Science and technology for development: planning in the STPI countries
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Science and Technology for Development:

Planning in the STPI Countries

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Foreword

This is the third in a series of publications arising from the Science and Technology Policy Instruments project. It differs from the others in that it is a collection of papers which were prepared for a project meeting on the theme of science and technology planning. The purpose of this meeting was to give an opportunity for those team members who were most concerned with planning problems to exchange experiences and to meet colleagues from outside the STPI network.

It was not intended initially to publish the proceedings of this meeting. It was seen as a means of promoting interchange among researchers whose work was still in progress. Nevertheless, the interest generated by these discussions has been so intense, and the requests for copies of the papers so numerous, that it was decided to make them available to a wider audience. By reproducing them in this volume, the IDRC hopes to stimulate discussion and debate on what continues to be a vexing problem: how can a country's investments in science and technology be planned so as to ensure the greatest benefit to development?

C.H.G. Oldham
Associate Director,
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Introduction

This volume is one of a series published within the framework of the Science and Technology Policy Instruments (STPI) project. The STPI project, a large collaborative research effort that involved 10 teams from Latin America, the Middle East, and southern Europe and Asia, was sponsored by the International Development Research Centre. Its principal aim was to examine the ways in which developing countries could ensure the effective contribution of science and technology (S&T) to development.

The central concern of the STPI project was the process of S&T policy design and implementation. A detailed examination was conducted of the policymaking process, the way in which policies were transformed into sources of influence through government action, and the impact that the various policy instruments at the disposal of the government had on the development of S&T capabilities. In addition, a number of complementary topics were chosen for detailed analysis. Among these topics, S&T planning was considered of particular interest to most of the countries participating in the STPI project. In some, such as India, extensive S&T planning was under way when the STPI project began. In others, such as Mexico and Venezuela, similar planning efforts were about to begin.

At a seminar held at Villa de Leyva, Colombia, in May 1975 the work done by the STPI teams was discussed and points of view were exchanged. The reports and essays presented at the meeting are gathered in this volume, along with two essays covering the Mexican and Venezuelan experience, contributed by individuals who were not at the meeting, but worked closely with participants in the seminar.

The reports and essays included in this volume can be classified into four categories. First are the essays that present an overview of the field, examining the main issues involved in S&T planning. Chapters 1, 2, and 16 belong to this category.

In the second category are the works that discuss the S&T implications of economic development plans. Chapters 3, 4, and 8, describing the Argentine, Brazilian, and South Korean experience, belong to this group.

The third category comprises the descriptions of S&T planning experience in the countries participating in the STPI project. Chapter 5 examines the Colombian experiments in sectorial S&T planning; chapter 6 describes the attempts at S&T planning in Egypt over 2 decades; chapter 7 examines the Indian S&T plan and the process that led to its design and implementation; and chapters 9 and 10 describe the Mexican and Venezuelan experience.

The fourth category contains the essays describing methods or
presenting other, more general, considerations in S&T planning. Chapter 11, prepared for the STPI project through a consulting assignment, suggests a normative framework for S&T planning; chapters 12 and 13 describe the methods used in Colombia and India to design S&T plans; and chapters 14 and 15 discuss anticipatory decisions and resource allocation in S&T planning.

From this material the reader will appreciate the great diversity of experience with S&T planning. This reflects the present state of the field. It will be some time before S&T planning is a well-defined area of concern and practice for scientists and for planners.

Francisco R. Sagasti
1. Science and Technology Planning in Developing Countries

Francisco R. Sagasti

This essay presents some reflections on the nature of and the problems involved in S&T planning in underdeveloped countries. Rather than seeking to provide answers, it highlights some of the issues usually left aside, with the aim of stimulating discussion.

The Context of S&T Planning

In the broadest sense, planning is anticipatory decision-making. It consists in making choices for situations that have not yet occurred but are envisioned to occur, are interrelated and interdependent, and are not known with certainty. The decisions are concerned with the generation, identification, and evaluation of alternatives. Policymaking can be distinguished from planning because it involves establishing the criteria for generating, identifying, and choosing among these alternatives. Planning methods are the procedures followed in fulfilling the commitments made by the planners and in translating anticipatory decisions into actual decisions. A plan consists of statements spelling out the anticipatory decisions taken, their interrelations, and the criteria used in making them.3

S&T planning can thus be defined as the process of making anticipatory decisions about S&T development and insertion into the socioeconomic development process. The criteria for making such decisions are derived from S&T policies, which in turn reflect, either explicitly or implicitly, the will of the government and the groups in power.

The growing attention that S&T planning has received during the past few years has distorted somewhat the perspective from which it should be viewed. S&T planning has become a kind of mirage that disappears as soon as the harsh political and budgetary realities are faced. Of course there are exceptions, and on occasion S&T planners have been able to convert some of their visions into realities, but usually in a limited way and only after bruising contact with others in the political process.

When development planning in general is not given great importance by the government, S&T planning is paid little attention. This may be either

3 For a more detailed explanation of these principles, see Sagasti, F., 1973. A conceptual systems framework for the study of planning theory. Technological Forecasting and Social Change (USA), 5, 379–393.
because such planning is marginal to the socioeconomic life of the country or because the planning establishment — when it commands attention and power — does not consider S&T planning as a significant component of development planning. But even when S&T are considered important, they usually are not awarded the same priority as other social and economic activities. This may lead to a pushing aside of S&T when funds are allocated, particularly in times of economic crisis.

S&T planning requires the active participation of the scientific and technological community, which usually takes place under the stimulus of vague political commitments at the highest levels of government. However, when other pressing issues take precedence over S&T, the scientific and technological community becomes disenchanted with the S&T planners, who are seen as failing to deliver their promises. This may jeopardize the chances for effective S&T planning in the future. Furthermore, there is often a cleavage between the “establishment” scientists and engineers (who obtain resources and funds through their influence on ministries, government agencies, foundations, or foreign organizations, and who resist planning efforts) and the younger scientists and engineers (who see planning as a way of redistributing resources and developing S&T in a more organized fashion, with definite objectives).

These remarks have been made to show the constraints within which S&T planning operates in most underdeveloped countries so that the discussions that follow will not be interpreted as giving S&T planning more importance than it really has. Only the government, if and when it can influence the socioeconomic system, will legitimize S&T planning and, in the face of resource constraints and adverse political pressures, give S&T planners enough resources and political support so that they can maneuver S&T development in the directions they establish.

**Economic Planning and S&T Planning**

At the outset it is necessary to establish a difference between the planning of S&T activities and the integration of technological considerations into economic development planning. The body of what can be called S&T activities comprises basic research, adaptive research, development, engineering design, support activities such as information systems and special training courses, and so on. It is to these areas — broadly speaking, the generation, importation, and absorption of technical knowledge — that the anticipatory decisions involved in S&T planning are directed.

Economic planning aims at regulating the activities of the productive system and the services related to it. From a particular structure of productive activities postulated by economic planners it is possible to derive the technological implications and, in turn, to examine the types of S&T activities required. The insertion of technological considerations into economic development planning involves both the explicit introduction of these considerations into all phases of planning, and the identification of technology policies implicit in the economic plans. These explicit and implicit aspects of technology in economic development planning shape, to the extent that the plans are implemented, the patterns of demand for technology.
It is not sufficient to devote attention to S&T planning alone, for this excludes the essential component of the pattern of demand for S&T activities. Whether economic planning aims at defining the types of activities in which the state will be involved (through direct financing, allocation of credit, activities of state enterprises, etc.) or at regulating the activities of nongovernment sectors (primarily private industry), the result is an economic strategy in which a technological strategy is embedded and technology needs are defined.

The first task is to spell out the technological implications of the plan, pointing out the types of technology required (for example, to satisfy growth and employment targets, or to exploit natural resources), the constraints imposed by the projects selected, the technical demands imposed by export targets, and so on. The second task is to introduce technology as a strategic variable (in the same way as with other multidimensional variables, such as employment and financing) in the making and implementing of economic plans.4

Table 1 lists the types of technological considerations that could be introduced into plans of various levels and durations. Another dimension that could be introduced is the regional, which would add specific environmental conditions to the issues being considered. The linkage between S&T planning and the incorporation of technological considerations into economic planning takes place through several mechanisms, as can be easily inferred from the table. Each type of technological consideration can be associated with a group of S&T activities and hence will affect the process of S&T planning.

Attitudes Toward S&T Planning5

The attitudes of scientists, engineers, planners, and politicians to S&T planning are of three types. Although these types are rarely found in pure form in individuals or institutions in underdeveloped countries, such classification does help in understanding the conflicts that emerge in S&T planning.

The first attitude is that of the liberal scientists, whose main interest is promoting the growth of science for its own sake; they assume that technology will follow automatically. They resist any intervention in the conduct of scientific affairs as an infringement of the freedom of research. They distrust the idea of S&T planning and prefer to see the evolution of science as linked to the world system for the generation of knowledge. “Science has no frontiers” and “Priorities must come from the evolution of science itself” are two of their favorite slogans. Liberal scientists can adopt a radical stance, rejecting any form of intervention in scientific activity, or a moderate one, accepting that there must be some government interven-

4 See, for example, Sachs, I. and Vinaver, K., 1976. Integration of technology in development planning, report submitted to the field coordinator’s office, STPI project.

Table 1. Technological implications of economic development plans.

<table>
<thead>
<tr>
<th>Level</th>
<th>Long-term</th>
<th>Medium-term</th>
<th>Short-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>Design of technological styles closely linked to development styles and consumption patterns</td>
<td>Identification of general strategy, priorities for the development of skills and capabilities, and overall targets for resource allocation</td>
<td>Definition of total budget for S&amp;T activities and project</td>
</tr>
<tr>
<td>Sectorial</td>
<td>Identification of requirements to build up domestic capabilities in priority sectors</td>
<td>Definition of sectorial strategies and identification of programs for S&amp;T activities</td>
<td>Definition of project activities and budgets linked to sectorial strategies</td>
</tr>
<tr>
<td>Project (investment)</td>
<td>Assessment of impact of investment projects and identification of technological constraints introduced (particularly for large projects)</td>
<td>Analysis of components of technology package and identification of those to be supplied locally</td>
<td>Identification of firms and institutions to perform project-related activities (engineering design, adaptation, construction, etc.)</td>
</tr>
</tbody>
</table>

tion expressing preferences about the activities performed. Radical liberal scientists are becoming rare, although they can be found among older renowned scientists who do not face difficulties in obtaining funds for research. Moderate liberal scientists usually become leaders in the scientific community; their view is that the government must support scientific activity and that in exchange scientists must accept general regulations, but that planning is not necessary and that with time the growth of scientific activity will lead naturally to the development of technology.

The technoeconomists view scientific activities, and technological activities in particular, as a means for accelerating socioeconomic development and, indeed, an essential component of a development strategy. They view government intervention as necessary to promote the growth of S&T activities and emphasize the importance of national objectives in guiding S&T development, rejecting the "internationalist" view of science. Technoeconomists may come in "pure" form, in which case they play down the importance of scientific activities and favour
technological activities, or they may see both types of activities as necessary, although they emphasize technology and accept science only in so far as it is necessary for technology. Technoeconomists are most frequently found among the young technocrats, politicians, and scientists who become involved in S&T planning.

The third attitude is that of the *growth advocates*. Whereas liberal scientists justify the pursuit of science for its own sake and technoeconomists are concerned with the integration of S&T activities into socioeconomic development, the growth advocates do not award S&T activities a distinct role in development. They view technology as part of economic growth and do not care about its origin. Unlike the technoeconomists the growth advocates are not prepared to accept any postponement in the achievement of growth targets for the sake of developing local technological capabilities. Through either open hostility or benign neglect, growth advocates oppose the idea that the acquisition of indigenous S&T capabilities is integral in socioeconomic development.

These different views and interests inevitably lead to conflicts in S&T planning, and they largely determine the impact of such planning. For example, liberal scientists and growth advocates often form a coalition against the technoeconomists, which results in the abandonment of technology considerations in development planning. At best, some of the funds available through established government channels, which are usually at the disposal of liberal scientists, are allocated to the technoeconomists, who are squeezed out of the planning process; and the S&T plan thus becomes an aggregate of research projects.

Technoeconomists may gain the upper hand in some instances, but usually at the price of alienating the liberal scientists and irritating the growth advocates. Initially the liberal scientists may see some advantage in following the point of view of the technoeconomists, particularly because it may lead to additional sources of funds, but later they resist the degree of control that the technoeconomists see as necessary for linking S&T activities to development objectives.

It is usually harder to find common interests between technoeconomists and growth advocates. This may be why technological considerations have not become an integral part of economic planning. To the extent that S&T planning is seen as a separate exercise, growth advocate planners have no objection to it. However, when technology impinges on growth, as it must when being integrated into the economic plan, they reject it flatly. One familiar example of this controversy arises when technological self-reliance is considered a legitimate development objective. The achievement of moderate technological self-reliance requires learning through the performance of engineering and research activities that may delay the completion of a project. This is anathema to the growth advocates, who favour the complete importation of technology rather than facing such delays.

**S&T Planning and Resource Allocation**

The margin for maneuver of S&T planners is determined by their capability for directing the allocation of resources to S&T. One approach to
securing this capability consists in consolidating into an S&T budget the funds allocated by various government departments. This may simply mean listing together in the budget the appropriations made by different agencies and ministries, showing their relation to wider development objectives. In this case S&T planners are just coordinators, with no power to interfere in the allocations made by the agencies: they suggest or induce rather than decide or execute.

A second way of influencing resource allocation is to establish a special fund, fed by government appropriations and managed by the S&T planners. This fund constitutes an additional source of financing for S&T, complementing allocations made by other agencies. S&T planners thus acquire an executive capability, although its impact depends on the relative magnitude of the fund. At times of economic crisis the fund tends to shrink because the activities financed by regular sources demand more aid.

A variation on this approach consists of feeding the special fund from directed appropriations that do not depend on budgetary negotiations. The resources may be obtained by establishing a tax on exports, credits, net income of enterprises, sales, and so on. Resources obtained from enterprises can be managed in a centralized way, or the enterprises can be given a say in the S&T programs to be supported. This approach would grant the S&T planners more room to maneuver and widen their support base. S&T planners may decide to adopt both these approaches to influencing resource allocation. Certainly the coordinating role is important, but it may prove sterile unless reinforced by the capacity to intervene directly through the creation of one or more special funds.

The Content of S&T Planning

S&T planning is frequently confused with research planning. There is a tendency to leave aside S&T activities other than research when discussing S&T planning; yet research may not be, particularly in underdeveloped countries, the most important component of the S&T plan. Assuming that planning should lead to the identification of S&T activities to be supported with priority so that S&T development objectives can be linked, it should be possible to identify activities as important as, or more important than, research that are related to the importation and absorption of technology (identification and evaluation of technological alternatives, regulation of technology importation, engineering design, technology adaptation,

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6 This is the approach followed by the Peruvian government through a network of sectorial funds and research institutes. For an example see: Sagasti, Francisco, 1975. The ITINTEC system for Industrial technology policy in Peru. World Development (England), 3 (11-12), December, 867–876.

experimentation in plants, etc.), to support services (documentation centres, information services, education and training programs, etc.), and to the promotion of the demand for indigenous technology (use of incentives, of industrial credit, etc.).

There are many ways of defining and classifying S&T activities. One that appears to be fruitful because it spans both S&T planning and the insertion of technology into development planning is to divide the activities into those related to the production of technology, the absorption of technology, the regulation of technology, importation, the supporting services (primarily information and training), and the promotion of the demand for indigenous technology. Given that these categories are primarily linked to technology, a sixth category comprising basic and curiosity-oriented research should be added. Subdividing each category by problem area, discipline, sector, type of activity, and so on, gives rise to the overall spectrum of S&T activities to be considered in planning.

Although S&T planning covers activities that are considered as part of science and others that belong to the realm of technology, the differences between the two types require that they be treated differently. Thus, under the overall umbrella of S&T planning and policymaking it is possible to distinguish between the set of criteria for anticipatory decision-making associated with science and that associated with technology, and hence between a science policy and a technology policy, the two of which are integrated within the framework of S&T planning. Table 2 lists some of the differences between the two types of policy. The confusion between the two has caused problems in S&T planning because the criteria and ways of thinking associated with one have been transferred to the other without consideration of their inherent differences.

