONACYT formulated in 1975/76 the first Science and Technology Plan, covering basically the 1976-1982 period but within the framework of a longer-term R&D strategy.

The confrontation of the existing situation with the country's probable R&D needs indicated that the science and technology system should expand considerably, requiring an increase in financial and human resources as well as an integration of those efforts into a general planning framework. Given the nature of scientific and technological activities, the characteristics of the Mexican economic model, and the official ideology, such planning cannot but be indicative and participative. As regards S&T, planning should not only foster the expansion of R&D but aim at creating demand for domestically produced scientific and technological knowledge, because in the developing countries the mere supply of know-how does not create the demand for it.

The Mexican Science and Technology Plan is based on two premises: first, that the importance of science and technology for socioeconomic development makes its longer-term planning an urgent necessity for any country; second, that the need for scientific and technological planning, while safeguarding freedom of research, is even more pressing in countries like Mexico, because of the persistence of underdevelopment, the relative scarcity of the government's financial resources, and the magnitude of the still unsatisfied basic needs of the majority of the population.

The main objectives of the Science and Technology Plan were defined as non-imitative scientific development, cultural autonomy, and technological self-determination. Scientific development should be understood here as the creation of a capacity for research in the exact, natural, and social sciences that would enable the scientific community to fulfill its social function and, at the same time, to participate meaningfully in the process of international scientific advancement. Cultural autonomy is an objective related to safeguarding certain societal values that are being lost in the process of industrialization in many developing countries. Lastly, technological self-determination is defined as the construction of a domestic capacity that would permit the demand for technology to be reoriented progressively to the extent needed toward local sources of technical knowledge, that would rationalize purchases of foreign technology, and that would help the assimilation and adaptation of the imported know-how, using it for the internal generation of technology.

The S&T policy required for this in the long run should be guided by the following principles:

(a) S&T policy should be integrated with development policy;
(b) The development of S&T should be adapted to the country's long-term objectives;
(c) Autonomous S&T development does not mean ceasing to employ external S&T knowledge;
(d) To overcome present S&T backwardness requires a joint effort by government, scientific, and educational institutions and the productive system;
(e) A favourable environment is needed, including the recognition of the social value of S&T;
(f) Excellence should be attained in some key fields hitherto little developed;
(g) Meaningful technological advance requires activity on several fronts: selected areas of conventional R&D, appropriate primitive technologies of local origin, and certain fields that offer hope for significant breakthroughs;
(h) The S&T system should have close links with the educational system and the economy.

Because of the present S&T backwardness, the Plan devotes much attention to problems of the S&T infrastructure, including training, diffusion of knowledge, information, statistics, engineering and consulting services, production and maintenance of scientific equipment and instruments, and international scientific cooperation. In each case, the Plan suggests long-term objectives and medium-term policy guidelines.

With respect to R&D itself, the Plan defines objectives and sets guidelines for problem-oriented research activities both in exact and natural sciences and in social disciplines. In the field of applied R&D it develops technological policy guidelines for nutrition, agriculture and forestry, communications, urban development, industry, energy, renewable resources, construction and housing, medicine and health, educational techniques, and natural phenomena research. The Plan emphasizes that the scientific advancement must be based not only on the recognition of university autonomy but on the state's commitment to guarantee the academic and research freedom necessary to foster scientific creativity. The specific scientific and technological policy guidelines are expected to be translated into institutional and sectoral programs with the aid of some relatively simple interinstitutional mechanisms designed to achieve that end. Just as the formulation of the Science and Technology Plan itself, these mechanisms for programing and implementation should be indicative, participative, and flexible.

The Plan postulates that by 1982, expenditures on science and technology in Mexico should reach a total of 16,200 million pesos ($1,300 million at 1975 prices), i.e., almost three times the 1976 spending level and slightly more than 1% of the GNP. The outlay for research and development alone should rise from 3,090 million pesos ($250 million) in 1976 to 9,200 million pesos ($735 million at 1975 prices) by 1982. A slight reduction in the government's share of total expenditures from its current level of 80% to 75% is assumed, along with the proportionate increase in private sector spending. Furthermore, planning offers medium-term targets for R&D support activities, and a package of science and technology policy instruments aimed at increasing the productivity of R&D is proposed. Finally, the setting up of mechanisms for evaluating the progress of the Plan's implementation is considered.

Independent of the degree of success that Mexico may have with the implementation of its Science and Technology Plan, the exercise of the Plan itself offers many lessons to other developing countries.

The first is the need to recognize that science and technology problems in the context of general underdevelopment differ basically from those encountered by science and technology in the advanced world. Thus, the advancement in this field in the developing part of the international economy can hardly be achieved by methods more or less successfully applied in the world's industrial centres. Since scientific and technological backwardness is part of the overall underdevelopment, science and technology policies must be integrated into the general development policy framework. The absence of such a framework limits severely the relevance of any attempt to build up domestic scientific and technological capacity.

The second lesson is that one of the major obstacles for the advancement of science and technology in a country like Mexico originates from the divorce between local R&D activities and the educational and productive systems. Consequently, whatever knowledge is produced domestically is used neither for improvement of the quality of education nor for productive purposes. Mexican experiences strongly suggest that the supply of internally produced scientific knowledge and technical know-how does not automatically create a demand for them, because the demand is historically directed to the outside world. Consequently, the advancement of science and technology in a developing country depends more upon the effort to establish links between the R&D system, the educational system, and the economy than upon the simple increase in human and financial resources allocated to R&D. Strategies that postulate the establishment of modern scientific institutes while leaving applied R&D effort to traditional international transfer mechanisms just cannot work. In the absence of demand for their output, modern scientific institutes set up in the developing societies wither away and become focal points of brain drain. At the same time, the dependence on traditional technology transfer mechanisms leads to the emergence of advanced technology enclaves that perpetuate themselves in the context of general technological backwardness. The question here is not whether such technology transfers, for example through foreign-owned enterprises, are of any use in the absolute sense. They may be useful or useless depending on the presence or absence of other vehicles for the transfer and propagation of technical know-how in a developing society. And only the technological strategy designed to establish permanent links between technological imports and the domestic R&D system, on the one hand, and the local R&D output and the educational and productive systems, on the other, can assure in the longer run the meaningful technological modernization of a developing country.

A third point is that the domestic science and technology system in a developing country must be defined not just as the sum of local R&D producing entities, but as the universe of all units dedicated to R&D, to R&D supporting activities, and to intermediating between the R&D institutions and higher-learning bodies as well as productive enterprises. The intermediation is not unidirectional - from those who produce knowledge to those who use it - but should be visualized as a sort of two-directional triangular relationship. If science and technology policymakers in the advanced countries seem to forget this, it is because they lack historical perspective. In all the advanced societies the sort of triangular relationship between science and technology, education, and production, absent in the developing societies, was built up slowly and without any sort of planning over the last two centuries. This statement also covers socialist societies. Contrary to widespread belief, they were not scientifically or technologically backward in their presocialist times, particularly when compared with the majority of developing countries as we know them today. The Soviet Union before 1917, Poland before 1945, and China before 1948 were quite advanced in all possible respects in comparison with most of Latin America, Africa, and Asia in the mid-20th century. Thus, if one wants to advance science and technology in the developing world, one faces a difficult task of devising policy instruments affecting the broad R&D system as defined above and revising at the same time educational and economic policies in light of the scientific and technological effort.

The fourth major lesson of the Mexican exercise may be that we know very little about the interrelations, particularly in the context of underdevelopment, present inside of the continuum known as R&D. The simplistic proposition that every country needs to support in a similar way all parts of that continuum (because allegedly pure science is needed to prepare the ground for applied scientific effort, which is needed, in turn, for technological development) is open to many criticisms on logical, structural, and historical grounds. Only by accepting our ignorance with respect to the relationships within R&D, by agreeing that the social functions of different parts of the R&D continuum vary considerably, and by relating the production of knowledge to some overall view of long-term social, economic, and national objectives of a given society, is it possible to arrive at a broad vision of national science and technology strategy for a developing country or region.

A final major point is that science and technology policy problems cannot be meaningfully handled just by scientists and technologists, if only because science and technology is not a specialized sector but affects every phase of social, economic, cultural, and even political life. Furthermore if the proposition that science and technology is not socially neutral is accepted, the conclusion may be reached that planning scientific and technological endeavours is a very complicated matter in which all available wise men from different walks of life, including wise politicians if available, should perhaps participate. This may be particularly true in the context of underdevelopment where it may well be that scientific and technological elites, while sometimes highly educated, are in other respects as backward as the societies in which they function.

Many other important lessons could be drawn from the Mexican exercise, but the purpose here is to highlight the key issues only.

VENEZUELA

The First National Science and Technology Plan

Venezuela recently prepared its Fifth Development Plan, and some time later work was started on a S&T Plan. The combined objectives stated in the Fifth Plan, with the state controlling over 50% of total investment, offered excellent opportunities for the country's S&T development, but for this it is necessary to establish an institutional structure that permits systematic and continuous interaction with the main decision centres that formulate policies or consume large volumes of technology. This situation also demands that research centres change that attitude and organization toward an effective management of technology to permit not only the solution of day-to-day problems, but also the capitalization of opportunities presented by the new dimensions of public and private investment.