The anticipatory decisions contained in S&T plans have usually referred to the definition of S&T activities and the allocation of resources. The idea that a plan is a collection of projects has prevailed in most S&T planning exercises, and this has led to a neglect of other issues involved in relating S&T to development objectives. The most important among these are the anticipatory decisions regarding the institutional structure for the performance of S&T activities, the patterns of interaction with the economic and educational systems, and the definition of a desired image for the development of S&T. The contents of S&T planning should be expanded to incorporate considerations of this type.8

The Organization of S&T Planning

The anticipatory decision-making that constitutes S&T planning has certain organizational requirements. Because so many people are involved in each planning exercise, the exercises have adopted the same personnel structure, consisting of a coordinating group with an executive secretariat assisted by a number of technical committees. The committees usually integrate researchers, staff members of the S&T planning agency, and, in

8 These concepts are elaborated in Sagasti, F. 1973. Towards a new approach to science and technology policy making and planning. Social Sciences Information, 12, 67—95.
Table 2. Differences between national science and technology policies.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Science Policy</th>
<th>Technology Policy</th>
</tr>
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<tbody>
<tr>
<td><strong>Objectives</strong></td>
<td>A. To generate scientific (basic and potentially-useful) knowledge that may eventually have social and economic uses, and will allow understanding and keeping up with the evolution of science</td>
<td>A. To acquire the technology and the technical capabilities for the production of goods and the provision of services</td>
</tr>
<tr>
<td></td>
<td>B. To produce a base of scientific activities and human resources linked to the growth of knowledge throughout the world level</td>
<td>B. To acquire a national capacity for autonomous decision-making in technological matters</td>
</tr>
<tr>
<td><strong>Main type of activities covered</strong></td>
<td>Basic and applied research, which generates basic knowledge and potentially-useful knowledge</td>
<td>Development, adaptation, reverse engineering, technology transfer, and engineering design, which generate ready-to-use knowledge</td>
</tr>
<tr>
<td><strong>Appropriation of the results of activities covered</strong></td>
<td>Results (in the form of basic and potentially useful knowledge) are appropriated by wide dissemination. Publishing is the way of ensuring ownership.</td>
<td>Results (in the form of ready-to-use knowledge) remain largely in the hands of those who generated them. Patents, secret know-how, and human-embodied knowledge ensure the appropriation of results.</td>
</tr>
<tr>
<td>Reference criteria for the performance of activities</td>
<td>Primarily internal to the scientific community. The evaluation of activities is based mainly on scientific merit, and in a few cases on possible applications.</td>
<td>Primarily external to the technical and engineering community. Evaluation of activities is based mainly on their contribution to social and economic objectives.</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>Scope of activities</td>
<td>Universal: activities and results have worldwide validity</td>
<td>Localized (to firm, branch, sector, or national level: activities and results have validity in a specific context.</td>
</tr>
<tr>
<td>Amenability to planning</td>
<td>Only broad areas and directives can be programmed. Results depend on the capacity of researchers (teams and individuals) to generate new ideas. Large uncertainties are associated.</td>
<td>Activities and sequences can be programmed more strictly. Little new knowledge is generally required, and existing knowledge is used systematically. Less uncertainty is associated.</td>
</tr>
</tbody>
</table>
In some cases, engineers and users of the results of S&T activities. They 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.

The variations among planning exercises arise out of: (a) the power
and mandate of the coordinating group; (b) the number, type, and
composition of the technical committees; (c) the mandate given by the
coordinating group to the committees; and (d) the degree of intervention
of the coordinating group and the committees in the implementation of
the plan.

The coordinating group may be subordinate to the central planning
agency, the S&T planners being part of the agency and reporting to it. But
more frequently the coordinating group is given, at least formally, equal
status with the economic planners; thus, the S&T plan is supposed to be
"coordinated" with the economic plan. However, even when equal status
is granted to S&T planning, the disparity of resources, political access, and
power relegates it to a secondary position.

The number of committees set up by the coordinating group usually
exceeds the number of ministries in the government. With the defence
ministries excluded (S&T planning normally covers civil science and
technology only), a certain number of sectorial committees correspond
roughly to the departments of public administration. Other committees
deal with special problem areas (energy, water resources, etc.), basic
science (usually subdivided by disciplines), and "horizontal" issues, such
as human resources and measures to enhance the productivity of research
organizations. One planning exercise may involve several hundred
participants.

Differences among S&T planning exercises arise to a large extent out
of the composition of the technical committees. The scientific community
may dominate the membership, most committee members may belong to
government departments, or there may be a balance of planners and
administrators, of scientists and engineers, and of users of the results of
S&T activities. The implementation of the plan depends on such a balance
because S&T activities cannot be carried out through imposition, and the
use of their results cannot be forced, which requires that those in charge of
making the transition from anticipatory decisions to actual decisions be
involved in all phases of planning.

The committees may be given a high degree of autonomy to define
priorities, strategies, resource allocation and even specific projects from
the beginning, the role of the coordinating group being limited to
assembling the committees' proposals. When such a broad mandate is
given to the committees it is almost certain that the S&T plan will be
derived from a collection of projects defined after hard bargaining among
committee members. Another approach is to give the committees, under
strong central guidance, the task of defining first a strategy for the sector,
problem area, or discipline of their competence, outlining areas of
concentration and general priorities. After revision and integration of
committee programs the coordinating group may ask the committees to
review their programs within a framework of maximum and minimum
resources. At this stage the committees may be asked to outline specific
research projects to be contracted out, or the S&T community may be invited to present projects in accordance with the program.\(^9\)

The degree of intervention of the coordinating group and the committees in the implementation of the plan will depend on the relative power of the S&T planners and on the resources at their disposal, particularly in relation to the traditional ways of channeling funds to S&T activities through government departments. If the plan is put into practice the committees may be given the task of monitoring its progress in their field of competence. When no role is reserved for the committees after the plan has been designed they may be disbanded, in which case monitoring becomes a function of the coordinating group. For important problem areas or issues that require attention over a long period, permanent committees may be set up under the aegis of the S&T planners and the corresponding government agencies.

**Limits of S&T Planning Methods**

There exists a relatively large number of methods devised to help S&T planners define priorities and allocate resources, particularly for research activities. Most of them have been used in demonstration exercises, but only a handful have been applied in real situations.\(^10\)

The general impression left by a careful study of the available methods is that theory runs well ahead of practice in S&T planning. Most of the quantitative methods require a wealth of data and introduce many assumptions that simplify the problems to the point of triviality. There is a manifest need for a systematic framework for the analysis of such methods and the value they may have for S&T planning.

In addition to the shortcomings inherent in the planning methods, S&T planners often compound the problem by expecting too much from methods. The technocrat's dream in which S&T planners plug data into a model to define priorities, resource levels, and projects, never becomes reality.

With regard to the identification of priorities, a few rules may provide some guidance. The first is to diversify as much as possible the sources of priorities, examining initiatives from the S&T community, problems posed by the users, government policies contained in the plan, invariant problems that will remain important for long periods, concerns arising out

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of short-term social or economic problems, and so on. Priorities for S&T activities should reflect an interplay of various forces, rather than the planners' views.

The second rule is to avoid treating the development plan as the primary source of priorities for S&T activities. There is no automatic relation between economic development priorities and S&T priorities. Their time frames are different, and giving too much importance to the economic development plan may lead to the ignoring of key contributions that S&T can make to development. There are probably many projects that are not included in the economic development plan because the necessary S&T capabilities are not available. If S&T priorities are extracted from the development plan the necessary knowledge may never be acquired.

Determining the appropriate level of resource allocation for a sector, problem area, or discipline has been a perennial problem of S&T planners. Allocations for existing activities are limited by the absorption capacity of the S&T system, and by the minimum needs of the programs. For new activities the limits are difficult to establish, although they can be related to the possibility of assembling a team of scientists and technologists that can absorb the resources without undue waste.

Concluding Remarks

S&T planning in underdeveloped countries is just beginning. It has not yet been fully legitimized and confronts the double opposition of liberal scientists and growth advocates. Therefore, S&T planners find it difficult to introduce technology considerations into economic development planning and to guide S&T activities. To perform these tasks adequately it is necessary to pay attention to the organization of S&T planning and to devise practical procedures to simplify the process of planning.
At the STPI project seminar on S&T planning held at Villa de Leyva, Colombia, in May 1975, the participants (see Appendix) discussed a variety of issues related to the aims, nature, organization, and effectiveness of S&T planning in developing countries. This chapter presents a summary of the deliberations, highlighting the most important points.

Reasons for S&T Planning

At the outset it was agreed that S&T development cannot be left exclusively to the interplay of market forces. It was also thought necessary to go beyond the forming of S&T policies as general directives and to engage in planning processes to define the types of S&T activities that should be undertaken. Among the reasons given for getting involved in S&T planning were: directing S&T activities toward socially desirable ends, thus increasing their relevance to socioeconomic development; exploiting fully the opportunities provided by the local environment and the available natural resources; and diffusing through society the fruits of S&T progress in the best possible way.

Furthermore, it was agreed that S&T planning is needed to make the best possible use of the scarce resources devoted to S&T activities. Developing countries cannot afford to do everything at the same time, and planning becomes most important if resources are to be used properly. This requires that the various fields, disciplines, problem areas, economic sectors, and so forth, related to S&T activities, be considered during S&T planning, so that the costs of development in one area and neglect in others can be identified and reduced. For example, it is likely that atomic energy "islands" of S&T activities have acquired a disproportionate share of resources and of the best minds, whereas little or no attention has been given to problems such as housing and public health, where technological development programs could have significant impact. Therefore, a comprehensive, balanced approach to establishing and implementing S&T development programs is preferable to concentrating on a few isolated problem areas.

Another justification for S&T planning arises from the fact that it exposes the various groups of participants — scientists, government officials, entrepreneurs, and professionals in general — to each other's ideas and points of view. Issues introduced include the relevance of
particular S&T activities to development objectives, the technical feasibility of certain development programs, the motives and interests of the government and of the industrial sector, and so on. In a number of instances participation has led to a reorientation of the activities of scientists toward problems more related to development objectives.

The Main Characteristics of S&T Planning

Two necessary components of S&T planning are: a policy framework of general guidelines that apply to all aspects of planning and operational programs defining the tasks to be undertaken. The policy framework is required to acknowledge objectives and demands and to secure the cooperation of people favouring the social use of S&T. However, the framework is not enough to orient S&T activities to desirable ends. Without specified programs for such activities, a policy framework could be opposed by scientists and government officials as simply a document stating good intentions but with no operational value. Nevertheless, the framework could help in obtaining the political commitment to ensure the financial support required to make the planning process operational.

As an example, the policy framework could be based on Sabato's triangle\(^\text{11}\) (in which the vertices represent the government, the S&T system, and the productive system), particularly if a fourth vertex were added to represent the international system. With such a framework the programming would be directed to building up the links within the triangle; external links would be de-emphasized. In other words, the demand for S&T would be oriented toward internal sources of supply, and the impact of external forces would be diminished. Most S&T policy documents elaborate on these principles.

Though it is desirable to have an agreed-upon policy framework before embarking on planning and programming, there may be instances in which this is not possible because of time pressures among other things. In such instances policy and programs have to be designed concurrently, and this may make it more difficult to obtain acceptance of the resulting plan.

Science Planning and Technology Planning

One question posed at the Villa de Leyva seminar was whether it is best to separate technology planning from science planning.

In general the participants felt that this should not be done because it might defeat the purpose of S&T planning. It would imply that science should be left on its own, without regard for its usefulness. But because modern technology is, in fact, applied science, it is not possible to distinguish neatly between scientists and technologists, and their activities should therefore be considered together. There could, however, be separate policies for basic science research and applied research.

It was also pointed out that initially S&T planning was confused with

research and development (R&D) planning, and thus the strictly technological aspects were overlooked. As a reaction, and to correct the situation, there appeared a tendency to separate science policy completely from technology policy. This, however, also oversimplified the matter. Science and technology are clearly distinguishable, and different strategies and mechanisms of planning are suited to each, but this is not sufficient reason for complete separation of policies related to them. Planning starts from the use of knowledge in the productive sector on the basis of specific demands and works backward toward the different S&T activities needed to satisfy these demands. One danger associated with the separation of science and technology policies is that science might become limited to exotic activities that are unrelated to national needs.

**Comprehensiveness of S&T Planning**

The issue here is whether S&T planning should be comprehensive or whether it should be confined to selected “leading sectors” that, through forward and backward links, would pull along the rest of the S&T activities.

The participants in the seminar favoured a comprehensive approach. It was remarked that one of the reasons for S&T planning is the need for an overall view. Government agencies do not have all the relevant information about their sectors, and in certain cases one sector is covered by several ministries. Therefore no single institution is responsible for sectorial development. S&T planning should cut across different institutions, tie things together, and establish programs that are carried out jointly by several administrative jurisdictions. The administrative structure of government is not divided into areas that adequately match the areas of S&T planning.

For planning purposes, S&T activities may be classified according to different schemes. It is not easy to decide how to “cut the cake,” but perhaps a three-way division into economic sectors, disciplines, and problem areas (such as water resources or the environment) can be made. An important consideration is how the three areas interrelate and influence each other.

Perhaps in the initial stages of planning, efforts could be focused on certain problem areas or sectors, though eventually comprehensive planning would become necessary. Examples of planning for specific areas are the indicative programs of Mexico, the special programs of Colombia, and the national programs of Argentina. Such programs are organized by the respective S&T policymaking bodies, which undertake promotion, provide financing, bring people together to define activities, and design work programs, etc. in areas such as food, health, housing, marine resources, electronics, and so on. The concerted attack on schistosomiasis (or bilharziasis) in Egypt is an interesting example of the need to plan S&T activities in a problem area. Schistosomiasis is not just a medical problem, to be handled exclusively within the medical disciplines or the health sector but also a rather complex social problem that affects one-third of Egypt’s population and has many different facets that must be tackled in a coordinated way.

The question of discipline-based S&T planning was also discussed, and it was pointed out that only a small part of S&T activities should be programmed according to disciplines. A planner has to deal with problems,
not with disciplines, and disciplinary committees tend to become fund-raising lobbies. Nevertheless, this should not prevent the allocation of a certain percentage of the available resources to basic research in the various disciplines. At any rate, the problem areas in the social sciences tend to correspond to certain disciplines, and, therefore, the distinction between problem areas and disciplines may be virtually meaningless.

In Mexico discipline-based S&T planning served as a way of bringing the scientific community into the picture, although 10 of the 14 committees that were established were sectorial or problem-oriented. It was remarked that disciplinary committees tend to be composed of scientists, whereas those organized by problem areas tend to have intersectorial representation.

The question of having a large scientific infrastructure that is not oriented toward development problems was also considered. It was suggested that market-incentive mechanisms be used, whereby initially the rewards for basic research would be diminished and those for applied science enhanced, then later the rewards for developmental work would be increased. This would probably have a greater impact on young scientists, who are more open to changing their attitudes. However, trying to move people into priority areas by means of incentives, selective budget allocations, and so on, is a slow process, as experience has shown in India. At the University of São Paulo, Brazil, the incentives used to be skewed in favour of basic research, because no consulting was allowed to full-time professors. When regulations were changed and professors could almost double their salaries through consulting activities, there was strong resistance by basic researchers, but most eventually began to market their work.

**Relations Between S&T Planning and Other Social Processes**

**S&T Planning and the Political Process**

S&T planning should be closely related to the political sphere, with regard to both the planning process and the documents produced. It should be established as legitimate at the highest level of government, even though this may entail a loss of "logic" on account of the necessary political bargaining.

Most S&T plans are prepared by technocrats and should be established as legitimate in three ways: they should be accepted by government, they should be accepted by the S&T community, and they should produce concrete results. There should be acceptance as well as effectiveness, even though the latter will be the dominant characteristic. Legitimacy may be established at the level of the president, a minister, or a top government official, at the level of the S&T community (if this community is persuaded to accept criteria other than sheer scientific merit), and at the level of the "environment" that is affected by planning (which would be different in centrally planned and market economies). Attempts should be made to motivate scientists, managers, professors, and others to aim for the general goals of the plan, such as the achievement of self-reliance, to get them to participate in the planning. For this reason science planners should be in contact with top decision-makers, particu-
larly those in the development planning agency, and the scientific community must be made to face political realities.

One factor that may threaten the legitimacy of the plan is the existence of heads of important sectors of, or institutions in, the scientific community. They may be against S&T planning, which could reduce their power, and would be reluctant to accept a broader framework in which to place their activities. They may insist that theirs is the key field: "Develop it and other fields will follow." Furthermore, the scientific community is strongly competitive and destructive, and if its leaders are brought into the planning their biases and jealousies are bound to follow. Hence, it may be better not to have such people in these exercises, at least in the working groups, although they may be incorporated later to sanction the plan.

Finally, the legitimacy of the exercise is closely related to the type of institution in charge of S&T planning and the way it relates to the government and the scientific community.

S&T Planning and Long-Term Development (Styles, Needs, Options)

The issue here is how far the perceived characteristics of the country's long-term development, or development style, should shape S&T planning and how they should interact. Because long-term development must be considered in S&T planning, the style of development is important. Questions such as the type of society desired — for instance, consumerist or egalitarian — must be examined, even though such considerations have not usually been part of S&T planning and decision-making.

S&T activities have a social function that depends on the prevailing type of society; existing S&T systems may be functional or dysfunctional in this respect. It is proper, therefore, to ask whether S&T may consciously be used as a force to change styles of development and perhaps to build up a new type of society. However, it is clear that there are many constraints and that in long-term S&T planning the realities that would probably not allow such use of S&T planning must be faced. For example, good S&T programs may be designed for non-Western development styles, though the developing countries usually follow the models established by Western industrialized countries.

A particular shortcoming of current long-term prospective studies is their lack of normative vision. Most studies on such matters as food, energy, and population are technocratic and extrapolative. If normative aspects were to be introduced, values, institutions, consumption patterns, and so on would have to be questioned, and this is not yet an accepted practice in development planning.

Relations of S&T Planning to Socioeconomic Planning

The relations between S&T planning and socioeconomic planning are varied and involve conceptual, methodological, institutional, and operational issues.

The first question is whether S&T planning should be derived from socioeconomic planning, or whether there should be close interaction between the two types of planning so that, despite their different time frames (that of S&T is longer), they would affect each other. It was agreed at the seminar that integration of the two types of planning is necessary, particularly because S&T planning may enrich socioeconomic planning.
The definition of objectives and the design of strategies are two important aspects of socioeconomic planning, and technological input is usually understood. However, there may be other technological options that can affect objectives and strategies, and these could be presented to the economic planners so that the framework and the content of the economic plan could be revised.

In some sectors there may be a choice between traditional and advanced technology. It may be foreseen that in a certain number of years a new technology will be available, and this should be pointed out to the economic planners. For example, if the use of satellite communication for educational and agricultural information programs in rural areas of a large country should prove to be feasible, the content of a socioeconomic development plan could be greatly affected.

Analyses of this type can be made for each sector, with programs examined in terms of S&T capabilities and their implications. The interaction between the two types of planning may take place at the overall level, at the sectorial or problem-area level, and at the project level.

In India, the second development plan was production-oriented; technological considerations played no role. The third plan paid some attention to S&T, because by that time certain large S&T institutions had been established. The next plan, that for 1971–74 included a mandate to devise an S&T plan, the task being entrusted to the National Committee on Science and Technology. However, the S&T input to the design of the economic plan was relatively small, and the S&T plan was derived mainly from the economic development plan. Interaction between the two planning processes was limited for various reasons: the large S&T institutions vetoed overall planning, acceptable methods of S&T planning were not available, and it was judged better to take a first cautious step in proving the value of S&T planning than to seek complete integration of the two types of planning (which would not have been possible at that time). Nevertheless, the S&T plan included basic research in areas of particular interest to India, such as tropical weather and cholera, that were not being studied by researchers elsewhere, and basic research that could be developed to the extent needed to provide support for applied research and development.

It appears to be easier to integrate S&T into mission-oriented development programs than into overall socioeconomic planning. In Colombia, for example, S&T was integrated in some specific programs, such as the National Plan on Food and Nutrition, which incorporated the Food Technology Program. National and sectorial plans in Colombia have been used to identify priority areas around which to structure S&T programs. However, S&T has not yet been able to contribute in an important way to the improvement of national plans. Activities have started in the field of technological forecasting, but it is not yet clear what feedback may take place on the basis of their results.

When interaction takes place at the level of specific projects, care should be exerted to counteract the biases of scientists, engineers, and project managers who may lean toward importing technology or toward providing technology from local sources, regardless of cost.

The interaction between S&T planning and economic planning may be enhanced if the committees involved have individual rather than
institutional representation, so that institutional and interagency squabbles are avoided. For example, an S&T planning agency and an economic development planning agency may be linked more easily through personal discussions than through formal institutional communications. However, this may only assist in the integration of technological considerations into the plan and may not lead to effective integration of S&T planning and economic planning.

In this regard there are two main options for an S&T planner. The first is to accept high-level economic planning decisions and transform them into S&T projects, and the second is to design an S&T plan and then seek support from economic decision-makers. A mixed strategy would involve having technologists on both the staff of the economic planning agency and the committees established to design the S&T plan.

Another aspect of the interaction between S&T planning and economic planning is related to the methods used in each process. Economists are familiar with formal analytic methods and employ them in their planning activities (growth models, input–output matrices, etc.) It may be possible to use similar methods in S&T planning. For example, economic planners in India assume static technological coefficients that reflect the preferred technology for the plan. If it were possible to devise methods to calculate and modify these coefficients on the basis of technological considerations, S&T planners could be involved directly in the socioeconomic planning.

Analytic methods may allow better interaction between S&T planners and economic planners, but the decisions will be made on the basis of political considerations, which leads to the question of legitimacy. The legitimacy of the two types of plans is different. Experience shows that the documents stating the policy framework, the plan, and the programs must be political rather than just logical, even though logical tools should be used in developing a political document.

**Design of the S&T Plan**

In the designing of an S&T plan two elements should be taken into account: first, the mechanisms and organizational procedures to be used in the exercise; and, second, the methods and decision tools to be used to guide it. These two elements may be labeled respectively as the “hardware” and the “software” of S&T planning.

Analytic methods for S&T planning are not well developed. However, the great amount and complexity of the information to be handled require that careful mechanisms and procedures be set up to organize the participation of people and institutions. It may even be better not to have explicit methods outlined but rather to stress the organizational procedures that would set planning into motion, ensure the interchange of views among the participants, and guarantee a certain degree of political legitimacy.

Most S&T planning exercises have involved elaborate organizational mechanisms but few analytic methods; decisions have been taken empirically, on the basis of opinion, pragmatic general criteria, and rules of thumb. Sometimes “informed judgment” is the main basis for decision-
making, and much depends on the personal qualities of those who participate in the exercise. For this reason it seems desirable to have wide participation from different sectors, supported by special studies and perhaps complemented by discussions with foreign experts.

Coverage and Structure of S&T Planning

Three situations were identified with regard to the coverage and the structure of planning: (a) overall planning, with the participation of several sectors, a coordinating committee, working committees, etc., such as has taken place in India and Mexico; (b) planning in selected sectors, with more limited participation through ad hoc or permanent committees, such as has taken place in Egypt under the Academy of Scientific Research and Technology, with its permanent councils, and in Argentina, Colombia, and Mexico, with sectorial or problem-area programing; and (c) partial planning for a sector, such as has happened in the national industrial technology institutes of Argentina (agrarian sector) and Peru (industrial sector).

Most countries that have attempted overall S&T planning have followed a similar approach. In general, there is a coordinating committee supervising a number of sectorial committees, each with several working groups. The coordinating committee establishes guidelines, gives directives, and controls the progress of the committees and working groups. A large number of people are involved in the planning — scientists, engineers, administrators, government officials, managers of public and private enterprises, and even politicians. Some of the participants provide links with other groups — in particular, the economic planning agency.

Groups in which only scientists participate are not adequate for S&T planning. For example, national research councils and universities, with heavy representation from the scientific community, are usually interested in programs that pay attention to scientific merit rather than to development goals. However, the participation and support of scientists in S&T planning should be sought. In India there were five regional meetings to discuss the document stating the policy framework of the S&T plan, and they were instrumental in obtaining the support of the scientific community. Later, when the plan was established, there were two more meetings with scientists, also with favourable results.

Plans cannot be generated in a totally rational manner. On the one hand there is a demand from the users of S&T knowledge, and on the other there are the interests of the mission-oriented government agencies. In the S&T planning in India there was an attempt to limit the relative weight and influence of mission-oriented agencies, even though many meetings were held with agency heads during the 18 months taken to form the plan. The first of these meetings was devoted to defining the policy framework, for which the agencies provided support. Furthermore, all civilian government agencies were also involved in the designing of S&T programs. For example, the Atomic Energy Commission, which possesses technical capabilities in fields other than its specific mission, was asked to separate its mission-oriented activities from the remaining one-third of its activities. The latter were discussed by the pertinent S&T planning groups; for instance, the biomedical working group examined the subject of isotopes. A similar approach was followed with the space and oil programs.
Planning in selected sectors has been done in Egypt, where the Academy of Scientific Research and Technology established 14 councils — to cover fields such as power, water resources, and basic sciences — with ad hoc members from the scientific community and the productive sector. Each council has a number of committees. The councils receive and discuss proposals for research programs from various sources — the prime minister's office, the academy, council members, etc. Ministries are asked to help in the implementation of the programs, and sometimes more than one ministry is involved in a program. At an annual conference, with about 200 participants chosen from the scientific community, all under age 35, the proposals are reviewed and modifications suggested. The results go back to the appropriate council for final discussion, and then to a meeting of all 14 councils for approval. In this way extensive participation is assured. Each council includes some ex-officio members (for example, ministers, rectors, and agency heads) as well as 10 appointed scientists, and all participate. However, the academy plan is not comprehensive: it does not touch on the research programs of established institutions.

Partial planning for a sector is exemplified by the involvement of the Industrial Technology Institute (ITINTEC) of Peru in S&T planning for the industrial sector. The institute has derived its research priorities from those established by economic planners and through contact with enterprises, scientists, universities, the ministry of industry, and so forth. It has forged links with various state agencies and enterprises, and has managed to have direct political access to the minister of industry. As a result of its independent source of funds (2% of the net income before taxes of all industrial enterprises) it is quite flexible. The institute has been able to create a mechanism within the industrial sector, through a pragmatic bottom-to-top strategy that allows it to identify priorities and design S&T programs in contact with industry.

The Approach to S&T Planning

It is possible to identify two contrasting approaches to S&T planning. The first, exemplified by the Mexican situation, is mainly deductive and normative. Requirements and priorities are identified, programs are laid out, and institutions are induced to work on them. This is a top-to-bottom approach, and to get results, much persuasion has to be applied. Many obstacles are likely to be encountered, because this approach may require substantial reorientation of S&T activities. The second approach is mainly inductive and pragmatic and consists in starting at the bottom, looking at the activities that are being carried out and trying to improve them, as has been done in Brazil.

S&T planners should, perhaps, steer between these extremes and use the best features of each approach. Either extreme approach may have technocratic or participatory characteristics, although the latter are clearly preferred. The approach to S&T planning in Brazil has gradually shifted from being purely pragmatic and largely technocratic to being more balanced. The first S&T plan consisted mainly of a list of activities already being done or programed for the plan period. In the designing of the second S&T plan priorities were made explicit through consultation with the ministries, and suggestions were made to the ministries about the activities they might undertake. These priorities were expressed in the
second plan. In the designing of the next plan it is expected that priorities will be carefully examined in a large exercise, with the help of committees involving government officials, scientists, managers, etc.

The Use of Formal and Analytic Models in S&T Planning

An important weakness in S&T planning is the dearth of analytic tools and planning models for resource allocation, such as are used in economic development planning. Until they are available, even in a crude form, S&T planners will have to rely primarily on informed judgment and on the political support for such judgment. This appears to be rather primitive in comparison with the practice of economists, who would argue that there are no objective validation criteria for what the S&T planners propose. The question would then be whether efforts should be devoted to developing analytic models for S&T plans so that the legitimacy of the plans can be established and discussions can be held with economic planners on terms they will understand and accept.

Many participants at the seminar argued that it was unwise to expend too much effort in this direction. S&T planning is much more complex than economic planning, as economic planners will admit. As well, economic planning techniques should not be regarded as valid, because most were founded on the shaky theoretical grounds of neoclassical economics and are generally used to validate decisions already taken, rather than as decision-making tools. The product of S&T activities is completely different from that of economic development: knowledge cannot be added to knowledge in the same way as economic quantities are added, and it is not possible to express the value of knowledge in monetary terms. There is also the danger that quantitative techniques will be developed and used without regard for their strong and inherent limitations. Finally, because the developing countries have few good economists with knowledge of S&T issues, these people should be put to work on more promising tasks than the development of formal quantitative methods.

The allocation of resources for S&T planning, both between sectors and within sectors, involves truly political decisions, which are almost impossible to formalize.

Some analytic techniques that have been used in S&T planning have had serious shortcomings. For instance, the matrix techniques whose development was sponsored by the United Nations Educational, Scientific and Cultural Organization were applied in Egypt and India and produced priority rankings that were considered to be erroneous by policymakers. Applications of analytic techniques have been mostly demonstrative, seldom allowing a political commitment to be made. These techniques do not give answers: at best they are of limited help.

Some work has been done on the use of optimization techniques, matrix techniques, social evaluation of resource allocation, etc. at the project level. At the program level the problem is much more complex than at the project level, and it becomes even more complex at the global level.

Empirical guidelines, rules of thumb, and informed judgment will likely continue to be used for a long time, but formal methods and analytic techniques, however primitive, should be explored and developed further to improve the designing of S&T plans and to make the plans more
rigorous and legitimate. Analytic techniques developed in the industrialized countries, which involve sophisticated models and require much data, have been used imitatively and without critical evaluation. Therefore in this regard there are many questions to be asked: Is it possible to formalize rules of thumb? Are quantitative techniques pointless? Is it possible to go beyond organizational mechanisms to pool and integrate informed judgments? It appears worthwhile to search for appropriate methods, starting at the empirical end of the spectrum and moving toward the mathematical end.

Some examples of rules of thumb were put forward at the seminar:

- If funds for activities were doubled or trebled, could the S&T system absorb them? There must be an upper limit to the absorption capacity. Brazil and India have been able to increase their allocation of funds to S&T activities in a most significant way in just a few years, but care must be exercised in equating the annual rate of increase in allocated funds to the absorption capacity of the S&T system, otherwise resources will be wasted.
- Problems that will remain for a long time may be identified, and planning may start with them. The legitimacy of the planning would then be almost automatically established because these problems are widely recognized.
- It must be accepted that there cannot be one-to-one correspondence between economic investment and S&T expenditure in a particular sector or problem area. Priorities for S&T planning cannot be derived automatically from investment plans.
- Upper and lower limits for certain variables, such as the critical size of particular S&T activities and the growth rate of resources, must be identified, and the S&T plan should attempt to steer these variables within the acceptable range.
- Project selection techniques that differ from those used by corporations should be developed. Among others, relevance matrices may be of interest, because they have an important normative component.

Finally, it should be remembered that even though formal techniques may be of assistance, the design of plans relies on judgment and involves elaborate bargaining by the interested parties.

Resource Acquisition and Allocation

Funds for S&T activities have three sources: the central government, which may allocate them through a central fund under the control of the S&T planning agency; the budgets of the S&T agencies; and private industries and organizations that finance their own S&T activities.

Resource allocation should be planned both within and between sectors and translated into annual budgetary allocations so that the programs will be effectively carried out. Control over these resources may be direct, as in the case of a central fund and, to a certain extent, agencies' funds, or indirect, as in the case of private funds.

A central fund amounting to 15–20% of the total S&T expenditure would allow the S&T planning agency to correct imbalances, steer the
activities of various groups and institutions, smooth ups and downs in the amount of money available to sectors, and introduce significant changes in these sectors. Matching grants may be used so that the central fund helps to raise additional funds from other sources while maintaining some control. There should be an appraisal of agency programs, and eventually the S&T planning agency should have veto power over them. To influence the S&T programs of independent agencies it is necessary to use both regulatory and promotional measures.

In some instances, sectorial funds may be set up. Examples are found in India, where the Electronics Commission appraises the R&D programs of all units and contributes to their funding from its own special fund; in Brazil, where two special funds, the merchant marine fund and the telecommunications fund, allocate substantial resources to R&D programs; and in Peru, where the Industrial Technology Institute supervises the fund for technological research in industry.

Care should be exerted to avoid the concentration of too much power and too much money in one S&T planning agency. It is difficult for one organization to have the necessary expertise and sensitivity to influence a large and complex set of programs; several institutions acting in coordination may be necessary. However, the planning agency should have a clear authority over the executing agencies, otherwise it will find itself constantly struggling and bargaining with the agencies. The size of the central fund should be sufficient to allow the planning agency to carry out effective steering.

Initially, when the S&T infrastructure is being built, it may be appropriate to concentrate resources in a few key sectors and institutions, but care must be taken that the established organizations do not stifle new developments. Once the heads of well established institutions are allowed to build up their bases without overall guidance it is difficult to bring their operations into a general S&T planning framework. Nevertheless, it should be possible to use the drive and commitment of these people. Having a central fund that consists of 20% of all the money allocated to S&T activities may help in integrating the large institutions into a comprehensive planning framework. The situation will vary from country to country, as will the risk of excessive centralization.

The allocation of funds for creating S&T capacity and for using the existing capacity can be a problem, for the relative importance of each type of activity depends on the country's stage of S&T development. In some smaller countries the aim is mainly to build S&T capacity in terms of human resources and institutions. In other countries, such as India, many years have been spent in building such a capacity, and the funds should mainly be devoted to the proper use of that capacity.

There are several ways in which allocations to S&T from the private sector could be influenced. For example, resources created through tax benefits could be used by private enterprise for programs to be approved by the S&T planning agency. In South Korea private firms can set aside up to 5% of payments for foreign technology and use the money, tax-free, for R&D. This scheme is supervised by the ministry of science and technology, which analyzes whether the company is able to carry out the proposed program; if it is not, the ministry asks other institutions to carry out the program for the company. Firms that do not import technology can write off in 5 years up to 50% of the total investment in R&D. If the investment is
partly in imported technology and partly in technology resulting from local R&D, accelerated depreciation is compensated proportionally. It can, however, be difficult to measure the proportion of imported technology.