This Plan, because of the quantity of accelerated investment involved, implies the risk of strengthening rather than reducing technological dependence. The main objectives of the Plan were:

- diversification of the economy
- full employment
- supply of the essential inputs for the majority group with low economic resources
- deconcentration of economic activity
- exportation of nontraditional goods
- protection of natural resources
- reduction of the external vulnerability of the economy.

These objectives make the following demands upon the local scientific and technological infrastructure:

(a) Generation of new methods and processes to increase agricultural and industrial productivity with emphasis on optimum employment generation.

(b) Production of technology that will permit rational use of nonrenewable natural resources and an increase in the local aggregate value of the basic products.

(c) Changes in the nutritional composition of mass-consumption food products without diminishing the purchasing capacity of the low-income groups.

(d) Rational selection of technologies, and capacity to use imported technology, to induce the development of local technology.

(e) Development of design engineering capabilities and of the technology of capital goods production as indispensable links between laboratory activity and the commercialization of the results.

(f) Macrosocial evaluation of technology in view of the criteria for optimizing the generation of employment and preserving ecological balance.

(g) Production of technologies to permit construction of housing adapted to the climatic and cultural conditions of each region.

(h) Production of new teaching systems that are better adapted to the nature of Venezuelan students, and that will permit greater access to the educational system and encourage its qualitative improvement.

(i) Increase in basic research in universities to guarantee a more qualified higher-education sector and to accelerate by means of better qualified human resources the innovation capacity of the productive sector.

Work on the S&T Plan was started a year after the Fifth Plan had been finished. Previous work on the STPI Project had allowed the National Council for Scientific and Technical Research (CONICIT), the agency entrusted with the task, to examine institutional aspects of the scientific and technological policy and the interactions with economic policy. This revealed the weight of implicit policy. Other work on the operative aspects of technology transfer (internal and external) revealed that one of the main obstacles to reorienting the local technology supply toward the requirements of the productive system was the users' inability to identify their needs and the lack of managerial skills of local suppliers that might have allowed them to present their developments in a usable manner. As a result of this research it became clear that any plan without the support of the economic and political decision centres would be converted into a simple academic exercise. Hence, a promotional strategy was adopted that gave the planning process a techno-political nature, seeking the participation of the highest political authorities in the country, who were given the responsibility of coordinating each work-group meeting during the central event, the First Congress of Science and Technology.

Very early it was decided that the S&T Plan should be an operative plan. However, CONICIT lacked the means for a correct appreciation of reality as well as the institutional channels that would allow it to make a precise diagnosis of the different component parts of the system. It could not be accepted as valid, given the existing separation between the productive sector and the research centres, that groups of CONICIT scientists and technicians should, in isolation, define the image to be pursued by the S&T system.

To overcome such restrictions, the planning exercise began with a national mobilization within principal sectors of the economy by means of regional meetings of entrepreneurs, researchers, science promoters, planners, and government leaders. Each event was like an open forum, with the CONICIT staff acting as technical secretaries and with flexible guidelines, the purpose being to draw up recommendations. Fifteen sectoral meetings were held in areas such as metallurgy, health, food technology, and agriculture. These events pursued the triple aim of:

(1) Broadening the support base for the plan;
(2) Obtaining information regarding the real requirements of the productive sector;
(3) Defining objectives that, although not necessarily ideal, would emerge from the decisions made by the consensus of the panel participants, using as a basis the sectoral priorities and plans already defined by the Fifth Plan.

After each meeting the participants were divided into specialized groups, which prepared documents for presentation at the First Congress of Science and Technology.

This Congress was attended by some 2000 participants, 60% from the research sector. It recognized CONICIT as the guiding organ of S&T policy, and accepted the need to reorganize S&T in relation to development objectives. Priority research areas were defined, grouped as regards their contribution to social variables (e.g., nutrition, housing, health), the modernization of the economy (e.g., capital goods), the raising of the value of nonrenewable resources, and the mastery of technology. CONICIT, as the principal implementer of recommendations, reorganized its structure to take on its new responsibility to make a coordinated plan.

CONICIT obtained a reformulation of the science and technology aspects in the Fifth Plan, and introduced elements of policy such as the obligation for state companies to open technological packets and the guarantee of financial support for research activities within these companies.

The most important characteristics of this process are the following:

(a) Mobilization of resources is begun even before the eleboration of the Plan, which makes the process dynamic.
(b) From the start the Plan was identified as a technical-political action, which eliminated the possibility of generating negative results.
(c) It has a participatory character: in each meeting a basic document was presented, which was then transformed and enriched with the opinions of the intervening groups.
(d) A support basis is obtained because each participant identifies with post-Congress action.
(e) The Plan emerged as a requirement of the community and was not something imposed by a group of intellectuals. Besides, it had political support even before it was launched.
(f) The institution entrusted with the definition and supervision of the Plan obtained strong support.
(g) The various decision-making centres that are as yet dispersed will attempt coordination to fulfill the directions of the Congress; this will provide an excellent opportunity to give a certain coherence to the system.

In synthesis, the most important aspect from an internal point of view is that this process constitutes a real experience with regard to learning on the job and technological independence in planning. Its main fault lies in the fact that the close attention paid to external planning aspects implies neglect for internal methodological aspects, such as the weighting of objectives, diminished distribution of resources, etc. Throughout the Plan, an effort is made systematically to adjust this phase of the process.

FINANCING

Financial instruments are keys in building up a S&T infrastructure and putting it to work according to the requirements of social and economic development. They are not easy to develop and perfect, and they need a good backing of policy and of skilled personnel; in fact the more scientifically developed the country, the more developed its financial mechanisms with respect to science and technology.

The experiences of several STPI countries are reviewed below; in addition there is a short description of financial instruments in Japan, as an example of the full development of such instruments.

Several interesting observations can be made from these examples, and a brief summary is attempted below:

(a) Without financial mechanisms it is difficult to influence the development of S&T capacity and the type of activities carried out by it.

(b) Financial instruments are not differentiated in practice according to whether they support the building up of S&T capacity or its use; both purposes may be supported by the same scheme, and in fact many programs have to do with both aspects. There may however be a case for using a specific fund for moderate to large investments in S&T capacity because criteria for the allocation of resources may be different in creating S&T capacity and in using existing S&T capacity.

(c) Financial mechanisms may be of a supplementary nature, i.e., funds that are allocated over and above the current budgets of institutions. This may be done through a central fund or through one or more sectoral funds. A more comprehensive approach would be to prepare a consolidated National Budget for S&T that incorporates not only the central and sectoral funds but also the individual budgets of government organizations devoted to S&T. This approach is being promoted by UNESCO and has recently been applied in Colombia. It requires a great deal of political support and commitment. The point is how far the the programs of institutions that are financed by their own resources can be influenced according to more general considerations. This may take a lot of effort in persuasion, and in fact S&T planning exercises seek this type of effect, as can be seen in the examples of India and Mexico.

(d) Some of the documents reviewed here suggest orienting the S&T effort through the judicious application of supplementary financial means, rather than centralizing decision-making and program formulation or evaluation. The question is how high a proportion of the total government expenditure in S&T may be needed in the central fund, or in sectoral funds, to produce a significant effect on the orientation of the resources directly handled by the agencies, particularly when the S&T system is organized in a pluralistic fashion with many centres of decision among which there is little coordination. In the case of Mexico it is felt that the present proportion of slightly over 11% is not enough, and moreover it is suggested that the experience of the National S&T Council shows that an organization of this nature - of which many exist in the developing countries - has little chance of being successful in its efforts at persuasion.

(e) It is likely that several different funds are needed, each with its own purpose, rather than just one central fund. The increase in the supply of S&T, the orientation of activities, and the increase in demand on the part of industry are the obvious purposes that are put forth by countries with a central fund only or a few sectoral funds. As development proceeds and experience is gained, as in Brazil and a fortiori in Japan, other important purposes are identified and specific financial mechanisms become necessary for them - for instance, the support for consulting activities in Brazil or the risk capital for industrial innovation in Japan.

(f) For a proper use of financial instruments several things are needed: a clear policy regarding the types of S&T activities to be supported - for instance, basic research, graduate training, technological development; a set of priorities regarding beneficiary branches, disciplines, types of institutions; adequate technical and administrative skills for evaluation, follow-up and other tasks; and project-formulation skills in the applicant institutions. General policy and guidelines regarding priorities may be put out by the central S&T authorities, but the translation of such policy and priorities into operative programs very much depends on the organizational structure in charge of the financial instrument (as can clearly be seen in the case of Brazil), so there may be considerable scope for second-level policy decisions, which in fact may end up shaping the instrument rather differently from what was originally expected by the planners and principal decision-makers.

(g) An interesting issue concerns the emphasis to be put on project funding rather than on institution funding. There are advantages and disadvantages to each procedure, and one of them may be more convenient than the other in certain circumstances. In general, funding by project would seem to be more appropriate because a purpose can be defined and a program of work assessed, and this also has a strong educational value for the institution. But it is the largest institutions that tend to obtain most of the funds - a small institution may not be able to prepare a good project proposal or achieve the minimum size needed to make the project worthwhile. As pointed out in the case of Brazil, a concentration of funds takes place in some large institutions, so that existing imbalances among institutions and regions are further reinforced. This "Matthew principle" has on the other hand certain advantages from the point of view of efficiency because the projects can be properly planned, with sufficient critical mass to ensure a good probability of success. Trade-offs between both effects would seem to be an important matter for debate. In the case of Peru's industrial R&D fund, the largest enterprises profit because they can formulate sufficiently large projects; medium and small enterprises will in many cases be obliged to turn the 2% funds over to ITINTEC, to be ultimately employed in activities that may not benefit them.

(h) The experience of Japan shows how long it takes to develop and perfect a system of financial instruments for S&T. Developing countries should be prepared to undertake a lengthy learning process.

KOREA

Funding of S&T by the Public Sector(13)

A powerful instrument for the promotion of science and technology is resource allocation. Research funds are drawn from government, private, and foreign sources. The government share ranged from 66% to 71% of the total annual R&D expenditures in the 1970-73 period. The figure in 1973 was 8.3 billion won while total R&D expenditure was 15.6 billion won.

The annual government budget for science and technology accounts for about 2% of the total government budget, a relatively low proportion compared with that of advanced countries. Of the 8.3 billion won allocated to research by the government and the public sector in 1973, 79% was spent on research in government-owned and public research institutes, 17% in private institutes, 2.3% in colleges and universities, and 1.9% in private businesses. The trend in the last 5 years shows a proportion similar to the allocation in 1973.

The budgetary instrument is a common tool of policy implementation and is ubiquitous both in developed and developing countries. To secure a sufficient budget for research, the concerned ministries have to produce justifiable and convincing documents. It therefore becomes a very difficult task to secure funds for a new project. Perhaps for these reasons, the government budget for research has not increased as much as the favourable public opinion toward science and technology. In this context, reliance on the budgetary instrument has limitations.

Allocation of the budget for research is as important as the source of funds. Judging from the disposal of R&D expenditures by the government, a large portion of the budget is spent on precommitted research and development, and a relatively small portion on project-based research and development. Ninety-five research institutes under different ministries carry on their own research activities, which tends to limit the relative size of the budget oriented to project-based research and development. The Ministry of Science and Technology manages approximately 200 million won of research grants on a project basis. The government being the promoter and initiator of research and development in the earlier stage of industrialization, a generous share of the government budget is used to promote scientific activities. Particularly, a sizable sum of uncommitted budget is needed to widen the horizon of research, which eventually enriches the national wealth. An institution-based commitment to research expenditure may run the danger of tying up the large budget. Consequently, flexible adaptability of the budget to the dynamic requirements of research needs can be hampered.

Scientific and technological activities are so diverse and extensive that practically all government ministries are partially involved in carrying them out and at the same time they turn to users of research results. To successfully implement science and technology policy, extensive coordination and interministerial cooperation is required. For instance, high-caliber manpower training and basic research have to be carried out at educational institutes. Except for the Korea Advanced Institute of Science, both public and private colleges and universities are under the supervision of the Ministry of Education. To implement and direct the scientific activities of the nation, a science and technology policy must be adopted by the Ministry of Education. Likewise, the enhancement and development of skills that are vital to production have to be carried out in part by educational institutes. It is particularly relevant that in-service training is deemed necessary under the circumstances of scarce skilled labour. The Ministry of Commerce and Industry is in a better position to induce industries to expand in-service training and to initiate vocational training at the Ministry's own cost.

In view of the large number of research institutes under different ministries and independent research organizations, it is inevitable that policy is implemented through a network of administrative and research organizations. KIST was established and is operated on a principle of autonomy of research. However, close communication between researchers and policy makers and the involvement of researchers in policy formulation have immensely improved the practicality of policy formulation and implementation. The interlocking of communication and information among concerned organizations has therefore to be established for the effective implementation of science and technology policy.

Persuasion is a kind of informal instrument. In retrospect, the frequent visits of government officials to research institutes served the purpose of persuasion. Public speeches and explanations of science and technology policy through mass communication media have helped gain public understanding of science and technology policy. The creation of a favourable environment for science and technology can effectively be achieved by persuasion.

The budgetary instrument is direct and may achieve immediate results. This instrument has the relative advantage of flexible maneuvering of scientific activities as needs are verified. The current S&T budget is largely tied to a fixed expenditure by maintaining a large number of existing institutions. The budgetary instrument can be used to reorganize existing government research organizations into a sizable multidisciplinary research organization. This reorganization can produce a better allocation of the budget for need-oriented, project-based research and can provide a base for utilizing the organization instrument more effectively.

The prevailing government budget allocation for S&T seems to be limited to supporting research at individual corporations because of other competing allocations. In view of the relatively small share of grant-in-aid budget for research and development, it appears necessary to raise the budget to maintain the flexibility of overall budgetary allocation. This measure will undoubtedly improve the effectiveness of S&T policy implementation. At the same time, a systematic approach is required to determine and set priorities of research needs in the context of economic activities.

COLOMBIA

Financing of R&D by the Public Sector[14]

The Central Fund: The Colombian Fund for Scientific Research and Special Projects (COLCIENCIAS) undertakes the financing of research projects with the aim of stimulating R&D activity in the country.

COLCIENCIAS has financed a total of 350 projects for a total value of about Col$50,000,000 (almost $2,000,000) in the course of its 6 years of existence. This financial mechanism has been the principal instrument for the implementation of the research policies formulated by COLCIENCIAS - in its role of Executive Secretariat of the National Council of Science and Technology - and it has been employed in a strategic way to complement the funds of the different institutes that are carrying out research.

Without this financial mechanism, the power to influence such activities in the country would be minimal. Hence the functions of financing and of formulating a national policy in this field are complementary and should be carried out in an integrated manner.

A valid question in relation to this financing activity is the effect that R&D activities have had on the economic and social development of the country. There are two aspects here. First, the stimulation of research through the financing of projects has helped to strengthen the infrastructure and the national S&T capacity by supporting the institutions dedicated to these activities, stimulating research in the universities and other centres, contributing to the training of researchers, increasing the facilities and resources of research in the country, and so forth.

Without denying the importance of this, a complementary question arises concerning the real use that is being made of the results of this research and the effective contribution that it is making to the development of the country. Such results should be transformed into concrete technological innovations that contribute to the solution of national problems or to the development of the country. This implies, among other things, that the function of COLCIENCIAS is not limited to financing research projects. It also includes the use of these results by the productive sector, which would imply following up the results or effects of each project.

Despite the fact that the majority of projects financed by COLCIENCIAS have been in the field of applied research, it is difficult to determine or estimate what proportion of them has been transformed into concrete technological innovations and is therefore contributing to the development of the country. Reference has not been made here to the fact that a research project can suggest theoretically, or on paper, a technological innovation, but to the fact that such results are being effectively put into practice in the productive sector (or for the potential users of this knowledge). Unless this is so, one cannot speak of technological innovation.

This point reveals an important bottleneck in the financial system of scientific and technological activities in Colombia. The funds of COLCIENCIAS are generally used to finance research (basic and applied) whose results might suggest or describe a new technological process or a specific technological innovation. The activity of this institution is much more limited in the phase that immediately follows, which is the financing of the transition from these results to their effective use in the productive sector. This transition phase includes activities such as the engineering of design and the setting up of an experiment or a pilot scheme that is transformed effectively into an innovation in the productive sector.

The lack of a financial mechanism specifically oriented to this transition phase is a serious limitation to the transformation of the national research effort into technological innovations that can contribute to the development of the country. One of the consequences is that research results tend simply to be filed away or are limited to the enrichment of scientific knowledge on the whole without this being transformed into concrete innovations.

In relation to this, COLCIENCIAS has been examining in conjunction with FONADE (National Fund of Development Projects) the possibility of creating a special fund specifically oriented toward financing activities of technological development that ensure or facilitate the connection between basic and applied research and the effective use of the results of this research in the productive sector. Given the nature of this activity, the fund would have to take into consideration explicitly the relatively high risk involved in defining the criteria it would use in its functioning.

National Budget for Science and Technology: Colombia has recently adopted a consolidated budget for S&T activities financed by the state and its agencies. This is a high-level central government mechanism to make explicit the public expenditures related to S&T activities, with the following purposes:

(a) To embody the Science and Technology Function within the functional classification of the National General Budget to be employed in the 1977 fiscal year and thereafter.

(b) To make explicit within the Science and Technology Function the present and future public expenditures for scientific and technological activities to be included in the National General Budget.

(c) To establish progressively the exact orientation and coordination of the program budgets for scientific and technological activities included into the Science and Technology Function, so that scientific and technological activities of the public sector will be related to the objectives of socioeconomic development.

The establishment of this National Budget for S&T activities is a joint project of COLCIENCIAS, the General Direction of the Budget, and the National Planning Department, the leadership having been assumed by COLCIENCIAS. The main achievements so far have been:

(a) The substantial modification of the forms and instructions to be used in the elaboration of the tentative budgets of public institutions for the 1977 fiscal year;
(b) The establishment of new budget programs for public scientific and technological activities;
(c) The explicit inclusion into the budget's functional classification of the Science and Technology Function and its five subfunctions (postgraduate education for science and technology; research and experimental development; diffusion, extension, and technical assistance; scientific and technological services and resources management; science and technology management).

The implementation of this mechanism is only just starting. Its achievements will depend on the institutional support it will gain.