In Peru all industrial enterprises have to set aside 2% of their net income before taxes to be used in technology research programs approved by the Industrial Technology Institute. The enterprise can perform the research itself or contract it out, and if the program is not approved, the funds are turned over to a central fund administered by the institute.

In India companies are registered with a registration committee for 3 years initially; registration may be renewed. Such companies can ask for tax exemption on 1% of their income, and sometimes more, to be used in approved R&D programs.

The use of such funds by private firms for R&D and other S&T activities must be guided by previously accepted priorities and programs to ensure the effective allocation of these resources. This scheme is tantamount to putting state funds at the disposal of the private sector. Whether such funds are put to better use by private industry than by the state and whether their availability may bring forth other company resources for socially desirable S&T activities are matters that should be examined.

Implementation of the S&T Plan

The structure of the planning agency is important. The Indian National Committee on Science and Technology, for example, was made up by 10 members chosen because of their sectorial expertise and their competence in S&T planning; heads of well established institutions were excluded. The committee was responsible for designing an S&T plan. The principal responsibility for implementation of the plan lay with the executing agencies in each sector, but the national committee was later restructured so that it would exert effective control.

In January 1975 the national committee had been enlarged to 18 members, including the heads of all the important S&T agencies, some of the former members (to provide continuity), and representatives from areas where there are no agencies, such as the Natural Resources Survey. The national committee is now a planning and implementing agency, and the heads of the executing agencies are accountable to it for their performance. A steering committee oversees the sectorial implementation.

Furthermore, the national committee now has a representative in each of the main economic ministries, who acts as a coordinator—secretary—member of a steering committee comprising, in addition, a permanent secretary of the ministry, and the head of the respective agency. Usually the national committee representative has taken part in the designing of the S&T plan and therefore has a good knowledge of it.

This structure works well in some sectors, though not in others. Its main aims are to involve ministers at the highest possible level, to put representatives of the planning agency inside the ministries, to maintain political support by having frequent reviews, to have a group with representatives from the national committee, the finance ministry, and the planning commission that meet before the national budget allocations are made to look in detail at the total funds to be allocated to S&T activities.
3. Analysis of the Technological Content of the Argentine 3-Year Development Plan (1974–77)

Eduardo Amadeo

Theoretical Framework

All policy instruments, and planning instruments in particular, contain a series of postulates that refer specifically to the goals of S&T activities, because the product of these activities is considered to be of primary importance in the achievement of a country's overall aims.

There are, on the other hand, S&T needs that can be inferred from a reading of the general and sectorial objectives, as well as the descriptions of the projects and programs planned to achieve these aims. The needs are implicit in the very existence of proposals for changes in a country's development. Observation of the normal development of knowledge and the incorporation of new knowledge into the elements of production has shown that new technological structures are a necessary part of any attempt to enhance development. Technological factors can affect an S&T plan in two ways: by influencing the attainment of immediate goals; or by influencing the attainment of all quantitative goals (immediate and long-term).

For example, the failure to incorporate modern technology may simply limit the possibility of achieving a desired rate of growth in productivity or it may simultaneously hinder the goal of growth and a goal of full employment at high salaries.

Another example, often found in dependent countries, of the importance of technology in S&T plans is the attempt to modify the structure of production by modernizing it, with a proportionate increase in "autonomy," when the capacity to generate knowledge is lacking. Generally this results in an increased dependence on foreign technological and financial assistance. The problem of the different time frames of economic development and of S&T development shows even more clearly the importance of studying the S&T content of a development plan.

The need to achieve rapid growth primarily in response to political restrictions is one of the principal influences that must be dealt with by all those who wish to effect structural changes in developing countries. Moreover, there are often lingering problems of scarcity of supply in vital sectors, financial strangulation, chronic lack of external balance, and so forth that are considered primarily as short-term problems whose solution demands an all-out effort. And it is here that the stereotyped prescriptions are used again and again, recommending accelerated accumulation of capital, supplemented by foreign contributions, and counting on imported...
technology for investment in sectors presumed to have the potential for tremendous growth and contribution to the economy. As a result of the attempts to achieve rapid growth, structural reform becomes deferred and undesirable structures are ratified.

The situation is even more serious if attempts are made to end technological dependence, relying on the local scientific community to create new technologies and the local production sector to absorb them. The process of establishing a scientific creative capacity that is durable and of high quality is long and costly.

It is essential that knowledge generated by the S&T system not only is of good quality but also meets the demand. Thus, there is a need for policy instruments that foster the relation between the scientific and the production systems, ensuring that the results obtained by the former are used by the latter.

Doubtless all these objectives exceed the aims of a short-term development plan, especially one of 3 or 4 years. However, this discussion has shown the need to analyze the relations between the proposals for structural reform, the need for growth, and the technological factors expressed in concrete plans, instruments, and programs for institutional reform either in the S&T plan or in other documents from the scientific area of the state.

Political Framework

The Argentine 3-year development plan is a document that expresses the political proposals of action of the "national bourgeoisie," a group with economic and political force that took power together with the Peronist movement early in 1973. In contrast, earlier plans, those created during the 1960s and early 1970s were the result of either purely political groups, such as the radical government of 1963, or technocrats affiliated to a transitory structure of power, such as that in 1966–73.

Thus, the importance of technological factors in the 3-year plan is clear. Technology is one of the elements that determines whether small and medium-sized firms survive on their own or must depend on other sources of capital, mainly foreign.

To understand the importance that the plan gives the state in the implementation of the proposed policies, one must be aware of another political factor: that in its struggle for dominance, the national bourgeoisie can make use of only one possible ally, the economic power of the state, and can do so only when it has control of the pertinent apparatus.

Principal Features of the 3-Year Plan

The primary objectives of the 3-year plan are to attain substantial general and sectorial growth and to modify some features of the social structure of Argentina. It does not propose modification of production relations but, rather, improvement in specific aspects of the elaboration and distribution of the product within a capitalistic system.

The principal objective of the plan is "to establish the bases of a long-term process that, while reaffirming the authority of the State's
decision over economic activity, will facilitate increasing production of goods and services and the full employment of productive factors within the framework of an equal distribution of income and wealth, and a balanced regional development.”

The plan is defined as a plan of change, in contrast to a continuity plan, which would be concerned only with the growth of measurable variables. This is expressed to some extent in the plan's general objectives, which include:

- Marked expansion of economic activity (doubling of the rate of growth of the previous decade) and increasing independence on all fronts.
- A high quality of life, with idiosyncratic patterns of consumption and without ecological problems.
- National unity and full regional economic independence.
- A marginal role for foreign capital, and renationalization of industry.

These general objectives become transformed into the following postulates:

- The restructuring of demand, which implies, among other things, that “in the choice of providing individual equipment for the higher income groups, or collective equipment for the community, the latter option will obviously prevail”;
- The need to transfer the dynamism of economy from foreign monopolies to national enterprises and especially to foster the activity of a large group of small and medium-sized firms;
- Opportunities provided for productive employment in the whole country; and
- The restructuring of the government, so that it may carry out efficiently its role as promoter and regulator.

The 3-year plan attempts, through these objectives, to transcend the purely evolutionary designs, in which changes of structure would be the long-term outcome of economic growth. The quantitative variations are significant, in that they aid in the attainment of the desired objectives.

**Bases of the Growth Model**

Three elements constitute the bases for achieving the goals of the plan: a high rate of growth of investments (average of 12% per annum), increased productivity of the installed capital, and doubling of the volume of exports.

The important increase in public and private investment should generate the desired rate of growth (7.5% per annum, cumulative), doubling the rate during the previous decade, because a high percentage of investments should be intended for installation and expansion projects in sectors producing intermediate and capital goods, as well as for the economic infrastructure.

Therefore, to ensure that the increase in investment would terminate in a more than proportional increase in production, it is necessary to have a
substantial decrease in the marginal relation of capital to product, which, together with increased labour productivity, would double traditional volumes. This would depend not only on more complete and effective use of existing productive installations, but also on the nature of the capital stock incorporated from the time the plan entered into effect.

Export goals constitute a principal element in the growth dynamics provided for in the plan, because the plan needs to ensure that "the import capacity will not hamper the attainment of the aims of growth programmed by the plan for different sectors, nor the level of foreign debt jeopardize the country's capacity to take autonomous decisions."

For the general aims of the plan to be achieved, these growth designs must be consistent with a sustained process of redistribution of income, in which the average real wage increases (by an average of 7%) and the participation of wage earners in the total income of the country rises through higher salaries and the elimination of unemployment. The planners considered that a substantial expansion of economic activity, particularly in the traditionally vegetating sectors that have a high employment capacity, would lead to the achievement of full employment, this being one of the primary general objectives of the plan.

A study of what the plan refers to as the "principal actors" in the proposed model — the state and the local enterprises — is of special importance. With regard to the state, the plan affirms that "the action of the State aims to fulfill the aspirations of the majority. . . . The State's function as regulator of the behaviour of economic agents and of the community as a whole, is considered essential to the needs of a development policy." Moreover, "the direct production of goods and services by the State holds an important place in Government Policy. Apart from the traditional activities which are increased to fulfill the needs of the population, and the formation of an economic infrastructure compatible with global and sectorial development objectives, the function of the State is to carry out large scale projects which constitute together with certain basic measures of economic policy, the supporting pillars of Argentine development." For this purpose, "a high administrative efficiency is needed, as well as a concentration of resources and a reform of the administrative structure, leading to the creation of optimal conditions for the coordination of effort."

As for local firms, "it is necessary to foster the activity of a vast sector of small and medium size firms which act as agents of change and promotion in many sectors and in specific areas," and to promote "the development and reconversion of some industries manufacturing durable and non-durable consumer products, which employ a large number of manpower. This would be the case . . . [for] . . . the textile industry, ready-made ware, leather, furniture, branches of the food and beverages sector, home appliances and 'printing and publications'."

In this respect, the plan proposes a change in one of the main features of the Argentine economy since the beginning of the 1960s: the marginal role of sectors producing goods for massive consumption, the "vegetative industries," which consist mostly of local firms.
Technological Implications of the General Objectives of the 3-Year Plan

The Role of Technology in Development Models

The 3-year plan proposes a qualitative and quantitative change in the socioeconomic structure of Argentina. Perhaps the most relevant components of the proposed qualitative change are: (a) the modification of the way in which basic needs are to be fulfilled; (b) the revitalization of small and medium-sized local enterprises; (c) the replacement of foreign capital with local capital in the economic structure; and (d) the establishment of the state as controller of economic activity.

To understand the technological implications of items a, b, and c, one needs an understanding of the reasons for a specific structure of production in a dependent country, such as Argentina.

The predominance of foreign capital, the marginal role of local firms (small and medium-sized firms in particular), and the existence of an unsuitable structure of consumption are part of the process initiated with the incorporation of Argentina into the development designs of world capitalism.

The structure of demand is founded on the cultural, economic, and political dependence that became a symptom of life in Argentina during the last decades of the 19th century and the first half of the 20th. Substitution of locally produced goods for imports is merely an attempt to satisfy a demand that previously necessitated importation. Successive development projects implemented by the government have, by different means, opened the door to foreign capital and continued dependence. The government’s concentration on improving income and social conditions constitutes fertile ground for substantial foreign investment that, with the help of the mass media, consolidated a structure of demand to fulfill the accumulation needs. Demand and supply cannot be considered independent from one another (though theory has always maintained the contrary); they are two aspects of the same process, determined by the evolution of world capitalism.

What role does technology play in this process? First, it largely determines the capacity to generate profits, whether through lower costs, diversification of products, use of raw materials, or other factors. These are the elements that, depending on the structure of the market, every business must confront and decide upon. Exclusive access to “modern” technologies generates monopolistic advantages, which at present belong to the industrialized nations and which largely account for the dependence of developing countries such as Argentina.12

Although modern technology is controlled primarily by the industrialized nations, it trickles out on a world scale due to the demand arising from specific expansion needs of capital. The means of fulfilling demands, the average size of the market, the degree of concentration of enterprises, and the general nature of competition provide specific guidelines for technological evolution with respect to the type of goods being produced, the nature of the capital goods used (their sophistication, degree of

automation, etc.), the nature and scale of the production, and the type of raw materials and intermediate products involved.

All these considerations restrict rather than expand the range of effective technologies (those that minimize the relation of capital to product, of fundamental importance in developing countries). If we admit that these observations are true, then we must admit that all policies that attempt only to modernize the production system must lead to the use of such technologies.

Implications of the Qualitative Proposals

I will now attempt to apply the foregoing discussion to the proposals for structural changes contained in the 3-year plan, particularly proposals to restructure consumption patterns (demand), to give preferential treatment to local enterprises, and to revitalize small and medium-sized firms.

Obviously, unless these proposals are supported by plans or research programs aimed at finding solutions that will make them technically feasible, they will remain as mere suggestions. The restructuring of consumption patterns requires a review of needs, with particular attention to those that have been ignored mainly because of the policy to redistribute income, and a search for new methods to satisfy the needs. The first question to be asked is: Are there any technological alternatives that allow the fulfillment of existing needs to the greater benefit of society? On the basis of experience the immediate answer appears to be No, and even if such technologies do exist they probably are obsolete. Food, clothing, transportation, communications, and leisure time are basic needs, the fulfillment of which in Argentina has traced, more or less precisely, the pattern of the United States. In this respect the most significant proposal concerning the reform of consumption patterns in the 3-year plan is: “In the choice of providing individual equipment for the higher income groups, or collective equipment for the community, the latter option will obviously prevail.” If this proposal were to be implemented, it would require total modification of the structure of public services and discouragement of the production and consumption of durable goods and services that are oriented toward the fulfillment of individual needs. The first to be affected would be the transportation and communication, health, education, and housing systems, but such complex variables as the whole design of urban structures would also be directly affected. The two greatest stumbling blocks are creating the knowledge necessary to determine pertinent technologies and convincing production managers to adopt them (maintaining the rules of the game of free enterprise).

The structure of production is not based on chance, but is the result of a process in which the distribution of income, the expectations for social improvement, and the types of goods consumed are determined by accumulation needs. A change in one of the elements of this equation requires appropriate changes in the other elements to maintain the balance. The balance is due to the benefit derived by the units producing the goods consumed; included in the calculation of this benefit are, among other factors, the cost and nature of the technologies involved, and the relations that such technologies may establish abroad. Therefore, the
new technologies must be economically acceptable to the production
sector if they are to be adopted without the use of coercion and without
change in the accumulation process.

Technological development is of the greatest importance in fostering
the activity of small and medium-sized firms. Although many of these firms' problems are financial, all have in addition technological characteristics that limit the possibility of an increase in productivity to allow them to compete effectively with large firms; thus they are condemned to perpetual marginality. The problem transcends national frontiers and becomes a question of technological development on a world scale. That is, technologies that lead to high productivity or to the production of goods that are able to generate monopolistic benefits on local or international markets are developed for large-scale activity far beyond the market possibilities of the small and medium-sized firms that need help.

Hence, research programs should be planned that are aimed at developing advanced technologies locally for small-scale production, and technologies generated elsewhere that are considered to be desirable for a market that the production of small and medium-sized local firms may satisfy should be adapted to a local scale.

Implications of the Quantitative Proposals

The goals that constitute the basis of the dynamics of the 3-year plan for the Argentine economy in the coming years are a high rate of investment growth, increased productivity of the installed capital, and doubling of the volume of exports.

A large percentage of the proposed investment will be applied to important projects in the industrial sector and to projects related to the economic infrastructure that would complete the vertical integration of industry and put an end to some of the bottlenecks restricting general expansion and regional integration.

Investment in important industrial projects will be in the areas of iron and steel (U.S. $1 140 million), petrochemicals (U.S. $581 million), and cellulose, paper, and wood (U.S. $500 million), and U.S. 3 764 million will be invested in building power plants.

These investments will be made taking into account two elements: the need to balance investment in growth with that in vertical integration of the industrial sector; and the fact that these investments will be the principal factors in the improvement of the structure of production to attain the desired rate of growth.

Although from the technological point of view, the plan specifically establishes that the largest possible portion of investment purchases should be made within the country, it also specifies that the core technology of the projects, whether incorporated or not, will have to be imported, owing to the nature of the projects, the limitations of existing installations, or the current creative ability in priority areas.

It appears, then, that the large investments will increase the degree of dependence on foreign technology in the sectors that are basic to the plan.

Political limitations make it necessary to place technological development on a secondary plane initially, although it would be unrealistic to expect a short-term alternative — more so in view of the chosen pattern of growth.
An additional comment should be made regarding the nature of the basic sectors chosen and the proposals in the plan for a change in the structure of demand. If a definite new structure of demand were created that would “find expression in a new national model, freed from consumption patterns imitating foreign models,” it would be necessary to provide for the resultant structural changes in the production of intermediate (or “basic”) products. If we failed to make such provisions, we would be proposing a different structure of final demand while extrapolating the existing structure to determine its downward requirements.