BRAZIL

Financing Instruments in the Second Basic Plan for S&T Development (1975-77)[15]

The Second Basic Plan for S&T Development (PBDCT) has as a financial scheme a 3-year budget by program, which however does not yet constitute a truly consolidated National Budget for S&T. Programs, projects, and activities in the Plan are to be financed by budgetary resources and various receipts of the federal organization (including enterprises), with supplementary resources channeled through special agencies and special funds, and to a small extent with resources coming from abroad. The proportions are 44%, 32%, and 4% of the total Plan expenditures in 1975-77; in addition 20% is to come from other internal sources. The supplementary resources are to come from the following sources:

(a) National Fund for S&T Development (FNDCT), which is the principal financial instrument of the Second PBDCT; it is administered by FINEP (see below);
(b) National Research Council (CNPq), which has a budget of its own to finance research programs and training and specialization programs;
(c) CAPES, a fund in the Education Ministry principally devoted to postgraduate fellowships in Brazil and abroad;
(d) National Economic Development Bank (BNDE), which manages a fund for technological development, FUNTEC, with applications preferentially oriented toward the funding of specific applied research and development projects in nationally owned enterprises;
(e) Financiadora de Estudos e Projetos (FINEP), which finances technological development projects of nationally owned enterprises, including support to national consulting and engineering firms.

Financial support is given to specific programs or projects carried out by public and private entities, through soft credits or nonreimbursable loans. The proportion of total S&T Plan expenditure financed by these mechanisms has gone up from 23% for the First Plan to 32% for the Second Plan. In this way a strong influence is exerted on the overall allocation of resources by making it possible to carry out certain projects and giving a minimum dimension to others that otherwise would not be efficiently carried out. In the implementation of a S&T policy, the catalytic function of certain organizations may be more important than the mass of resources they contribute, principally when this takes place in an institutional context of traditional fragmentation and low coordination levels, as it does in Brazil.

The National Fund for S&T Development (FNDCT) was created in 1969 to give financial support to prioritary programs and projects of S&T development, particularly in relation to a future Basic Plan for S&T Development. Resources in FNDCT have grown year by year and are principally oriented to the physical modernization of the existing S&T infrastructure and to the building up of a nucleus of persons that will permit adequate utilization of that infrastructure. The Fund is managed by FINEP through transfers to other institutions or directly by allocations to programs and projects. The three principal users of the Fund are the National Development Bank (for FUNTEC, the fund it administers), CNPq, and FINEP itself, entities that themselves redistribute those resources to the final users. Among the principal beneficiary sectors are, first, the educational sector, followed by the industrial sector, directly through programs and projects for the transformation of industry and indirectly through the development of new technologies e.g., (nuclear, space, ocean studies).

The National Research Council (CNPq) distributes different types of fellowships: (a) for new researchers, to allow them to get started on research under the supervision of an experienced professor or researcher; (b) for the improvement of researchers, similar to (a); (c) for postgraduates, to attain higher degrees (MSc, PhD): these have grown considerably, from 18 in 1962 to 1,259 in 1973. Fellowships are given principally for training in Brazil, students being sent overseas when they cannot get further training of the required quality within the country. Most fellowships are for basic and applied research, whereas those for development (technology) are barely over 10% of the total. About half of all the fellowships are in medical sciences and agriculture. It is also significant that the principal field in overseas fellowships is technology, with 27%.

The Council also assists institutions that have reasonable conditions for S&T work. They are evaluated according to their human potential, and funds are provided for installations, new equipment, documentation, and various expenses.

In the early 1950s CAPES started its activity of supporting both training (with scholarships for study in Brazil and abroad) and the growth and consolidation of advanced training centres, which offered graduate training after 1964. From 1952 to 1972 CAPES awarded over 9,000 scholarships and, in addition, it helped 3,000 persons to use scholarships given by other organizations or to undertake short study trips. Its programs for the support of graduate institutions and graduate courses are instrumental in the continuation and improvement of this level of education.

The Fund for Technological Development (FUNTEC) was created in 1964 with the idea of using 40% of its resources for graduate education courses in physics, chemistry, and engineering, and 60% for R&D that would help to produce innovations, adapt and improve currently used processes, develop processes to utilize domestic natural resources better, put out technical standards, etc. The Economic Development Bank could apply resources from the Fund for donations, grants, reimbursable loans, and equity participation. Modifications occurred throughout the years: resources were applied to technical training and other graduate study areas were included (basic sciences, applied sciences, social sciences, biological sciences, and later, economics, administration, planning, and organization of services). In 1973 the objectives of the Fund were more carefully defined as "promoting and supporting, through complementary financial cooperation, the carrying out of programmes and projects to enlarge, develop and improve techniques, processes and products, and their utilization by the national economy." From this time the Fund started to give greater support to technological activities more directly applied to industry, and less support to graduate training and basic research. The Fund's Program of Technological Development has two subprograms, one for technological research proper and the other for the utilization of advanced technology by industry, particularly technology generated in the country.

A precise evaluation of the Fund has not yet been made, but some preliminary observations can be made. First, in 1965-73 more than half of the Fund's resources went to three institutions: the Universities of Sao Paulo, Rio (Federal), and Rio (Catholic). This may be due to a strategy of making up critical mass in some units of the university and research system that were capable of carrying out such a strategy. This concentration has aggravated regional imbalances. The need for Bank funds by institutions of the educational system shows the deficiencies of this system and raises the question of what would happen if the Bank decided to support technological research rather than graduate education and basic research. Among FUNTEC users are the military ministries, which have been increasing their share in recent years. Thus, S&T problems are receiving growing emphasis on grounds of national security and are translated into projects of a more technological character than those of the universities. On the other hand, enterprises have hardly benefited from the Fund. Since there is good contact between enterprises and the Bank, this cannot be attributed to lack of communication; it is perhaps due to a preference for technology imports as well as to a decision to carry out research - if research is performed - with the help of funds from other sources, possibly for reasons of secrecy or to avoid costly project preparation. This situation may not be favourable to a change in emphasis by the Fund toward technology projects. In fact, the Fund has found it difficult in recent years to use all its resources on account of a lack of projects.

The Fund has introduced the project as the unit on which decisions are taken: this has had a salutary effect on the planning of activities at the beneficiary universities.

Finally, it should be noted that FUNTEC represents only a small share - about 4% - of the total credit operations of the Development Bank, and furthermore, that this is completely covered by resources from FNDCT so that the Bank is not committing any resources of its own. This would show that FUNTEC has a rather low priority for the Bank, an institution that has traditionally been engaged in financing fixed assets and solving bottleneck problems for key industries, but not in building up human and knowledge resources.

FINEP, the funding organization for studies and projects, was created in 1965, and through the years its mission has been greatly expanded. Since 1971 it has been the Executive Secretariat of the National Fund of Scientific and Technological Development (FNDCT), referred to above. FINEP is the orbit of the Planning Ministry and has become an instrument for the support of the S&T sector, at the same time retaining its traditional program of studies and projects and its support to consulting and engineering firms.

The funding of studies and projects is carried out largely with the collaboration of a network of state-financing agents, so that the program has acquired a decentralized characteristic. The principal users are institutions linked to the sectors of the various states in Brazil, which in this way can improve their planning and decision-making processes, using the services of consulting firms to supplement their often meagre qualified manpower. In 1973 some 280 projects were funded, principally related to studies of the conditions of the social and economic infrastructure.

To strengthen consulting firms, which are a vital link between S&T and the productive system, FINEP inaugurated in 1973 its Program for the Support of National Consulting, which funds physical investments, working capital, and training expenditures of consulting firms.

As manager of FNDCT, FINEP is applying substantial resources to S&T, principally with regard to the modernization of the infrastructure and the training of human personnel who will allow the infrastructure to be utilized. However, application of resources of technology is still moderate, although it is growing. The Fund is managed through transfers to other institutions, principally the Economic Development Bank, or directly through financing given by FINEP for different programs and projects. In this regard FINEP has created a Program of Development of Industrial Technology to stimulate domestic industry to create technology through the development of new products and processes and to support it in expanding technological capacity in research centres, personnel training, etc.

Some general conclusions about the use of financial instruments may be added:

(a) The principal direct instruments in S&T policy in Brazil have been financial. The Basic Plan for S&T Development has basically consisted of a collection of projects suggested by federal institutions.

(b) Users of financial support are institutions, not persons, which limits the number of investors.

(c) Financial support has been principally directed at the improvement of conditions in the supply of knowledge, and in particular basic, nonapplied scientific knowledge.

(d) Demand for the resources has not been sufficient to employ them fully, and the quality of projects has not been fully evaluated because not enough information has been asked of the applicants.

(e) The lack of demand is probably due to organizational and human resource difficulties in educational and research institutions, and to the lack of interest on the part of enterprises, which prefer to import technology. A contributing factor is the limited staff of the institutions that manage the financial mechanisms.

(f) The instruments for implementing the financial policy - notably the project - are a means to improve the decision-making process and the organization of educational and research institutions.

(g) On account of these difficulties there is a large concentration of resources in a few institutions, widening the relative imbalances but on the other hand allowing the building up of critical masses in the receiving institutions. The trade-off between these two effects, however, is not easy to determine.

PERU

Funding of S&T in the Public Sector[16]

Peru has a legal instrument (Article 10 of Law 17096/1968) that creates the National Research Fund, to be administered by the National Research Council. However this instrument of S&T policy has not yet been implemented, even though almost 10 years have gone by, because of the many ups and downs suffered by the Council. However, the current restructuring of the Council should make it possible to create a mechanism for gathering economic resources and allocating them for the support and promotion of S&T activities.

The tendency in Peruvian S&T policy has been to create stable sources of funds at the sectoral level, which will not depend on the process of negotiation that governs the budgetary allocations of the state and its ministries. The General Laws of Industry, Fishing, Mining, and Communications establish percentages of the net income of enterprises that are to be devoted to R&D - the figures are 2%, 2%, 1%, and 1% respectively - which has opened the possibility of about 10 times more resources being devoted to R&D than was the case in the early 1970s.

The mechanisms that the ministries have established to implement their S&T policy with the help of these funds principally work on the supply of S&T and on the training of human resources, save in the case of industry, where the Institute of Industrial Technological Research and Technical Standards (ITINTEC) is also attempting to generate demand for R&D and other S&T services in the productive enterprises. The administrative load involved in the efficient administration of these funds is very heavy. The identification, selection, evaluation, and control of research projects require highly qualified personnel, and with some exceptions such personnel is not available in the ministerial staffs.

It is in the sphere of the Ministry of Industry that use of this type of fund has gone furthest as a way of implementing the sectoral S&T policy. The organization in charge of this - ITINTEC, which was created in 1972 - has been able to develop policy guidelines and to establish a detailed mechanism for that purpose. Research programs can be carried out by the enterprises themselves, individually or collectively, or can be contracted out to research centres. Programs are approved and controlled by ITINTEC. If the firm does not use its 2%, this amount goes to ITINTEC, which may then apply it to support other programs of its own. This flexibility in project execution allows the incorporation of more universities and other research centres, linking them up with the productive sector. It also allows S&T capacity to be enlarged through the channeling of projects to universities and the acquisition of equipment and installations that did not exist in the country.

ITINTEC has established criteria for the approval of projects and programs of research that are principally based on the objectives sought through industrial technological research. At the same time ITINTEC takes into account the priority criteria established in the Industrial Development Plan of the Ministry of Industry, and the cost-benefit analyses of program proposals presented by the enterprises.

From the time ITINTEC took up its functions until 1975, a total of 353 projects had been presented, of which 215 had been authorized for a total amount of 324 million sols; 89 more projects were presented for 1975, for 236 million sols. Of this, 44% was for the food and the chemical branches, which are directed toward the more urgent needs of Peruvian society, and the rest was distributed in metal-mechanics, electronics, textiles, electricity, construction, and metallurgy.

Among the drawbacks of this set-up is the fact that large enterprises stand to profit more than small ones, because resources at their disposal may allow them to set up programs of a sufficient size to be efficient and significant. A further drawback is the question of ownership of results, which presents a difficult legal problem. Another question is the definition of R&D, which, if very strict, would mean that many programs would not qualify. However, in this respect ITINTEC has adopted a flexible approach and has allowed many important S&T activities to profit from the powerful funding mechanism it administers.

MEXICO

Federal Funds for S&T[17]

The National S&T Council (CONACYT) was created in 1971, and shortly thereafter it started to channel additional resources to research institutions, programs of human resource training, and technical cooperation programs. This was done, however, without a general frame of reference regarding sectoral priorities, quantitative goals, and policy criteria. A first attempt to rationalize this situation led to the establishment of "indicative programs" that were to link research efforts with national development goals, with the participation of government organizations, higher-education institutions, and users of R&D. The Council was to contribute financial and administrative resources to these programs for the achievement of objectives jointly defined by the scientific community and the users of R&D. However, administrative changes toward the end of 1972 did not allow the programs to function, with the exception of the one on food.

Later on, a new administration within the Council gave considerable support to the indicative programs, which were taken to be one of the most important mechanisms of CONACYT. CONACYT. Between 1973 and 1976 some 13 programs were designed and started (food, demography, tropical ecology, education, health, agricultural development, pharmaceuticals, ocean resources, mineral resources, meteorology, seismology, basic sciences, strengthening and creation of new research centres).

On the other hand, the Council is empowered to channel additional resources to academic institutions or research centres for the promotion and execution of studies around specific programs and projects. In 1974 the policy on the channeling of resources was defined thus: "CONACYT should support scientific and technological research by means of additional resources but it cannot be the main source of funds within the S&T system. The Council should have a limited participation, since the important thing is that it should act on the system fundamentally through the formulation of plans and programmes ... orienting and not centralizing the efforts of the country on matters of science and technology." Only a small part of the resources the state devotes to research are channeled through CONACYT (11% to 15%), and the purpose is to orient the action of the S&T system by applying these resources at strategic points in the system.

The question is whether it is possible to orient new research toward economic development objectives with such a low proportion of additional resources (note that one-fourth of the funds at the disposal of CONACYT are spent on administration). This question is particularly important because the structure of Mexico's S&T system corresponds to what has been termed the pluralistic model, in which decisions related to S&T are taken in an isolated manner by different agencies and departments without any overall coordination. The different research centres and institutes that operate in Mexico are more or less independent decision centres; among other factors, ministerial control over some centres, entrenched interests in others, and the important question of university autonomy make it difficult to coordinate the components of the S&T system.

At present the Council attempts to deal with this situation by formulating a general framework for S&T policy that will allow it to set up priorities to guide resource allocation according to quantitative goals in the medium and long term. To do this the Council has created two organs, one of them for integrating the federal R&D budget according to the framework established by the Indicative S&T Plan, the other for policy formulation. Time will show whether this system of policymaking and budget formulation will be successful; the experience of other organizations similar to CONACYT (such as TUBITAK in Turkey), and the experience of CONACYT during its first few years, have not been too encouraging.

JAPAN

State Financing of Scientific and Technical Activities[18]

The system of state financing of research in Japan began quite early, in 1918, with the subsidies to science started by the Ministry of Education. Nevertheless, this policy instrument, as an independent tool, was to acquire full importance only after World War II, and even more so after 1960. Up to the War, the main thrust of government policy was on the importation of technology and direct government intervention in the generation of technology for war purposes. After World War II, the key development was to be the importation of technology coupled with large "digestive" R&D expenses, particularly through the activities of key engineering and consulting services, which in turn promoted the demand for indigenously developed technologies (peripheral technologies and some modular ones).

Under those conditions it became necessary to enlarge and rationalize state support for science and technology. The first move in that direction was the creation in 1950 of a system of subsidies to private firms, under the institution in charge of screening foreign technology: the Agency for Industrial Science and Technology (AIST). The volume of funds channeled through these subsidies was not very large from 1950 to 1970: only $39 million was allocated for a total of 3,400 items. In addition to the system of subsidies, AIST used other means for supporting the development of Japanese technologies, closely associated with its advisory role in screening foreign technology. These means were the direct financial assistance given to Japanese firms interested in applied research and the advice given to the Japan Development Bank (the financial arm of MITI) about the convenience of favourable credits to firms whose production was based on nationally developed technologies.

At the beginning of the 1960s a substantially different institutional set-up for financing scientific and technological activities had to be created. The continuous growth of Japanese industries could not rely entirely on imported technologies if Japan was to engage in large-scale competition in the world market. Moreover, there could be no further digestion of foreign technology if the relation between the scientific and technological infrastructure and industrial technology was not substantially intensified, particularly at the level of industrial firms. The governmental infrastructure was relatively well developed, especially since AIST took over the centralized administration of a number of large research institutions. AIST had channeled industrial demand toward these institutions during the period of predominantly imported technology. The problems were elsewhere: in the insufficient financial resources for the development of technologies by industry itself. Foreign suppliers were increasingly reluctant to sell technology to potential competitors, and were charging higher prices and imposing stiffer conditions (restrictive business practices).

It is implicit in the very character of the institutions created in Japan at that time that the country considered financing as the key factor in the development of more fruitful relationships between the scientific and technical infrastructure and industry. In 1961 the Japanese Research and Development Corporation (JRDC) was founded, attached to AIST and with the specific purpose of providing risk capital for scientific and technical activities.

However, JRDC did not limit itself to the provision of risk capital. It also considered it necessary that active promotional activities should go along with the provision of funds. In fact, the Corporation carefully selects those activities of basic or applied research being undertaken at universities, research institutions, or by individuals that may offer possibilities of being developed into industrial processes or products with sales perspectives. Once having identified such potential developments, JRDC makes an open call to various related firms, suggesting that they themselves assume the responsibility for the development work needed, including the construction of pilot plants of prototypes at the industrial level. JRDC then selects the most suitable firm or firms and finances the entire cost of the development project. As with all forms of risk capital, funds are not returnable if the development work is not successful. On the other hand, if the results are positive, funds have to be returned on a long-term basis, but (and this is not a common feature of risk capital) bearing no interest.

The JRDC literature describes the procedure that a firm has to follow to get a development research contract in these terms:

(a) Detailed study of the development project.
(b) Determination of the financial assistance to be advanced by the corporation and its method of payment.
(c) Licencing and other protective measures.
(d) The setting of standards to determine the success or failure of the project.
(e) Determination of royalties and method of payment.