The plan has failed to make these provisions, and therefore leaves a situation in which the future characteristics of the society depend on the immediate needs of growth.

Similar comments on the relation between long- and short-term goals can be made about the need, explained in the plan, of achieving a substantial increase in employment together with a decrease in the growth of the capital/product relation. Careful evaluation is required of the technologies that would make the objectives feasible.

In view of these considerations and the experience of Argentina during its period of rapid capitalization (1958–62), it is likely that a significant increase in employment capacity and a decrease in technological dependence of industry are possible only through proper control of the technology incorporated in the new investments. This is especially true for the traditionally employing industries, which, in the sectorial strategy of the plan are given great responsibility to generate employment for the plan’s duration.

As for the proposals made in the plan to double the volume of exports, the goals pursued are diverse: to obtain in the short term an influx of foreign currency such that the import capacity will not hamper the plan of general expansion; and to make a significant change in the industrial structure, enabling it to generate at least as much foreign currency as may be necessary for its own expansion.

The first aim may be achieved by strong financial or credit incentives (reimbursements, drawback, credit promotion, preferential exchange rates, etc.). These incentives do not, in principle, modify the structure of the benefiting industries to such an extent that they are forced to abandon the foreign market as soon as the government ceases to give such incentives. They only provide the means for greater efficiency through greater production. On the other hand, provision of these incentives necessitates redistribution of the resources of the whole economic system toward the export sectors, and this may involve considerable sums.

It is obvious that Argentina needs a consolidated and dynamic structure for the export of manufactured products, one that will make it possible to overcome the cyclic limitations of supply of primary products. This can only be achieved through the production of goods able to hold their position on the international market, either by lower cost or diversification. Therefore, policy instruments should selectively support these products and attempt to change the structure of their production through intense technological activity, the granting of loans, and the action of specialized state agencies, such as the Corporation of State Enterprises and the National Industrial Technology Institute.

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Explicit Technological Policy of the 3-Year Plan

At this point, two aspects must be considered: the explicit statement in the plan regarding technology in general, and the concrete measures proposed for the achievement of the plan's objectives in this area.

Perhaps the most complete statement in the plan is the following:

Scientific and Technological development shall constitute one of the pillars of the efforts toward reconstruction and liberation . . . . It is fundamentally a question of placing the talent and creative ability of the Argentine people in the service of the highest objectives of the plan. In particular, the end of technological dependence . . . . This involves the development of a capacity to solve our technological problems, resorting to foreign cooperation only when it is indispensable. This, of course, does not mean that we must reject new international advances in the scientific and technical fields; only to strengthen our ability to choose from these advances what is most useful to our future progress. It is essentially a question of relating functionally technical development and the nature of the destinataries of production . . . .

This means that preference should be given to some lines of technological development more than to others, and in particular:

- The creation or adaptation of technologies leading to the full employment of the labour force, growing productivity and remuneration; decreasing costs and improved quality of goods and services, which will strengthen the economic integration of the industry through the development of the production of capital goods.
- Improving the ability to adapt technological advances to Argentina's structure of consumption and production.

Briefly, this is the position with regard to the nature of the desirable technological structure, according to the general objectives of the plan.

The policies proposed in the plan to achieve these objectives include:

- Intensifying basic and applied research, using selective standards that will direct it to serve national aims and not to supplement the S&T progress of great international industrial centres.
- Establishing a solid S&T infrastructure.
- Strengthening the role of the state, through its agencies and firms, as the promoter of technological development and as the inductor for the absorption of new developments into the country's production and distribution machinery.

These policy guidelines will be supplemented by the action of the institutions created by the plan, particularly the Corporation of State Enterprises and the Corporation of Small and Medium-Sized Firms.

Clearly the plan establishes the characteristics of an optimal S&T system acting in perfect harmony with the global objectives of the proposed model of development. In other words, the global objectives appear to have been "interpreted" so as to arrive at the S&T structure that should be useful to these objectives.

With regard to the technological policy as it appears in the plan, instruments are lacking that would clearly define the lines of action that, in
general, would lead to the attainment of the objectives established for the area. Just as the plan details the nature of the instruments that will implement sectorial policies, it should set out the most important aspects of the S&T policy, especially the forms of financing, the necessary reforms of institutions for the planning and performance of science, and the mechanisms and instruments to ensure national development and absorption, by the production sectors, of technology.

The failure of the plan to provide such definitions suggests that it contains only a series of pronouncements impossible to implement or that implementation has not been planned.

It is interesting that there has been no intervention of the Secretariat for Science and Technology during the design and implementation of the plan. The main implication of this is that the technological policy was to be carried out mainly through the institutions and instruments controlled by the Ministry of Economics. Apart from the internal political problems that led to the division between the economic and technological areas, this suggests that the technological proposals of the plan do not take into account the technological alternatives available in the country and the existence of "idle capacity," or lack of it, in the scientific system to fulfill the intermediate demands stemming from the final technological requirements.

Conclusions

If a general conclusion can be reached concerning the technological content of the 3-year plan, it would be that the technology policy implicit in the desired aims, and even more in the objectives, is richer and more complete than specific technological policies and measures proposed.

The proposal to obtain a high rate of growth and to modify patterns of consumption without changing the basic features of the capitalistic system implies creative effort of hitherto unknown proportions to modify technology — a central element of the economic system — in such a manner as to maintain a balance in the system.

Achievement of the task is considered doubtful because it is not reconciled with other goals, such as redistribution of income, full employment, regional balance, the fostering of national capital, and investment in small and medium-sized firms.

Experience shows that efforts to achieve speedy capitalization as a means of attaining a high rate of growth in a short period are apt to condition the structure of production for many years. But if economic growth is a short-term economic necessity for structural changes, it is necessary to provide the mechanisms for progressive change at the same time that speedy capitalization is attempted. One of the basic mechanisms for this is S&T creative ability (and therefore the ability to decide), which, while allowing progressive reduction in the greater dependence arising from the process of capitalization, 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 S&T creation without greatly affecting the total conduct of investment. Furthermore, political will to attain this goal does exist.

The concrete proposals in the plan concerning the implementation of an S&T policy leading to the attainment of the global objectives are clearly insufficient. The most notable lack is precise sectorial definitions concerning the S&T needs to be fulfilled in the course of the plan, both the existing ones and those that may arise from the investment process. The plan also fails to propose specific changes in the generation of scientific knowledge: guidelines for the organization of institutions, standards for the allocation of resources, and relations with potential users, etc. These will, apparently, not be taken into account in view of the lack of a specific S&T plan.

Perhaps one of the principal reasons for the marginal role of S&T in the development model of the plan lies in the planning process. In the 3-year plan, technology is introduced from outside to inside and from above to below, almost as if it were a patch inserted in the process.

In practice this means that the technological implications of global aims are ignored because the necessary basic studies have not been carried out. Briefly, planning consists in defining the way to balanced growth on the basis of the existing balance of input and output and general political restrictions (desirable external debt, level of employment, distribution of income, etc.), not including the technological needs that may be implicit in global and sectorial alternatives.

The Argentine 3-year plan does not escape this general rule, although ambitious proposals are included concerning S&T.

Finally, the plan gives the state a role as one of the main elements for the attainment of the proposed changes. This implies that the state has the technical capacity to search for technological alternatives, to interact with its "environment," and even to develop original technological answers to the problems posed by accelerated growth. This is not the case in Argentina, where, with very few exceptions, the state has proven its very limited possibilities, despite huge resources. The most crucial point, however, is that the national bourgeoisie believes that the state can reorient its activities and use its power effectively for their political needs. The Corporation of State Enterprises was created as one of the main instruments for this purpose.

Once the national bourgeoisie lost its political power in early 1975, the corporation practically disappeared, and all the measures taken concerning the technological behaviour of state enterprises vanished and the enterprises returned to their traditional passive and dependent behaviour.
4. Science and Technology in Brazilian Development Plans: 1956—73

Eduardo Augusto de Almeida Guimaraes and Ecila Mutzenbecher Ford

This chapter aims at assessing the importance given to S&T in the Brazilian government’s development plans elaborated between 1956 and 1973. In particular, an attempt is made to identify to what extent the technological needs originating from development in Brazil are reflected in those plans, and to determine whether the plans propose measures that can be characterized as constituting an S&T policy.

The Brazilian government’s emphasis on S&T planning is recent and is increasing. On the one hand, this fact may lead observers to conclude that no worry has existed in the past about the country’s S&T and/or to assert that in the past too high a value has been placed on the accumulation of physical capital, as opposed to the formation of human capital, in economic development. On the other hand, observers may exaggerate the government’s possibilities for promoting the country’s S&T development, such development often being considered as an exogenous factor capable of affecting economic growth independently from, or despite, other government policies. Both conclusions are mistakes, stemming from two causes. First, the people who subscribe to them have read only government documents that explicitly refer to S&T and have not examined the technological implications of other government policies. Or, the people fail to consider that an S&T policy can have various objectives (aside from the hypothetical autonomous ones) and that the concrete directives associated with each objective have distinct aspects in each of the stages of economic growth.

In this chapter we intend to avoid these mistakes and to analyze, besides the S&T policies explicitly outlined in each of the government’s plans, the technological implications of the directives associated with economic policy proposed in these plans, as well as to characterize the objectives of the explicit and implicit S&T policies.

Basic Propositions

It seems necessary to identify, together with an explicit S&T policy, or in view of the lack of such a policy, the dispersed but specific elements in the government’s plans that form an implicit and specific S&T policy, as well as the technological implications of other sectorial policies that characterize an implicit and derived S&T policy. Such a study will allow us
to assess to what extent government plans in which an S&T policy was not outlined were permeable to the technological needs of growth, and also to detect incompatibilities between the S&T policies formally stated and the general development strategy of the government plans.

At this point it is worth stressing that government plans are not always totally implemented; that the most important measures of economic policy are often adopted only when not in opposition to such plans; and that sometimes the planning documents do not express the consensus and the intentions of the government team. Thus, evaluation of the S&T policy in a certain period demands an examination of the measures specifically related to S&T, as well as the consequences of actions in other areas of economic policy. Such comprehensiveness is not intended in this chapter, which is restricted, in general, to analysis of the policies found in the government plans.

A second point to be stressed refers to the objectives of an S&T policy. Unless the policy defines its own objectives, two alternative objectives could be considered, with technological dependence as the criterion of differentiation: (a) to answer the technological needs of the production system by speeding up the incorporation of innovations into the system, without consideration of whether technology should be produced domestically or imported; and (b) to reduce the use of imported technology by enlarging the national capacity for the creation, adaptation and incorporation of technical knowledge. To make future reference easier, a policy devoted to objectives of the first kind can be called a policy of response; the alternative is a policy of relative autonomy.

A policy of relative autonomy can have different objectives. On the one hand, it can reflect the intention of inducing, or creating conditions for, reorientation of the process of growth, aiming at reaching new patterns of development. On the other hand, it can aim only to answer the needs derived from the production system using domestic sources of technology to reduce the dependence on foreign sources, but without intending to modify the prevailing framework and direction of growth.

The basic approach of this chapter is to distinguish between the two types of policy. However, with government plans that contain an S&T policy of relative autonomy, we must examine what was intended in the policy's formation from the viewpoint of the more general characteristics of growth.

When distinguishing between the two types of policy, one must consider that each stage of economic growth has specific technological needs. It is also possible to distinguish the ways in which these needs are satisfied, whether domestically or through the transfer of know-how from abroad. Furthermore, a policy of relative autonomy, even when successful, will not necessarily lead to a decrease in the technological dependence on foreign countries, for it can be linked to the emergence of technological needs of another kind and, therefore, of new forms of dependence; in this sense, such a policy would refer to a specific kind of transfer of technology. Therefore, it is necessary to define the elements of a policy of response and the feasible objectives of a policy of autonomy in each stage of development.

In the first stage of industrialization in Brazil the demand for technology was not explicit but was implicit in the demand for capital
goods and for technical personnel with certain qualifications. The ways in which the demand was satisfied were the importation of the capital goods required, the incorporation of qualified immigrants into the production process, and the domestic training of individuals to operate the existing industrial plants. With the undertakings that involved more complex technologies there were also no internal resources capable of making the necessary investments, usually with a long period of maturation. Not only the technology and the capital goods but also the capital that made the undertaking possible were obtained abroad. Nor was the demand for technology made explicit once the transfer of technology constituted a byproduct of the investment of capital (Biato, Guimaraes, and Figueiredo 1973).

As industrialization went ahead, those kinds and channels of supply of technology became insufficient for an increasingly complex demand. The purchase of capital goods no longer provided the production units with the technology required; "the new productive processes and the new products required more than mere instructions supplied by the producers of the capital goods utilized" (Biato et al. 1973). What became necessary was the mastery of more sophisticated technology than that required for the operation of the industrial plants. As a consequence, besides resorting to the already mentioned forms of transfer of technology, the Brazilian production system began to resort to contracts with foreign agents, trying to obtain engineering projects and services necessary to the solution of specific problems, as well as to ensure permanent technical assistance to the operation of the country's production units. Furthermore, for products protected by patents and the use of trademarks, the mastery of the technology involved was not enough. The Brazilian enterprise was forced to contract the cession of the legal privileges with their foreign owners (Biato et al. 1973). In this context, the demand for technology by the country's production system became explicit.

In the first stage of industrialization a policy of response would consider above all making possible the importation of capital goods, promoting the formation of human resources needed for the operation of the production system, and attracting foreign capital for the productive activities requiring a more complex technology. On the other hand, among the possible objectives of a policy of relative autonomy, taking into account the prevailing form of transfer of technology, the substitution of domestically produced capital goods for imported goods stands out.

In the second stage of industrialization one objective of a policy of response, in addition to those mentioned for the first stage, would be to increase the flow of new technical knowledge from abroad through contracts with foreign agents. With a policy of relative autonomy the basic directive would be to promote the domestic production of the technical knowledge required by the production system.

Such considerations reappear in our examination of government plans formed in the period 1956–73. In fact, the following analysis is outlined by the attention to the specific needs of each stage of industrialization in Brazil; by the preoccupation with identifying, besides the propositions spelled out in the plans, elements that characterize implicit S&T policies; and by the acknowledgment that other orientations and objectives of the S&T policy may be designed and implemented.
The Target Program

A set of sectorial objectives drawn up by the government in late 1956 made up the target program for the period 1956–60 (presidencia da república — conselho de desenvolvimento, 1958). The program had as its frame of reference a stage in the process of substituting domestically produced goods for imported goods in which the segments of the production system producing nondurable and less complex durable consumer goods had already been consolidated; these segments, together with some undertakings in the spheres of intermediate products and capital goods, characterized Brazil's new industrial nucleus. The program established absolute priority for improving the industrial structure by setting up industries producing basic and capital goods, as well as for forming the capital that should support that structure; the targets proposed were grouped in five sectors — energy, transportation, food, basic industries, and education.13

The orientation proposed in that document for Brazilian development led to a significant increase in the technological needs of the country's production system. The mere listing of the segments included in the targets related to basic industry suggests the additional supply of technology required: steelmaking, aluminum, nonferrous metals (lead, tin, nickel, copper, and zinc), cement, alkalis, cellulose and paper, exportation of iron ores, automobile industry, shipbuilding, mechanical industry, and heavy electrical material.

Moreover, the sophisticated technology demanded in the new stage of industrialization required more frequent and more intense use of disembodied technical knowledge of greater complexity, and resort to new sources and forms of supply of know-how.

In fact, the technology required by the existing industrial enterprises — in general restricted to the technology embodied in the capital goods used and to relatively simple and diffused technical knowledge — had thus far been supplied by the importation of such goods and the instructions provided by their producers, by the learning in the industrial plants, the reading of technical literature, and the training and theoretical education supplied by the engineering colleges in the country. However, these sources were insufficient to meet the needs of the new phase of industrialization.

In spite of this, the target program was timid in its explicit S&T policy. Besides a marginal preoccupation with the S&T aspects of the nuclear power program, the target program restricted itself to the target of training sufficient technical personnel; this target, however, was emphasized more as a way of satisfying the need for technical cadres to operate the expanding production system than as an effort to have more effective national participation in the supply of the technology linked to the new wave of investment.

The program acknowledged that economic development presupposes an increase in productivity through techniques, such as better use of the

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13 For an analysis of the Brazilian economy in the 1950s and an assessment of the proposals and the implementation of the target program see: Candal (1969), Ianni (1971), Lafer (1970), Lessa (1964), and Tavares (1972).
factors of production, labour, and capital by means of technological advancement, and spoke of education for development. Among others, it established as targets to increase the capacity of the schools of engineering to 1,000 new students per year, to strengthen industrial and agricultural secondary education, and to set up 14 institutes of research, education, and development (2 each of mechanics and chemistry, and 1 each of mathematics, physics, electrotechnics, geology, mining and metallurgy, genetics, economics, agricultural mechanics, rural technology, and rural economics).