If the results are positive, both the proprietor of the original research and JRDC are to receive a previously agreed royalty rate. During the first 10 years of experience of the JRDC fund, over 100 risk capital loans had been granted. Of these, 55 had finished the development work in that period, with a success rate of 90%. Such a high success rate now makes it possible for JRDC to obtain 50% of the necessary financing from its own income (returns and royalties).

It should be remembered that all these forms of financing constitute direct government support of industrial R&D and do not include the substantial financing given to the many research institutes and associations in Japan, most of them directly depending on a ministry. By the end of the period under examination, new forms of financing were becoming necessary. The aggressive penetration of world markets and protection vis-à-vis foreign competition at home (regulations concerning foreign investment had been liberalized) could only be secured by Japan becoming the chief innovator in certain fields. Also, the basic problems of energy and pollution had acquired much greater importance.

An institution was created in 1966 for the specific purpose of confronting these problems. Its need emerged out of the period being examined and its characteristics are worth examining.

This institution is the National Research and Development Programs System (NRDPS). This System consists of direct government financing of R&D with carefully programed objectives. Urgent projects are selected where the spontaneous market forces do not provide the necessary incentives, because the urgent projects require a great deal of financing and a long period for their completion, as well as involving considerable risks.

This System is also under AIST. About 40 persons administer its application through wide consultations with official technology agencies, research institutions, bureaux of various ministries, and industrialists; such a consultation process provides the basis for selecting the projects and programs that will compose the System. Certain social criteria are used to establish priorities, such as the effect on the use of natural resources and on environmental pollution, and the contribution to economic development and industrial efficiency.

Projects in NRDPS are finally evaluated according to costs, duration, required resources, and estimated quantitative results when applied at an industrial level. The availability of objective criteria for the evaluation of results and the guarantee of its potential application in Japan (that is, the availability in Japan of the necessary means and resources for its industrial application) are both prerequisites for approval of the project. The system is entirely administered by AIST: it signs the contracts, commissions the execution of specific projects with industrial firms or laboratories, and appoints a director for each project. Every 6 months the project is reexamined, and after the results have been obtained, AIST secures the financing and promotion for the industrialization of the results through the intermediate of MITI.

Of the nine projects approved between 1966 and 1971, only one had been cancelled due to a revision of the cost estimate. Most of the projects being long term, no information is yet available for an evaluation of the results.

Table 1: Institution Building in Korea

Institution	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
MOST		■														
KIST	■															
KAIS																
KORSTIC		■														
ADD						■										
KAERI									■							
KDI						■										
DAEDUCK SCIENCE TOWN (5 research institutes and one educational institute)								□								

■ : Establishment of Renovation of Institution

□ : Plan

Table 2: Dae Duk Science Town in Korea

New Institution	Functions
Shipbuilding Industry Technical Services	To support the fast-expanding Korean shipbuilding industry and relieve the foreign currency drain due to the purchase of technological know-how and construction plans.
Ocean Research and Development Institute	To establish a core for the survey and dissemination of data on marine resources such as minerals, fish, tideland, etc.
Electronic Communications Research Institute	To promote standardization and local manufacturing of communications equipment, technology import, and manpower training; also, to develop a high-speed, high-capacity transmission systems.
Petroleum Institute	To solve technological problems in energy petroleum products supply, as well as in petrochemical industries, and to have self-sufficient technical capability to digest the imported technology.
Mechanical Engineering Research Institute	To solve problems in casting industries, to develop design and high-quality machining technology, and to develop die-making technology.

*Relocated institutions

1. National Industrial Standards Research Institute
2. National Geological Mining Research Institute
3. National Agricultural Products Inspection Office
4. National Institute for Agricultural Materials
5. National Agricultural Products Experimental Office
6. Central Fisheries Products Inspection Office
7. Food Research Institute
8. Central Monopoly Research Institute
9. Technical Research Institute of Office of Tax Administration
10. Railroad Technology Research Institute
11. Electricity and Telecommunication Laboratory
12. National Institute of Health

*Service Institutions

1. Administrative Office
2. Library Information Centre
3. Computer Centre
4. Workshop and Maintenance Centre
5. Analysis and Testing Laboratory
6. Science Centre
7. Conference House

NOTES

(1) R. Maheu, National science policies in countries of south and southeast Asia, Paris, UNESCO, 1965.

(2) This tendency toward institutional imitation has been responsible for several deficiencies found in Peruvian institutions, particularly in the fields of health care, higher education, industrial development, and even science and technology.

(3) A. Aráoz and M. Kamenetzky, Projectos de inversión en ciencia y tecnología, Buenos Aires, Centro de Investigaciones en Administración Pública, 1975.

(4) One of the advantages of a close cooperation between small countries (such as those in Central America or the Caribbean) is that through a common S&T policy at the subregional level it may be possible to complement national efforts to attain a complete spectrum. A good example is the University of the West Indies, with four campuses in four English-speaking Caribbean countries, which between them cover the scientific fields of more relevance to these countries.

(5) INTI material supplied by the Argentinian STPI team.

(6) Source: S&T Plan, 1974-79, section 3.18.

(7) Source: Second PBDCT

(8) Another very important effort of institution building is to take place in connection with nuclear research and its applications, with German cooperation.

(9) Source: Reports by the Peruvian STPI team.

(10) Source: Reports on Phase II by the Korean STPI team.

(11) This approach has been followed in practice by countries as varied as Brazil, India, Mexico, Egypt, Korea, Colombia, and Venezuela.

(12) For a more complete treatment, and for the different national reports on which the summaries of the country experiences are based, see F. Sagasti and A. Aráoz (editors), Science and technology for development: planning in the STPI countries, Ottawa, International Development Research Centre, 1979.

(13) Source: Reports on Phase II by the Korean STPI team.

(14) Source: Reports by the Colombian STPI team.

(15) Source: Document No. 2 by the Brazilian STPI team, and the Second PBDCT.

(16) Source: Reports by the Peruvian STPI team.

(17) Source: Chapter 1 of A. Nadal, Instrumentos de política científica y tecnológica, México, El Colegio de México, 1976.

(18) Source: S. Barrio and F. Sagasti, Technological policies of postwar Japan: a background report; Report to the STPI Project, Lima, 1975 (mimeo).

Appendix 1
INSTITUTES AND COUNTRIES PARTICIPATING IN THE STPI PROJECT

Argentina	Secretaria Ejecutiva del Consejo Latinoamericano de Ciencias Sociales (CLACSO) Country Coordinator: Eduardo Amadeo
Brazil	Financiadora de Estudos e Projetos (FINEP) Country Coordinator: Fabio Erber (until September 1974) and José Tavares
Colombia	Fondo Colombiano de Investigaciones Cientificas y Proyectos Especiales "Francisco José de Caldas" (COLCIENCIAS) Country Coordinator: Fernando Chaparro
Egypt	Academy of Scientific Research and Technology Country Coordinator: Adel Sabet (until July 1975) and Ahmed Gamal Abdel Samie
India	National Committee on Science and Technology Country Coordinator: Anil Malhotra (until June 1975) and S.K. Subramanian (until March 1976)
South Korea	The Korea Advanced Institute of Science (KAIS) Country Coordinator: KunMo Chung
Mexico	El Colegio de Mexico Country Coordinator: Alejandro Nadal
Peru	Instituto Nacional de Planificacion (INP) Country Coordinator: Enrique Estremadoyro (until February 1975) and Fernando Otero Technical Directors: Fernando Gonzales Vigil (until February 1975) and Roberto Wangeman
Venezuela	Consejo Nacional de Investigaciones Cientificas y Tecnologicas (CONICIT) Country Coordinator: Dulce de Uzcategui (until July 1974) and Ignacio Avalos
Yugoslavia (Macedonia)	Faculty of Economics, University of Skopje Country Coordinator: Nikola Kljusev

Appendix 2
SURVEY OF THE COUNTRY TEAM'S WORK

The organization, composition, and orientation of each of the country teams reflected the own interests and those of the institutions that hosted them, always within the framework of the STPI project concerns. A brief review of the approach and the work of each team may help to place the STPI project and the comparative reports in perspective. To complete the survey, a description of the field coordinator's office work is given.

ARGENTINA: The initial location for the Argentine team was the Department of Economics of the Catholic University. However, after some months, the university decided to withdraw its application and the country coordinator moved to the Argentine branch of the executive secretariat of the Latin American Social Science Council (CLACSO). The team was headed by Eduardo Amadeo, an economist, and two other members were appointed to work full time on the project. An advisory committee of several researchers and policymakers active in science and technology policy was formed. To carry out the research, the team relied on consultants who wrote reports on specific subjects that were integrated into a final report.

A significant change took place when the country coordinator was named president of the Instituto Nacional de Tecnologia Industrial (INTI), the national industrial technology institute, which is the largest and most important industrial research organization in Argentina. Mr Amadeo never relinquished his formal role as coordinator; after 6 months, he left his new post and resumed his position as country coordinator. Because most of the work was well under way, his absence did not substantially alter the team's pace, although the preparation of the Argentine synthesis report was postponed. Part of the team's work was reoriented to be most useful to the coordinator in his new position.

The Argentines focused on two branches of industry - machine tools and petrochemicals - but studied many broader issues. For instance, the reports include a document on the technological content of the 3-year development plan (1974-77), a study of the Argentine industrial structure, a description and brief analysis of technology policy instruments in Argentina, a study of the system for regulating technology imports, and several short reports on international technical assistance as an instrument of technology policy.

The structure of the Argentine scientific and technological system was studied in detail, as were the conditions under which it could be made more responsive to industry's needs. The Argentines covered the public sector, examining the possible role of the public sector as promoter of scientific and technological development. Detailed studies were carried out at two enterprises: one in charge of generating electricity in Buenos Aires (SEGBA) and the other in charge of generating and distributing gas for household and industrial consumption. Other contributions of the Argentine team were a study of the emergence and development of engineering and consulting firms in the chemical process industries, a detailed analysis of two research centres within the national industrial technology institute (INTI), and two short papers on capital accumulation and on the crisis of capitalism.

The Argentine team followed the methods guidelines; however, they produced a series of thematic reports on issues of actual and potential interest to policymakers in the country, coinciding with the themes selected for study in STPI.

BRAZIL: The Brazilian team was hosted at the research group of the Financiadora de Estudos e Projetos (FINEP), the state agency in charge of financing studies for investment projects and also the executive arm of the national fund for scientific and technological development. The first coordinator was the director of the research group, Fabio Erber. When he took a leave of absence from FINEP in September 1974, he was replaced by José Tavares, the new head of the research group. The group at FINEP had been carrying out research on science and technology policy for some time, and the STPI assignment was one of its tasks for 1973-76. Practically all of the work was done by members of the FINEP research group, although two or three reports were contracted to professionals outside FINEP.

From the beginning, the Brazilians decided to concentrate on the role of state enterprises in technology policy. They chose branches of industry that were dominated by state enterprises (oil and petrochemicals, steel, and electricity), conducting detailed interviews, analyzing existing data, and testing hypotheses systematically to cover issues such as the selection of equipment and processes, the purchase of engineering services, the performance of research and development, and the planning activities at these state enterprises.

In addition to the new material generated by the Brazilian team during STPI, several reports based on past research carried out by FINEP were made available to the STPI network. These included background reports on the organization and structure of the Brazilian science and technology system, a study on the machine tool industry, a report on the demand for services of 12 research institutes, and a background report on industrial policies in Brazil during the last 2 decades.

In parallel with the work for STPI, the FINEP team was also engaged in a research project on the diffusion of technical innovations in three industrial branches (pulp and paper, cement, and textiles) and they agreed to put their results at the disposal of the STPI network as an additional contribution.

The Brazilian team used the guidelines only as a general reference, given that most of their work went along different lines from those originally envisaged for the project. Nevertheless, the richness and variety of their material effectively upgraded the comparative reports.

COLOMBIA: No Colombian participant was present at the initial organizing meeting, and the Colombian application to join the STPI network was received later and formally accepted at the Rio meeting of the coordinating committee. The team was hosted by the Colombian Council for Science and Technology, COLCIENCIAS, and was headed by a sociologist, Fernando Chaparro. In spite of joining the STPI network late, the Colombian team caught up with the pace of work and finished all its work by the deadline.

COLCIENCIAS organized a special team with five members who devoted practically all their time to research in STPI. Several other consultants were also asked to prepare reports on issues of specific interest such as selected policy instruments. For example, a study was commissioned on the impact of tariff mechanisms; a report was prepared on the influence of price controls; and a preliminary analysis of the possible use of the state's purchasing power as an instrument of technology policy was also prepared. The branches chosen for study were all linked to agriculture: fertilizers and pesticides, agricultural machinery, and food processing, taking into consideration the interests of Colombian policymakers as perceived by the team. In these branch studies, the methods guidelines were closely followed.

Other reports prepared by the Colombian team include a study of science and technology planning, an analysis of implicit industrial technology policies, a conceptual framework for the study of consulting and engineering organizations, a series of reports on industrial branches based on discussions with panels of experts, a study of science and technology policies in the agricultural sector (to complement the analysis done for industry), and two essays on the process of industrialization in Colombia and its technological implications.

Five groups of policy instruments were studied in detail, and their impact on each branch was examined through interviews at various enterprises. All of the findings were integrated into the final report of the Colombian team.

EGYPT: Although an Egyptian representative participated in the initial deliberations leading to the STPI project, it was not possible to organize the team to carry out research and prepare inputs for the international comparison. There were several administrative difficulties and staffing problems that prevented the organization of a working team. The host institution was the Academy of Scientific Research and Technology and the first coordinator was Adel Sabet, who was replaced by Gamal A. Samie in July 1975. The Egyptian team presented papers that were personal contributions based on past experience rather than the result of research carried out by a team; and research was not begun at the academy until the second half of 1976.

INDIA: The host organization in India was the National Committee on Science and Technology, and the first coordinator was Anil Malhotra, who was replaced in June 1975 by S.K. Subramanian. Mr Subramanian resigned in March 1976, and no one replaced him. No funds were requested to set up a country team in India, and the Indians provided background material that had already been collected as background for a new science and technology plan.

Three background documents were distributed along with the final S & T plan to all the teams in STPI. In addition, a report on foreign collaboration, a note on science and technology planning in India, a survey of engineering consultancy services, a report on the development of the electronics industry, and two papers on small-scale industries and technology transfer were distributed by the Indian coordinator. No empirical research was done following the methods guidelines, and the Indian contribution to the comparative reports reflects this.

SOUTH KOREA: The South Korean team was one of the first to be organized and was estalished at the Korean Advanced Institute of Science, KAIS, as part of the activities of its science, technology, and society program. KunMo Chung was named country coordinator and the team consisted of five other members. All but one of them had other academic duties and could allocate only a portion of their time to STPI research. Then, Graham Jones was hired to advise in the preparation of the report for phase 1.

The South Korean team advanced rapidly and completed its work in time for the Sussex workshop, following the methods guidelines and introducing modifications only where necessary. Two reports were produced corresponding to the requirements for phases 1 and 2 of the project.

The branches chosen for study were electronics, petrochemicals, and powder metallurgy, and a report was prepared for each one. In addition, the team prepared documents on engineering services and industrialization in South Korea, on the Korean Institute of Science and Technology, on transfer of technology in the electronics industry, on the interface between the science and technology plan and the economic development plan, and on state enterprises in technical development.

Although most of the work was done by the team located at KAIS, consultants were asked to deal with specifics. The team predominantly represented engineering and physical sciences, but an economist who was a senior government official, helped to relate the results to South Korean policymakers and to balance the other team members' biases.

MEXICO: The Mexican team was among the first to start working in STPI and was located at El Colegio de Mexico, an academic and social research and graduate training organization. Alejandro Nadal was country coordinator and there were four other members of the team who worked full time on STPI. The Mexican team initially followed the guidelines rather closely and was one of the first in suggesting modifications and changes as a result of contrasting concepts with preliminary research findings. In particular, the team found it difficult to interpret the results of interviews in enterprises using the schema proposed to study technological behaviour. The branches chosen for detailed study were capital goods, food processing, and petrochemicals.

A background report on the structure and evolution of the Mexican scientific and technological system was prepared, together with a description of the industrialization process and of agricultural development. Documents on particular subjects included a report on engineering firms, a study of the technology policy of PEMEX (the state oil monopoly), and progress reports dealing with hypotheses on the impact of policy instruments on technical behaviour at the enterprise level, a description of policy instruments in Mexico, etc.

Most of the findings of the Mexican team were integrated into the main final report, part of which was delivered at the coordinating committee in New Delhi (January 1976) and the rest at the Sussex workshop (June 1976). The work of the Mexican team covered practically all the research topics considered in STPI, and its contribution to the comparative report reflects this. The Mexican report was published in Spanish in 1977 and was awarded second prize in a contest for the best works in economics.

For various reasons, the Mexican team chose to limit its direct interaction with policymakers and followed its own research program. Results were made available to policymakers in the form of draft reports, and through the participation of the coordinator in one of the committees established to prepare the Mexican plan for science and technology.

PERU: The Peruvian team was established within the research group of the National Planning Institute. A series of administrative difficulties affected the progress of the team, including a change of technical director, when Fernando Gonzales Vigil was replaced by Roberto Wangeman in February 1975. Approximately two-thirds of the research was completed in time for the Sussex workshop.

From the beginning, the team decided to adopt a sectorial approach to the research. Efforts were focused on the study of industrial branches connected with the extraction and processing of minerals and with the provision of machinery for the mining industry. The steel industry was also studied, with emphasis on the state enterprise in charge of the largest steelworks. This meant that the guidelines were used primarily in sectorial studies and in the analysis of policy instruments.

Background reports on the situation of the scientific and technological system and on the evolution of Peruvian industry were prepared following the general framework put forward in the guidelines. In addition to these and the sectorial reports, the team prepared other documents, dealing with issues such as explicit and implicit science and technology policies, consulting and engineering capabilities, the possible use of state enterprises as instruments of technology, and the governement administrative machinery for science and technology policy.

The Peruvian team was located within an official government organization, but its direct impact on policymaking is difficult to assess because it took the form of daily contact with government officials. On the basis of the sectorial reports on mining, a committee has been set up to review the findings of the STPI team.