The targets of training sufficient technical personnel and establishing a nuclear power program exhausted the portions of the plan that can be characterized as constituting a specific S&T policy, though some references are made to agricultural research and to the technological problems in the production of paper and cellulose. However, the other directives of economic policy in the target program contained implicit solutions for acquiring the technology required in the new stage of industrialization. The solutions appeared in the context of the policies relative to foreign capital and to the production and importation of capital goods.

As to the former, the liberal treatment of and the incentives granted to foreign capital — including the setting up in Brazil of subsidiaries of enterprises based in more industrialized countries — led to effects of two kinds. On the one hand, they created a channel for the transfer of technical knowledge into the country as a consequence of the necessity that the mother companies provide their subsidiaries with the technology required for their setting up and operation. On the other hand, they affected favourably the national capacity for importing capital goods, whether through the inflow of foreign exchange brought about by foreign investment or through the entry of machines and equipment into the country as part of the foreign investment.  

Another important concern during the implementation of the target plan was to render feasible the importation of the capital goods necessary for industrial expansion. This concern was reflected not only in the emphasis on overcoming the economy's foreign constriction through the attraction of foreign investments and financing, but also on the concession of a more favourable exchange rate for the importation of machines and equipment, and on the reduction of the customs tariffs applicable to capital goods whenever the impossibility of obtaining the product domestically was proved.

The measures and policies mentioned above — both those specifically related to technology and those having indirect consequences on technological matters — outlined an S&T policy that can be characterized as one of response, for if on the one hand they were aimed at satisfying the

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14 Foreign investment in the form of machinery and equipment, a mechanism widely used during the period of the target program, had been regulated through the superintendency of money and credit of the Bank of Brazil, instruction 113, January 1955. For a discussion about the importance of that instruction in the formation of physical capital and in the participation of foreign capital in Industrialization, see Bonelli and Tolipan (1974).

15 These regulations were introduced in the Law of Customs Tariffs in August 1957. On this subject see Lessa (1964).
requirements arising from growth, on the other they proposed to do so without changing the country's dependence on the external world.

However, the implications of the target of developing the Brazilian capital goods industry defined, from the technological viewpoint, a different picture and suggested themselves to be elements of a policy of relative autonomy, for they suggested the replacement of external sources of supply of embodied technology. But it remains worth asking whether such a proposition should be seen as an autonomous objective or as a result of the logic of the process of import substitution, as well as whether the fulfillment of such a target really means a reduction of the technological dependence on foreign countries.

As to the first question, it should be stressed that, in contrast to the targets related to transportation and energy, the success of which was indispensable to the successful working of the economy, the substitution of domestically produced capital goods for imported goods was not necessary for the correction of the disequilibria in the external sector; when the plan was being implemented import substitution acted as another source of pressure on the demand for imports. Although not necessary in this sense, the adoption of those objectives was undoubtedly induced by the country's economic evolution. On the other hand, the repressed demand for those goods — above all, items of transportation — gave rise among their former exporters to a structure of interests favourable to the internal production of such goods, the free importation of which was then impossible (Lessa 1964).

In any case, even if such objectives are understood as being autonomous, their relation to the increase in the domestic capacity for technological development and to the reduction in technological dependence on foreign countries was not explicitly considered when they were being designed.

As to the second question, the way in which domestically produced capital goods were substituted for imported goods reduced the importance of the inflow of foreign embodied technology but led to an increase in the inflow of foreign disembodied technical knowledge because of the presence of foreign enterprises in the sector and contracts of technical assistance signed by the national enterprises. 16

This way the policy of relative autonomy implicit in the policy of substitution for imported capital goods must be understood in its strict technological meaning. The reduction of the dependence on external sources was certainly not the aim of the government’s global policy, which in reality was promoting a new mode of inserting the Brazilian economy in the international capitalist system. It was not by accident that the effort to reduce the importation of incorporated technology was accompanied by the consolidation of new forms of transfer of technology: such forms corresponded to the new economic links between Brazil and the rest of the world.  

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16 National enterprises counted mainly upon two foreign sources of disembodied technology: engineering firms and industrial enterprises that neither had nor intended to set up subsidiaries in Brazil but wanted to participate in the country’s market in view of the restrictions on imports, the presence of foreign competitors in Brazil and the possibility that national enterprises could be set up with know-how from other sources. On this point see Biato et al. 1975. As regards the specific case of the capital goods industry see Erber et al. 1974.
The 3-Year Plan

The 3-year plan of economic and social development for 1963–65 (presidencia da república, 1962) was designed when inflation was accelerating and the rate of growth of the national product was declining in a reflection of the worsening tensions and disequilibria and the exhaustion of the possibilities of expansion through import substitution. On the other hand, the years preceding and the year following the elaboration of this plan were characterized by marked political and institutional instability, which, together with the problems faced by the economy, brought about the absence of perspectives and the indefiniteness and transitoriness of the proposed economic policies.

The 3-year plan was affected by such instability, its implementation being gradually abandoned in 1963, and so before the institutional changes caused by the 1964 political events. In this sense, the remarks that follow refer to the intentions and directives outlined in the plan rather than to the economic policy implemented in this period.

Although among the plan’s basic aims the maintenance of a high rate of growth of income ranked higher than the gradual reduction of inflation, the focus of the preoccupations, in contrast to that of the target program, moved from industrial development to the slowdown of inflation. On the other hand, in what are referred to as “long-term preoccupations . . . it is possible to distinguish a vague tendency to the diversification of the objectives proposed . . . be it on account of the demand for basic reforms or on account of the requirements of a diversified structure . . . together with a preoccupation with the complementation of the industrial system, partial measures oriented towards regional development, the transformation of the agricultural sector, the encouragement of industrial exports and so on” (Lessa 1964).

From the viewpoint of its technological implications, the proposed development strategy of the 3-year plan, in contrast with that of the target plan, would not have caused a significant increase in the demand for technology by the production system. It is true that the Brazilian economy’s technological needs were then significantly more complex and more intense than in the middle of the previous decade. This situation, however, was a result of the evolution of the Brazilian economy, especially of the expansion of the mechanical and electrical industries and of the segment producing intermediate goods. With the 3-year plan, it was only the intention of promoting the restructuring and modernizing of the agricultural sector that led to the changes in the demand for technology; the other indications of sectorial policies, such as the expansion of the capital goods industry, pointed only to the need for increasingly sophisticated technology which was already apparent.

Moreover, in the course of the Brazilian economy’s evolution, channels of transfer had been established that ensured the supply of the technology required for industrialization. The problems the economy faced in the early 1960s threatened the efficiency of operation of these channels: the reduction in the importation of capital goods also reduced the access to the embodied technology; in addition, the loss of dynamism from the growth process, the unfavourable economic situation, and the political instability discouraged the entry of foreign capital.
From the viewpoint of a policy of response, however, such obstacles did not imply the necessity of adopting specific measures in the area of S&T. The barriers to the continued supply of needed technology from foreign sources were caused by problems that could be overcome only through the adoption of more general measures of economic policy.

Therefore, it is worth pointing out the government’s actions in those areas, as well as identifying the meaning they had for technology.

First, the importance attributed to foreign capital in Brazil’s economic growth was less in the 3-year plan than in the target program. A measure adopted outside the framework of the 3-year plan, Law 4131, regulated foreign investment and the remittance of profits abroad (restricting to a maximum of 5% in 5 years the rebates allowed in the income tax statements of corporations for remittances corresponding to imported technology), and had a neatly restrictive and disciplining effect.

Although the target program did not emphasize this aspect in its policy on foreign capital, the setting up and operating of foreign enterprises constituted an important channel of transfer of technology into the country; with the 3-year plan the supply of technology obtained through this channel was to be reduced.

As to the difficulties in the balance of payments and the consequences in relation to the use of the technology embodied in the imported capital goods, the 3-year plan was clearly preoccupied with advancing the substitution of domestically produced machines and equipment for imported; this was evident from the large proportion of resources devoted to this aim and from the target of producing domestically two-thirds of the equipment necessary for the implementation of the plan’s industrial policy.

Thus, the apparent intent of the 3-year plan was to promote the directions that economic development was taking, both in the area of import substitution (a proposal of the target program) and in the area of basic reforms, especially agrarian reform. Moreover, the government’s political discourse emphasized these perspectives of change. It was therefore to be expected that the changes indicated by the more general political directives would be accompanied by a reorientation of the S&T policy that would support the new course of events. That is to say, although from the viewpoint of a policy of response the need for specific measures in the area of S&T was limited, a vigorous policy of relative autonomy was required to make feasible the proposed changes in the patterns of development.

The 3-year plan made clear its attention to the country’s S&T development by listing among its basic objectives:

... To intensify substantially the government’s action in the fields of education, of scientific and technological research, and of public health, in order to assure a rapid improvement of man as a factor of development and to allow the benefits of cultural progress.

And, in its basic directives relative to nuclear power the plan indicated that this objective was not restricted to ensuring that the technological demand be satisfied, but also included the intention of promoting the country’s ability to produce its own technology:
... To the extent that one considers industrially developed a country which can satisfy its basic needs by means of a technique and resources of its own, Brazil will not overcome (not even in the long run) the cycle of underdevelopment if, on account of a deficiency of the government program, of industrial technique and aptness, it remains dependent upon the importation of experience, techniques, equipments and nuclear fuel — with the resulting outflow of foreign exchange — for the production of electricity on a nuclear basis.

Although the plan did not present an explicit S&T policy, segments of such a policy were identifiable in the directives related to the nuclear power program, the technological needs of agricultural sector and the training of technical personnel.

In relation to nuclear power, the plan outlined a set of initiatives that characterize well a sectorial program of S&T development of obvious importance to the planners. The program, which should be implemented by the National Nuclear Power Committee in cooperation with research bodies and private industry, established, together with the construction of nuclear power stations, the production of nuclear fuel and the prospection, mining and processing of nuclear minerals, that S&T research should be carried out, especially in the field of reactors and of materials for reactors, and that the technology of radioisotopes should be developed, with the aim of their production and application.

As to the agricultural sector, the plan stated the intention of promoting its modernization and restructuring, identified the country’s deficient agrarian structure as the most serious obstacle to the rational use of the land and to the permanent technological improvement of agricultural activity, and included among its basic aims “to gradually eliminate the institutional barriers responsible for the wastage of factors of production and for the slow assimilation of new techniques.” Moreover, the plan recognized that increasing the incorporation of technology into agriculture depends to a large extent on the intensity and continuity of the works of research, experimentation, demonstration, and incentive, which, owing to their nature and cost, can only be carried out through government agencies. It also stated the need for a new structure and new norms of operation of the government apparatus and proposed to expand government expenditure in programs of research and incentive. The plan, however, did not go beyond this indication of directives, nor did it specify more concrete measures.

The training of technical personnel received less attention in the 3-year plan than in the target program. The brief program of education concentrated on primary and secondary education, although 31% of the proposed budget was devoted to university education. Resources allocated to S&T research constituted 1.2% of the total planned expenditure of the program, but the application of these resources was not specified.

Although less emphatic than the target program, the 3-year plan did not ignore the production system’s need for specialized personnel, and outlined these needs in the context of the industrial development program with more clarity than the target program. It acknowledged the shortage of qualified personnel at all levels as an obstacle to the acceleration of industrial development and stressed the need for training technicians,
especially engineers and project designers, to satisfy the expected expansion of the mechanical industry.

The directives related to the training of technical personnel were geared to supplying the technical cadres required for the production system. The previous expansion of the capital goods industry had resulted in a greater demand for technicians in that industry because it had become convenient for the industry to develop its own capacity for planning nationally. Furthermore, the 3-year plan stated that foreign participation in the installation of new industrial units had reduced the competitiveness of the national capital goods industry because of the difficulty of untrained individuals in following the specifications; besides the training of engineers and project designers, the plan proposed the organization of specialized bureaus to assist in the installation of new industrial units.

Finally, one should stress as an initiative parallel to the 3-year plan the approval of Law 4131, which not only regulated foreign investment and the remittance of profits abroad but also defined for the first time the legal situation of contracts with foreign parties related to the transfer of technology and established norms about the payments to be made. This legal text, although part of a law whose basic concern was restricting the remittance of earnings abroad, aimed at fostering the absorption of technology and created a structure of incentives differentiated according to how essential the industry was that would be using the technology (Biało et al. 1973). The decree of the executive power that regulated this law introduced important changes in relation to the transfer of technology by limiting to 5 years the period in which contracts with foreign parties would be allowed to generate remittances and restricting the amount of such remittances to 2% of the cost or of the gross earnings of the product.

The measures specifically related to S&T were undoubtedly insufficient to replace the foreign sources of technology and thus support an overall policy of transformation of the economic links between Brazil and other countries.

Nor was it possible to identify an implicit S&T policy in the other directives of economic policy of the 3-year plan that could lead to the necessary transformations. In contrast, the target program, though not containing an explicit S&T policy, presented the answers to the needs of that stage of Brazil's growth in other instruments and measures of policy.

The policy of the 3-year plan of maintaining the level of public investment had favourable effects on the capital goods industry because the state was the main (and in some cases sole) buyer of capital goods. In the same way, the favourable attitude toward this industry was translated into proposals of more rigorous application of the idea of domestically producing machinery and equipment that had been imported.

In the same line, the 1961 exchange reform was introduced to establish a more efficient market reserve for the national capital goods industry by raising the relative prices of those goods (Lessa 1964).

The Government's Program of Economic Action

When the government's 1964–66 program of economic action (ministério do planejamento e coordenacao econômica, 1965) was elaborated, the Brazilian economy was much the same as it had been when
The 3-year plan was drawn up; however, the tensions and disequilibria had increased, and, as a consequence, the rate of inflation had increased and the slowdown in economic growth had worsened. The differences between the two plans seemed to stem rather from the important politico-institutional changes of 1964.

The basic aims of the economic policy outlined in the program of economic action were close to those presented in the 3-year plan: to speed up economic development; to contain inflation gradually; to reduce the sectorial and regional economic imbalances and the tensions generated by social disequilibria; through the investment policy, to ensure opportunities for productive employment to the growing labour supply; and to correct the tendency toward uncontrolled deficits in the balance of payments. Among those aims the fight against inflation was undoubtedly given the highest priority, under the assumption that improvement in the rate of growth would follow.

The program of economic action did not outline a specific S&T policy; moreover, it presented very few measures specifically linked to S&T activities. Those presented were in the area of educational policy and were aimed at increasing access to education, rationalizing the use of available resources, and adjusting the educational structure to the technical and cultural needs of modern society.

The lack of an explicit policy for the promotion of the country's S&T development did not mean, however, that the program ignored the Brazilian economy's needs in that field. In fact, the document stated that "technological improvement is as important as, or even more important than, the increase in the rate of capital formation itself in the process of development." But the planners apparently considered that those needs should be satisfied from foreign sources, and their proposed answers to the technological questions in Brazilian development are implicit in the other directives of economy policy.

In this sense it is worth stressing the policy of encouraging the entry of foreign capital, a policy based on the recognition that foreign capital was important because of the marginal growth of the investment rate and because of the need for reinforcement of the country's import capacity, for technological contributions to the modernization of the Brazilian economy, and for increased national productivity. This policy aimed at correcting, even by means of changes in the profit remittance law, the inadequate treatment of and hostile climate to foreign capital, which had contributed to stopping its inflow in the recent past, after it had made an important contribution to the development of the national economy in previous years, chiefly in the period 1957–61, in response to less restrictive legal treatment.

This way the program of economic action resumed the opening of the Brazilian economy to foreign countries promoted by the target program, deepened the Brazilian economy's insertion in the international economic system, and emphasized the advantages of maintaining a certain degree of international division of labour.

From the viewpoint of technological contributions to the country's production system, the policy of encouraging the inflow of foreign capital had a twofold objective: first, to increase the importation of capital goods and of the embodied technology, and, second, to supply more technological knowledge and thus save Brazil from substantial expenses in research.
International connections represented the most accessible way for Brazil to become updated in that basic requirement of economic progress.

The proposed solutions of the program of economic action for the technological problems associated with growth and with the operation of the country's production system characterize a policy of response that corresponded at the technological level, to the reopening of Brazil to the external world proposed by the economic policy. In this sense the problem was to reconstitute the now less efficient channels of transfer of technology created by the target program and thus make it possible to go on satisfying the production system's demand for technology.

The reconstitution of the channels of transfer was not restricted to attracting foreign capital, but included the creation of conditions favourable to the establishment of contracts of transfer of technology and to the importation of capital goods. With the reform of the profit remittance law the 5-year limit during which contracts of technical assistance were allowed to give rise to remittances was abolished, as was the limit on the amount of such remittances of 2% of the cost or of the gross earnings of the product.

As regards the strengthening of the Brazilian capital goods industry, a fund was created for the financing of the purchase of industrial machinery and equipment. The support given by this fund to the industry was, however, initially limited because of the short terms and the not very favourable conditions of payment in comparison with those of the international market. Other measures were aimed at reactivating the demand for capital goods without specifically establishing privileges for the national producers. Among these measures several stand out: the policy of public investment in the economic and social infrastructure; the immediate incentive to investment in several sectors represented by the permission to accelerate the depreciation of new equipment; the textile industry's program of modernization and re-equipment; and the programs of investment in the steel and chemical industries, particularly in the areas of petrochemicals and fertilizers. The facilities granted for the importation of equipment required by high priority projects often reduced the impact of such programs upon the Brazilian capital goods industry.

In fact, the metallomechanical enterprises were in a general state of recession, with much of their capacity idle and with serious financial difficulties. Hence, any attempt to advance the process of substitution of domestically produced capital goods for imported was not feasible. In the planning of policy for this sector, the recovery of its level of activity should be considered.

The Strategic Development Program

The strategic development program for 1968–70 (ministério do planejamento e coordenacao geral, 1968), though very close to the government's program of economic action in its objectives, had signifi-

See on this subject Biato et al. (1973). Although the legislation did not impose any limits on the amount of remittances, in practice the percentages adopted for income tax rebates were established as the limits for the earnings remitted.
cantly different emphases and priorities. The new program presented as its basic aims the acceleration of economic development at the same time as the containment of inflation, social progress, and the expansion of employment opportunities; but, in fact, it put in second place reducing the rate of inflation and concentrated its efforts on the resumption of growth.

Starting from a diagnosis of exhaustion of the process of import substitution as the cause of the slowdown in growth, and of cost pressures as the chief obstacle to the elimination of inflation in the recent past, the program proposed increasing the overall rate of savings and investment, both public and private, and maintaining a high level of private consumption and of overall demand.

As regards industrial development, the program stressed the need for diversifying the sources of dynamism by expanding the internal market, developing import substitution in the mechanical, electrical, chemical, nonferrous metals, and steel industries, and promoting exports. This required an increase in the national industry's competitive power through an increase in its efficiency, the expansion of a certain number of dynamic sectors, and the reorganization and modernization of traditional industries.

From the viewpoint of S&T this program was an important landmark: not only were the needs of the Brazilian economy in this area emphasized, but also the document proposed the first explicit, systematic S&T policy for the country. No longer were the answers to the technological problems of Brazilian development simply implied in diffuse measures or in the other directives of economic policy. The new program devoted two chapters to an assessment of the role of technological progress in a country's development and to the programming of initiatives in this field. Moreover, the emphasis on technology also appeared in the indications of sectorial policies, especially industrial policy.

The directives based on the S&T policy — a policy that incorporated in its justification the experience of more economically developed countries — stressed not only the need to speed up the incorporation of imported technology in the production system, but also the importance of the country's undertaking its own research because "imported technology is not always adequate to the importing country's constellations of productive factors" and "as industry becomes integrated, the absorption of technology itself requires local research and development." In fact, as the program noted, it would be difficult to cite an example of a country in which fast and self-sustained growth has not been supported by domestic technological development.

The strategic development program emphasized the importance of the development of S&T research, its main objectives being to stimulate the knowledge of the country's natural resources and to solve the specific technological problems, to support and develop national technology, and to follow S&T progress elsewhere. Its guidelines were the principles of coordination of government action, decentralization of implementation, concentration of national financial resources, and provision of incentives to the participation of the private sector. It was recognized that, more so than in more industrialized nations, in Brazil the government would play the chief role in the financing and directing of research, in view of "the global insufficiency of knowledge, the scales of production and the
predominance of foreign enterprises with substantial research plans in the mother companies.”

These objectives would be pursued through the activities of the National Research Council; the coordination of a basic plan of S&T Research, which would put together priority programs and projects to receive preferential financing; the strengthening of national research institutions; the concentration of public resources and the collection of private resources for the research programs; the financial support of the training and the work of researchers; and the reorientation of university education.

The financial support of S&T development would be strengthened through the National Research Council (which managed funds aimed mostly at basic research) and the National Development Bank (which from 1964 ran the Fund for Techno-Scientific Development, a fund geared almost entirely to training programs), as well as the creation of the National Fund for Scientific and Technological Development. Lastly, basic government programs in the S&T area were set up, to be coordinated by the National Research Council, the National Fund for Scientific and Technological Development, the National Committee of Space Activities, and the National Nuclear Power Council.

These measures were essentially the same as those advocated in subsequent government plans, though various improvements were introduced in the later plans.

The persistence of the directives proposed in the strategic development program is even more remarkable when one considers the pioneering nature of the propositions. Not that there had never been in Brazil government action in the S&T sphere (the National Research Council was created in 1951), but such action, besides being sparse, was radically distinct from what the government intended to do, according to the directives in this program. Previous action had been oriented, above all, to scientific research in universities and had paid no attention to the research needs of the national production system (Biato, Guimaraes, and Figueiredo 1971). In this sense, the government, with its S&T policy, planned to have a significant influence on the practices of scientists and researchers by emphasizing technological research and attributing priority to the activities more directly linked to the needs of Brazilian development.

On the other hand, the S&T policy of the strategic development program was a policy of relative autonomy, for among its objectives was not only the more rapid incorporation of imported technology but also Brazil’s creation of its own technology so as to reduce the dependence upon foreign sources of know-how. Such a directive constituted a radical change from the implicit orientation of the program of economic action, with its exclusive emphasis upon the contribution of foreign technology. That directive deserves, therefore, closer examination, to identify whether it corresponded to new needs linked to changes in the more general directives of economic policy.

The two programs differed in the priorities given to the several aims of the economic policy. This reshufling of priorities, however, did not imply on its own the need for greater technological autonomy. However, the strategic development program went further when it emphasized, as a necessary condition for fast and self-sustained economic growth, the
creation of a mass market — a large percentage of the urban and rural population that had an income capable of allowing them regular consumption of industrial goods, chiefly nondurable ones, so as to sustain the growth of the traditional industries.

The directives in the strategic development program related to S&T seem to be associated with the creation of a mass market through the development of technologies more adjusted to the country's production factors and, therefore, capable of ensuring greater absorption of labour without threatening the growth of the product.

In this context, the reorientation of the S&T policy proposed in the strategic development program could be understood as a requirement of the program's overall development strategy.

Nevertheless, such an interpretation deserves some qualifications. First, given a certain structure of demand and consequently a certain structure of production, the existing technological options are not unlimited. In the same way, the use of more labour-intensive techniques depends not only on their availability but also on the entrepreneurs choosing them. In this sense, emphasizing the development of labour-intensive techniques from the viewpoint of their contribution to the expansion of employment and to the enlargement of the domestic market could mean overestimation of the potential influence of S&T development on the pattern of economic growth — even more so if the expansion of the domestic market finds no support in other areas of economic policy.

The planners of the strategic development program were not unaware of these matters, for the program pointed out the factors that, in the course of industrialization, reduced the rate of absorption of labour, and outlined some measures aimed at speeding up the expansion of employment. In the same way, it proposed a policy of income distribution that considered both the employment policy and the rise in the workers' real income to be brought about by programs of housing, education, health, sanitation, and changes in the tax policy.

Nevertheless, the evolution of the industrial sector in that period, especially the growth in the demand for nondurable consumer goods, reflects the failure of this policy of enlargement of the domestic market through the incorporation of the strata with less purchasing power. The maintenance of the level of private consumption stemmed chiefly from the increased demand for sophisticated goods — above all, durable consumer goods — by the upper income groups. This way, in contrast to what was planned in the target of creating a mass market, not only did the high degree of income concentration become a factor making feasible the expansion of private consumption, but also this expansion was directed to sectors that are characteristically capital-intensive. In the same way, the increase in industrial employment was a consequence of the dynamism of those sectors; the low growth rate and the modernization of production in the traditional branches resulted in a small expansion of employment in most of these branches and, in some cases, a reduction in the number of people employed.

In presenting such evidence, it is not our intention to point out a failure of the S&T policy. This policy could not — and was not designed to — give results in the short term. Our evidence suggests, however, that the Brazilian economy's evolution — which was markedly influenced by the economic policy implemented in the period — was following a pattern
other than that envisioned by the planners of the country’s S&T development.

Thus, beside the propositions regarding S&T, the strategic development program contained a technological policy implicit in the directives and measures related to economic policy adopted in the period and distinct from that specified in the program.

The Targets and Bases for Government Action

The government’s plan for 1970–71, targets and bases for government action (presidencia da republica, 1970), responded to the need of more time for the setting up of the first national development plan and of the new planning procedures established in the 1969 legislation. Its transitory character would make a detailed examination of this document a fruitless exercise. Moreover, from the viewpoint of the actions proposed in the S&T sphere such an analysis is not necessary.

The document defined as the national priorities for the period a revolution in education, agriculture, and food supply, an acceleration of the health and sanitation program, and of S&T development, and a strengthening of the national industries’ competitive power; it retained the emphasis on S&T of the strategic development program.

As regards the last field, the 1970–71 plan had the following basic aims: to keep abreast of S&T progress, particularly in areas with wider technological perspectives; to adapt imported technology to the national conditions of production; and to solve technological problems specific to Brazil, chiefly in the spheres of industry, agriculture, and research into natural resources.

The initiatives suggested for promoting S&T development were basically the same as those of the strategic development program. They aimed at creating the physical, institutional, and financial bases for making development feasible. Moreover, the objective of more significant participation by the private sector in S&T development was given more emphasis than in the strategic development program. The attainment of this objective was to be supported by the following: fiscal incentives for the promotion of research and the use of innovations; encouragement of the development of product engineering and, gradually, of process engineering; the search for ways of leading foreign enterprises actively to participate in national research; and the integration between university and industry.

Lastly, on account of their later development into the directives of the first national development plan, one should take note of the technological initiatives directed at strengthening the national industry’s competitive power: the definition of technology-intensive sectors that the country might develop in a rational way to participate in the new industrial revolution, and the analysis of technological evolution in the other industrial branches to consider how to make this evolution compatible with the policy of expanding employment; the adoption of special measures of support to the national entrepreneur, including the financing of and the provision of incentives to S&T research; the transfer of the results of domestic S&T research to industry.
The First National Development Plan

The first national development plan (República federativa do Brasil, 1971), intended for the period 1972–74, corresponded to a new economic conjuncture. The program of economic action had been drawn up during a period of economic recession and uncontrolled inflation, and the strategic development program had been drawn up when inflation was reasonably contained but the recession still existed, and economic activity fluctuated during the program’s term. The first national development plan, in contrast, was designed following the resumption of growth and the maintenance of a high rate of expansion for 4 years.

In this context the new plan presented the following as the great national objectives of Brazilian development: to raise Brazil within a generation to the category of a developed nation; to double the country’s per capita income by 1980; and to reach, while the plan was in force, a growth rate of between 8% and 10% per year in association with expanding employment, a decreased rate of inflation, and an international economic policy that would accelerate the country’s development.

The objectives were to be reached through the greatest possible exploitation of the country’s potential for growth, the growth and expansion of the market, and the consolidation of Brazil’s competitive power. The last was to be accomplished through the development of a basic nucleus of expansion to ensure the supply of essential input at prices near those of international competitors; a capitalization policy to give the financial system a more important role in the formation of the enterprises’ real capital; the creation of a Brazilian model of industrial capitalism aimed at creating the large national enterprises or at leading Brazilian enterprises to participate in large-scale undertakings; and a policy of modernization of the national enterprise (public and private) in both technological and managerial respects.

The plan’s main directives for industrial strategy, besides the strengthening of the national industry’s competitive power, were the strengthening of national private enterprise (by equalizing the conditions under which it and foreign enterprise operate) and the enlargement of industry’s role as an instrument of technological change in the other sectors. The technological implications of those directives were emphasized by the plan when it gave a strategic importance to the capital goods sector and when it proposed the development of new sectors with a high technological intensity, the modernization of the traditional industries, and the expansion of the exportation of manufactured goods from industrial branches with more refined technology.

Starting from this reaffirmation of the importance of the country’s S&T development for the fulfillment of the national objectives, the plan defined its S&T policy, associating it with the strengthening of the national competitive power in priority sectors, among which were certain industries with a high technological intensity.

Such a policy emphasized, together with the acceleration and orientation of the transfer of technology, the supplementation of importation of technology with technological adaptation and the creation of a local technology, because an increase in the national industry’s competitive power depended on greater domestic production of technol-
ogy. The incorporation of the so-called product and process engineering to create national models and processes allowed on the one hand better adaptation of the products to the market conditions, and on the other better use of the country's comparative advantages as regards production costs.

The directives of the S&T program were: to direct and speed up the government's action in the area, chiefly through the operation of the supporting financial system for technological development and the coordination of the actions of the main government research institutions by means of a basic plan of S&T development; to develop priority technological areas (nuclear power, space research, oceanography, technology-intensive industries, infrastructure technology, and agricultural research); to strengthen the technological infrastructure and the capacity for innovation in the national enterprises, private and public; and to accelerate the transfer of technology, through integration of industry, research, and university.

This program of government action constituted, in fact, a reaffirmation of initiatives established in the strategic development program, though improvements were incorporated that had been suggested by the implementation of some measures proposed in that program. It unfolded into the first basic plan of S&T development for 1973–74 (presidencia da república, 1973), a plan that was really a detailed version of the policy directives and the lines of action defined by the first national development plan, and presented, besides an S&T budget, the priority programs and projects to be implemented during 1973–74.

The first basic plan of S&T development was significant because it represented both a reaffirmation of the government's preoccupation with the country's S&T development and an effort at coordinating the various segments of the national S&T scheme.

The new development plan emphasized two areas that had received little attention from the first national development plan: the development of technology applied to social development, and the activity of fundamental research and postgraduate courses.

From the viewpoint of the analytic framework presented initially, the S&T policy made explicit by the first national development plan and reasserted by the first basic plan of S&T development, in the same way as the one outlined in the strategic development program, can be characterized as a policy of relative autonomy. It was intended to reduce the technological dependence on the external world through greater adaptation of imported technology and the creation of local know-how.

Nevertheless, the objectives and the direction of technological development were distinct in each plan. The strategic development program emphasized adapting imported technology to the country's production system, chiefly aiming at a higher rate of expansion of employment and thus growth of the market. This implied that the effort to develop local technology should be within the traditional segments of the industrial sector, where the potential technological options were wider; in fact, good results would be unlikely in the more dynamic industrial sectors, characteristically the capital-intensive ones.
The first national development plan did not refer to such adaptation.\textsuperscript{18} In the context of an economic policy that concentrated on the maintenance of fast growth, postponing the problem of income distribution (and opposing growth and redistribution), such a preoccupation would undoubtedly be out of place. The country's technological development was covered in the plan's directive of increasing the national industry's competitive power, particularly in sectors using advanced technology.

In both the strategic development program and the first national development plan technological development appeared to be necessary for expansion of the market: in the former, the link was on the demand side; in the latter, it was on the supply side, through the intention of reducing costs so as to enlarge the domestic market and penetrate foreign ones, and of adapting the products to the conditions of demand and to the changes in consumption habits. The technological development proposed by the latter was to be in the most dynamic segments of that demand, domestically and abroad.

The S&T policy of the first national development plan gained in realism when it abandoned the preoccupation with inducing the growth of employment. Although one could find a justification for the strategy outlined by the strategic development program, the orientation proposed in the first national development plan for the country's technological development, besides overestimating its potential for promoting changes, reflected preoccupations alien to the economic policy implemented in this period. One could ask, however, whether this orientation was part of the plan's overall strategy as well as whether it was in accord with the economic policy implemented in the period. Such questions deserve to be treated separately.

The directive of strengthening the national industry's competitive power implied the demand for deep changes in the country's industrial set-up through intense and permanent technological updating. But such a requirement did not lead to the necessity for domestic creation of technology. The presence — often dominant — of foreign enterprises in the most technologically dynamic sectors and the relatively easy access to the know-how available in the international technology market undoubtedly made possible a supply of the innovations required for the fulfillment of that directive — that is, the links between the Brazilian economy and the nucleus of the international capitalist system were favourable to continuing economic growth of Brazil without the need for domestic creation of technology.

In this sense, when it proposed that the country reach greater technological autonomy, the first national development plan went beyond the mere preoccupation with satisfying the needs stemming from economic growth and made explicit its intention of reducing — or, at least, of avoiding the growth of — Brazil's dependence on world economic centres. Thus, technological development also appeared to be associated

\textsuperscript{18} The proposals linked to the expansion of employment did not consider the development and use of labour-intensive technologies, and the first basic plan of S&T development referred only marginally to the importance of associating technological policy with employment policy, aiming at ensuring the compatibility of the former with expanded employment.
with the intention of strengthening national enterprise, both public and private.

As a matter of fact, with the recognition that technological progress rapidly changes the structure of production and management, leading in particular — together with economic and financial factors — to an increase in the number of large-scale projects, conglomerates, and multinational enterprises, the S&T policy aimed at the strengthening of the capacity of absorption and creation of technology by national enterprise, both public and private.

The contribution of foreign enterprise was not discarded, but it was considered that foreign enterprise should orient its investments chiefly to areas with more refined technology, where the transfer into the country of new technologies and modern managerial methods would be more important; the plan stressed, however, that the action of foreign enterprise in fields already occupied by national enterprise having adequate know-how and capacity for investment was particularly undesirable. In this context it seems reasonable to infer that a growing technological qualification of national enterprise would mean a progressive limitation of the field open to the foreign enterprise.