VENEZUELA: The Venezuelan team was hosted by the national council of science and technology (CONICIT) and was among the first to start working. The team was initially dominated by sociologists, although economists increased their participation at later stages. The first coordinator, Dulce de Uzcategui, was replaced by Luis Matos, who was soon followed by Ignacio Avalos. Three other members worked full time, and the team was biased toward sociology and economics.

They progressed through two stages punctuated by a change in government. In the first stage, most of the background reports corresponding to phases 1 and 2 of the STPI methods were prepared, covering the science and technology, the political, the educational, and the economic systems. These reports were made obsolete by the change in government. In the second stage, the team tried to adjust to the new situation, repeating some of the earlier studies and continuing the research. However, the organization of a national congress on science and technology, which mobilized all the staff working at CONICIT, affected the team's progress.

The branches chosen for study were capital goods, electronics, and petrochemicals. In addition, reports were written on specific issues such as the governement organizational structure for science and technology policy, instruments for industrial science and technology policy, economic and financial policy instruments and their impact on technology, the purchase of capital goods in two industrial branches, and the relations between the financial system and technology policy. The Venezuelan team concluded its research shortly after the Sussex workshop.

The fact that the Venezuelan team was located in a government agency that took a very active role in science and technology policy after the change in government created both opportunities and problems. As a result of the new tasks undertaken by CONICIT, the pace and continuity of the STPI work was frequently altered. On the other hand, there was more possibility for actively contributing to policymaking. The Venezuelan contribution to the comparative reports reflects this situation.

YUGOSLAVIA (MACEDONIA): The Macedonian team was organized at the faculty of economics of the University of Skopje. A senior faculty member, Nikola Kljusev, was appointed coordinator. The team was composed of a very large number of faculty members and researchers who devoted part of their time to STPI. The tasks were subdivided and individual reports requested from various members of the team, although at a later stage two team members were asked to work full time on STPI.

The Macedonian team did not follow the guidelines, except in the preparation of a background report for phase 1. Individual reports were submitted on issues of interest to the STPI network, covering topics such as the problems of research and development in industrial enterprises, aspects of science and technology policy in Yugoslavia, the metallurgical industry in Macedonia, and the growth of engineering firms in Yugoslavia.

The Macedonian team's specificity is reflected in their relatively limited contribution to the comparative reports. At any rate, given the high degree of participation of professionals at all levels in policymaking in the Yugoslav self-managed economy, it is rather difficult to assess their contribution toward policymaking in conventional terms.

THE FIELD COORDINATOR'S OFFICE: In August 1973, at the first meeting of the coordinating committee, Francisco Sagasti was appointed field coordinator of the project and his office was established shortly thereafter and began operating in a limited way. Staffing was completed in April 1974 with the addition of two members.

The field coordinator's office was independent from the teams and was not engaged directly in empirical research. It offered organizational and technical support and contracted consultants to prepare reports on topics defined by the coordinating committee.

The field coordinator, first, drew up methods guidelines for phases 1 and 2 of the project. Background reports on technology policy in China, on technological dependence/self-reliance, on science and technology planning, on technology policies in Japan, and on technology transfer were also prepared, either by staff members of the field coordinator's office or by consultants. The guidelines for phases 3 and 4 of the project were prepared jointly by the field coordinator and a consultant. The office also organized the Sussex workshop and drafted the comparative reports. The field coordinator was also active in the board of the Peruvian Industrial Technology Institute (ITINTEC).

With the exception of the teams that were engaged in science and technology policy research as part of the activities of their institutions (the Brazilian and South Korean teams, for example), the teams were dismantled after the STPI project was completed. The field coordinator's office was closed in December 1976, and the comparative reports were prepared during 1977-1978, although some teams had not finished their work by April 1978. Even though most teams had concluded their STPI activities by the end of 1977, this does not mean that the team members left the field of S & T policy research and that their effort in STPI was not followed up. What was dismantled, as planned from the beginning, was the formal structure of the STPI project. The network of personal contacts remains in operation and most of the former team members are active in the field of science and technology policy, carrying the experience accumulated in STPI to their new positions.

Key to STPI Publications

STPI

Primary (A)

(1) The STPI Project
(2) Methodological Guidelines
(3) Main Comparative Report
(4) Planning
(5) Chinese Technology Policy/ Industrialization

Modules (B)

(6) S&T: Differing Schools of Thought
(7) Evolution of Industry
(8) Evolution of S&T
(9) S&T - Present Status
(10) Policy & Generation of Technology
(11) Policy for Imports
(12) Policy for Technology Demand
(13) Policy to Promote Industrial S&T
(14) Policy for Industrial S&T Support
(15) Industrial Technical Changes
(16) Industrial Technology Behaviour
(17) Technical Change Studies

Selections (C)

(18) S&T Policy & Development
(19) Engineering Consulting & Design in LDCs
(20) Technology Transfer in LDCs
(21) State Enterprises & Technological Development

Background Papers (D)

(22) El INTI en la Industria Argentina
(23) El Sector Maquinas Herramientas en la Argentina
(24) Los Instrumentos de Politica Cientifica y Tecnologica en Argentina
(25) Brazilian Machine-Tool Industry
(26) Los Bancos y Comercializacion de Tecnologia
(27) La Industria Petroquimica
(28) La Variable Tecnologica y las Variables Horizontales
(29) Indian Electronics Industry

Country Papers (E)

(30) Mexico
(31) Korea
(32) Peru
(33) Colombia

A GUIDE TO THE SCIENCE AND TECHNOLOGY POLICY INSTRUMENTS (STPI) PUBLICATIONS

A. Primary Publications

(1) The Science and Technology Policy Instruments (STPI) Project (IDRC-050e) (out of print)

(2) Science and Technology Policy Implementation in Less-Developed Countries: Methodological Guidelines for the STPI Project (IDRC-067e) (out of print)

(3) Science and Technology for Development: Main Comparative Report of the STPI Project (IDRC-109e). (Also available in French (IDRC-109f) and Spanish (IDRC-109s).)

(4) Science and Technology for Development: Planning in STPI Countries (IDRC-133e)

(5) Science and Technology for Development: Technology Policy and Industrialization in the People's Republic of China (IDRC-130e)

B. Modules

These constitute the third part of (3) above and provide supporting material for the findings described and the assertions made in (3).

(6) STPI Module 1: A Review of Schools of Thought on Science, Technology, Development, and Technical Change (IDRC-TS18e)

(7) STPI Module 2: The Evolution of Industry in STPI Countries (IDRC-TS19e)

(8) STPI Module 3: The Evolution of Science and Technology in STPI Countries (IDRC-TS20e)

(9) STPI Module 4: The Present Situation of Science and Technology in the STPI Countries (IDRC-TS22e)

(10) STPI Module 5: Policy Instruments to Build up an Infrastructure for the Generation of Technology (IDRC-TS26e)

(11) STPI Module 6: Policy Instruments for the Regulation of Technology Imports (IDRC-TS33e)

(12) STPI Module 7: Policy Instruments to Define the Pattern of Demand for Technology (IDRC-TS27e)

(13) STPI Module 8: Policy Instruments to Promote the Performance of S and T Activities in Industrial Enterprises (IDRC-TS28e)

(14) STPI Module 9: Policy Instruments for the Support of Industrial Science and Technology Activities (IDRC-TS29e)

(15) STPI Module 10: Technical Changes in Industrial Branches (IDRC-TS31e)

(16) STPI Module 11: Technology Behaviour of Industrial Enterprises (IDRC-TS32e)

(17) STPI Module 12: Case Studies on Technical Change (IDRC-TS34e)

C. Selections

These are a selection of the numerous reports prepared for the STPI Project chosen as a representative sample of the various topics covered by the STPI Project in the course of the main research effort on policy design and implementation.

Science and Technology for Development: A Selection of Background Papers for the Main Comparative Report.

(18) Part A: Science and Technology Policy and Development (IDRC-MR21)

(19) Part B: Consulting and Design Engineering Capabilities in Developing Countries (IDRC-MR22)

(20) Part C: Technology Transfer in Developing Countries (IDRC-MR23)

(21) Part D: State Enterprises and Technological Development (IDRC-MR24)

D. Background Papers

(22) El INTI y el Desarrollo Tecnologico en la Industria Argentina (In press)

(23) El Sector Maquinas Herramientas en la Argentina (In press)

(24) Los Instrumentos de Politica Cientifica y Tecnologica en Argentina (In press)

(25) The Brazilian Machine-Tool Industry: Patterns of Technological Transfer and the Role of the Government (In press)

(26) Rol de los Bancos en la Comercializacion de Tecnologia (In press)

(27) Comportamiento Tecnologico de las Empresas Mixtas en la Industria Petroquimica (In press)

(28) Interrelacion Entre la Variable Tecnologica y las Variables Horizontales: Comercio Exterior, Financiamiento e Inversion (In press)

(29) A Planned Approach for the Growth of the Electronics Industry — A Case Study for India (In press)

E. Country Reports

(30) Instruments of Science and Technology Policy in Mexico (In press)

(31) Technology and Industrial Development in Korea (In press)

(32) Los Instrumentos de Politica Cientifica y Tecnologica en el Peru: Sintesis Final (In press)

(33) STPI Country Report for Colombia (In press)