However, technological changes are certainly necessary conditions, but not sufficient ones, in the determination of significant alterations in the patterns of economic growth. Moreover, S&T development can be unsuccessful when its direction does not converge with the natural evolution of the economic system or when the development is not supported by measures of economic policy in the same direction.

The previous characterization of the S&T policy made explicit in the two development plans as one of relative autonomy implies the recognition of the nonexistence of that convergence. Therefore, we should now examine the economic policy implemented in the period and its implications from the viewpoint of S&T development.

The Economic Policy of 1967—73

The economic policy implemented in 1967–73 did not correspond entirely to what was contained in the government plans in force, in some instances because the way the programmed action was conducted led to results distinctly different from those expected, in others because policy instruments and measures whose use was not predicted were employed, and in others because the economic policy was not implemented according to the principles and directives proposed in the plans.

These “disadjustments” were not specific to the period in question, but they seem to have been important enough to characterize an S&T policy implicit in the economic policy implemented in the period, an S&T policy distinct in several respects from those outlined in the strategic development program, the first national development plan, and the first basic plan of S&T development.

However, even when such divergence has been verified, it does not exclude the possibility that the actions planned in the S&T area will be carried out. But discrepancies of this kind not only restrict the efficiency of the program as regards the fulfillment of its objectives, but also can
perpetuate the autonomous nature of the S&T policy, isolating this policy from the government’s policy.

Some of the aspects of the period’s economic policy, especially the industrial one, that relate to the questions asked in the text and whose technological implications are more apparent and immediate will now be examined.

The examination — a partial and incomplete one — will be developed therefore, at two levels. First, we will identify the degree of convergence between the economic policy of the period and the objectives pursued in the proposals for the promotion of S&T development — that is, assess to what extent the preoccupation with the increase in the rate of labour absorption and the consequent growth of the internal market, as well as with the strengthening of national enterprise, manifested itself in the economic policy of the period. After that we will evaluate the technological implications of some of the policy instruments and measures adopted.

The question of increasing the rate of labour absorption was previously related to the structure of demand, which can direct the expansion of production to sectors that present few technological alternatives, and to the effective choice by entrepreneurs of the most labour-intensive alternative. In particular, the option of postponing the efforts toward income redistribution with the aim of maintaining the accelerated growth undoubtedly resulted in directing the expansion of the industrial sector to its most capital-intensive segments. This tendency, on the other hand, was reinforced by the promotion of consolidation and growth of the financial system and the resulting expansion of financing operations for the consumption of durable goods.

As to the strengthening of national enterprise, it is possible to identify policy instruments and measures that were mobilized in this direction, among which stand out the policy of the government financial agencies, especially the national development bank, and the procedures adopted in the expansion of the petrochemical industry. The government financial agencies were restricted to financing national enterprise as well as creating specific funds for industrial financing. As regards the petrochemical industry, the formula of coparticipation of the state, national private capital and foreign capital in the newly formed companies ensured the participation of national entrepreneurs.

The concession of fiscal incentives to the merger and incorporation of enterprises and the institution of bodies aimed at giving administrative and managerial assistance to small and medium-sized enterprises were initiatives that could lead such enterprises to become more efficient and thus strengthen their competitive power.

Nevertheless, the results of the efforts undertaken in that direction were not very significant. Their positive effects were compensated by the foreign enterprises’ greater dynamism in a context in which the most significant incentives offered to the private sector — the incentives to industrial development and to exportation — benefited national and foreign enterprises equally.

The industrial policy of the period had as its central instrument the subsidy to capital formation in the priority industries by means of exemption from the import tax and from the tax on the circulation of commodities in the case of purchases abroad of machinery and equipment.
when similar goods were not produced domestically, and, from 1970, exemption from the tax on industrialized products and imported capital goods, credit to the buyer of national equipment in the value of the corresponding tax on industrialized products, and the right to consider accelerated depreciation of domestically produced goods for income tax purposes.

But the implementation of this policy by the Industrial Development Council was not very selective: not only were such incentives extended to nearly the entire manufacturing industry, but also the approval of projects submitted to the council was practically automatic, the reasoning being that the basic responsibility of the investment decision remained with private enterprise.

Although this policy of cheapening the cost of capital was efficient in the sense of encouraging the expansion of investment in industry, the indiscriminate concession of incentives prevented this instrument from being used to adjust the investment flows to the objectives of government policy. Instead, the investment options suggested by the market were merely made more profitable, and the incentives were granted equally to national and to foreign enterprises.

The policy of incentives to exportation was characterized by the continual mobilization of new instruments and measures, which implied the raising of burdens, the granting of subsidies, and the encouragement of the enlargement of productive capacity.

Among the incentives aimed at increasing the competitiveness of Brazilian products in the international market, which benefited both national and foreign enterprises, some stand out: the fiscal credit of the taxes on the circulation of commodities and industrialized products relative to the products exported; the exemption from the import tax and the tax on industrialized products in the purchase of capital goods, input, and raw materials by exporting enterprises; and the government financial assistance to the export activity.

Other incentives adopted in 1972 were aimed at inducing export-gear investment decisions: with the concession of exemption from the import tax and the tax on industrialized products and the abandonment of the law of the domestically produced similar article, new and second-hand equipment and whole industrial sets could be imported, even after being in use abroad, under the condition that in Brazil they produced essentially for the foreign market. Such benefits had as their main target the big multinational corporations installed in the country and those that might settle in Brazil in the future, which would be better able to bring about substantial increases in exports. But essentially national firms, especially small and medium-sized ones, could occasionally find themselves, as a consequence of those measures, in a position of relative disadvantage, not only in the foreign market but also in the domestic market. In fact, these incentives did not affect the relative performance of national and foreign enterprises (Doellinger, Faria, and Cavalcanti 1974).

With the strong incentives that benefited equally national and foreign enterprises, the greater flexibility and operational dynamism of the multinational enterprises allowed them to respond more promptly to the market indications and to the government incentives; thus, their position in the Brazilian economy relative to the national enterprises was strengthened. There were undoubtedly some exceptions, but these were
mainly in sectors such as steelmaking and petrochemicals in which the implementation of industrial policy had particular characteristics. In these sectors, despite the high capital density and the high degree of technological complexity, the position of national capital was preserved and its participation reasserted. The fact was, however, that government action here was not restricted to the manipulation of indirect incentives but included the mobilization of more concrete instruments, the definition of targets, the delimitation of the roads open to private enterprise, and the effective participation of public enterprise.

Lastly, among the instruments and measures of economic policy adopted in this period, were those with more immediate repercussions on the country's S&T development.

Let us first consider the central aspect of the policy of encouraging industrial development — that is, the policy of cheapening the cost of capital implemented by the Industrial Development Council. The unfavourable effects of that policy as regards the consolidation of the capital goods industry have been widely emphasized. This was especially true up to 1970, when the incentives referred only to imported goods, although the effects were still apparent, albeit milder, after the changes introduced that year. In stressing the preference for imports the policy of subsidy to capital formation undoubtedly limited the expansion of the capital goods industry; above all, it discouraged the substitution of domestically produced goods for imported goods through the production of technologically more sophisticated machines and equipment. Even after 1970 some discrimination remained against domestically produced capital goods, represented by the tax on the circulation of commodities, which was rebatable in the case of imports, although this should have been compensated by the accelerated depreciation allowed only to nationally produced capital goods. As regards the incentives to export-gear investments, their significance from the viewpoint of the national industry of machinery and equipment is obvious.

Although several government documents emphasized the importance of giving priority to machinery and equipment produced in the country in the case of government purchases, public enterprises nearly always ignored this directive, and an important instrument was thus lost that might have helped to improve the technological level of the country's mechanical and electrical industry. In fact, because one of the main obstacles to technological progress in this sector is the uncertainty about the evolution of the demand and the resulting disinclination to face the risks involved in the development or the purchase of new technologies, the long-term programming of government purchases and a clear statement of preference for national products could stimulate entrepreneurial initiatives in this sphere. In particular, the anticipation of future demand seems to be, particularly for capital goods made to order, indispensable in the support of the expansion of this industrial segment by domestically developed technology.

On the other hand, an initiative that reflected favourably on the capital goods industry was the introduction, by the fund for the financing of the purchase of industrial machinery and equipment, of new schemes of financing the production and sale of capital goods made to order, in which longer terms and lower interest rates were established.
Another point to be stressed in relation to the technological implications of the experience in the petrochemical sector is that new relationships between the state enterprise and national and foreign private capital were created. At first this consolidated a new system of transfer of technology in which the contribution of foreign technology was not linked to the setting up of a subsidiary of a foreign enterprise (thus appearing as a result of the investment made) nor did it result from mere contracts signed between enterprises in the country and abroad. Part of the foreign participation in the capital of the enterprise was paid for with the technology itself; the process know-how and part of the engineering services were paid for with shares of the enterprise.

The new system allowed the setting up of a sophisticated industrial branch that would probably operate according to the most recently updated international technical standards, with enterprises controlled by national capital and without the resort to state monopoly for their setting up. On the other hand, it could be said that the enterprises were acquiring capacity much more in the sense of operating their factories than of mastering the knowledge that was being incorporated into them, owing to their lack of contact with the central problems in engineering and production. Nevertheless, the contracting of engineering services to be carried out in the country had been concentrated upon a small number of engineering firms, and this might have allowed the strengthening of a nucleus of engineering enterprises that, though not playing as important a role in the absorption of technology, might have become an important instrument in overcoming these restrictions (Araujo and Dick 1974).

Although these considerations do not constitute a detailed analysis of the economic policy in 1967–73 and its technological implications, they seem sufficient to allow us to answer some of the questions we posed before presenting them.

The directives to increase the rate of labour absorption and strengthen national enterprise, linked respectively to the S&T policies of the strategic development program and the national development plan and first basic plan of S&T development, were not dominant preoccupations of the economic policy of the period. It is possible to show measures aimed at supporting national enterprise but such measures were not within the mainstream of the economic policy in force.

That is why if one cannot consider the S&T policy proposed in the government plans as an isolated aspect of the government's policy one must at least recognize that such a policy articulated itself precariously with the overall aspects of the economic policy implemented in the period.

The central objective of this policy — the maintenance of a high rate of economic growth — could dispense with significant advancements in the country's qualification for the creation and adaptation of technology once the required rhythm of incorporation of new technologies could be, as it was, assured by means of the importation of know-how and of capital goods. The principal instruments and measures of economic policy that were mobilized were directed only to the intensification and acceleration of the transfer of technology. Therefore, it would be correct to characterize as a policy of response the solutions for the technological needs of the process of growth implicit in the economic policy implemented in the period.
Conclusions

The target program and the program of economic action, although not presenting an explicit S&T policy, contained, implicit in directives of economic policy, answers to the technological needs in the respective stages of industrialization, besides proposing diffuse measures in the field of S&T. The policy was unmistakably one of response, for it aimed at ensuring the supply of technology required by the production system from foreign sources. It corresponded to the proposition of opening the economy to foreign countries and of deepening the links that connected Brazil to the world economic centres.

Similarly the 3-year plan did not contain an explicit S&T policy. On the other hand, although its economic strategy showed the need for a vigorous and clearly autonomous S&T policy, it proposed actions that were insufficient from the viewpoint of defining an alternative to the foreign sources of technology that would support the changes intended in the form in which the country was inserted in the world economic system.

The strategic development program defined an explicit S&T policy and presented a program of action that basically reappear in the following plans — the targets and bases for government action and the first national development plan. The policy proposed in those plans was one of relative autonomy, for it included among its objectives the country's qualification for the creation and adaptation of technology so as to reduce the dependence on foreign sources of know-how.

The strategic development program emphasized the development of technologies more adjusted to the country's endowment of production factors, so as to ensure greater absorption of labour. The program's preoccupation with the creation of a mass market as a means of ensuring self-sustained growth was absent from the economic policy implemented in the period, and the evolution of the Brazilian economy reflected the failure of this policy of enlargement of the domestic market by the incorporation of strata with less purchasing power.

This preoccupation was also ignored in the S&T policy proposed in the first national development plan (and expressed in detail in the first basic plan of S&T development), which, while reasserting the intention of reducing the dependence on foreign know-how, linked this directive to the propositions of strengthening Brazilian industry's competitive power and strengthening national enterprise. The increase in Brazilian industry's competitive power did not justify on its own the directive of promoting the country's greater qualification for the creation and adaptation of technology, because the technical knowledge that should be incorporated continually by the production system to reach that aim could be supplied by foreign sources, either through the participation of foreign enterprises or through the importation of technology. In this sense that directive appeared to be necessary only when linked to the proposition of strengthening national enterprise and ensuring its participation in the economic growth of Brazil.

Nevertheless, despite the government's initiative of support to the national enterprises, the strengthening of such enterprises was not the dominant preoccupation of the economic policy of the period, which was directed mainly to the maintenance of a high growth rate. In the same way,
the solutions for the technological problems linked to the country's growth that were implicit in the chief instruments and measures of economic policy were aimed, above all, at ensuring the transfer of technology, and thus characterized a policy of response.

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

From this viewpoint, one should stress that, although the adoption of an adequate S&T policy is one of the factors making feasible a certain pattern of economic growth, government action in the sphere of S&T is not on its own capable of determining this pattern. This is so because the efficiency of an S&T policy depends on its degree of convergence with the natural evolution of the economic system or with the economic policy in force, or both, as well as on the support it receives from the other policy instruments and measures.

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5. Evolution of Science and Technology Planning in Colombia

Fernando Chaparro

Changing Views on the Nature and Role of S&T Development

A series of studies undertaken in the 1950s demonstrated the limitations of the traditional production factors (capital and labour) in explaining economic growth. As a result, the following years witnessed a growing interest in S&T as one of the main additional factors that could be used to explain and promote economic development. This interest accounts for the efforts initiated in various countries to promote national S&T activities and to adapt them to local economic and social needs. Thus a new dimension was introduced in national development policy.

In recent years this process of promoting, planning, and coordinating S&T development has been characterized by three specific approaches: scientific, economic, and integrated. Each approach corresponds to a different view of the nature and role of S&T development.

The Scientific Approach

This approach emphasizes the development of a scientific infrastructure and national competence in the field of S&T. It assumes that the strengthening of the scientific capacity and of the research facilities in a country will somehow generate new knowledge and technology relevant to the development needs of the country. Furthermore, it assumes that this knowledge or information will somehow be incorporated into the production sector, thus improving or developing the country’s industrial capacity.

According to this point of view the basic problem is the development of a national S&T capability by strengthening the infrastructure related to these activities through such means as the training of personnel, the creation or strengthening of research centres and postgraduate programs, increasing the financial resources allocated to these activities, etc.

As part of this effort, S&T councils or similar bodies were established in many countries, and these institutions have made important contributions in the areas of research promotion and personnel training.

However, the limitations of this approach became increasingly evident when the simple strengthening of the national S&T capability did not necessarily bring about technological innovations or a greater rate of economic development. The limited capacity of the production sector to absorb and use the new technological knowledge and information, as well
as to identify its technological needs, was increasingly recognized as a serious obstacle. Thus, the problems related to the aspects of demand for S&T knowledge and activities became as important as the problems of their supply.

The Economic Approach

This approach emphasizes the fact that developing countries import most of the technology they use, at great cost, and frequently in a disadvantageous manner owing to market characteristics. Concern about this has generated a series of national and regional studies to determine the following: the characteristics of the transfer of technology; the conditions under which such transfer takes place; the forms of transfer; the obstacles to transfer, such as lack of information and a weak bargaining position; the relation between imported technology (especially when it is inadequate or inappropriate) and the needs and characteristics of the country; and financial and technological dependence. These studies have made significant contributions toward our understanding of the basic problems related to technological development.

One of these contributions has been the creation of special bodies (particularly the royalty committees) and programs to control the importation of technology or to correct its deficiencies and distortions. Nevertheless, this approach considers only a few of the many factors to be analyzed in relation to S&T development.

The analyses of the transfer of technology have generated two important trends. First, various countries have established important measures to regulate the importation of technology, especially in relation to royalty payments. This perspective is very limited, for it takes into consideration only one aspect of the problem (balance of payments). Originally its emphasis was even more restricted. Recently the functions of the royalty committees and registries of licencing agreements have been redefined in an attempt to overcome these limitations. Second, recent studies on the "commercialization of technology" have attempted to integrate the different aspects of the transfer of technology within a much wider context, to include market characteristics and the role of multinational companies. The studies undertaken by the regional program for S&T development of the Organization of American States and by the Andean Pact made important contributions toward a better understanding of this process and the factors affecting it in Latin America.

This approach is also limited in its treatment of the problem. Even though the commercialization of technology is vitally important, it is only one aspect of S&T development and should not be divorced from the strengthening of the infrastructure and national competence in this field. Likewise, the strengthening of the infrastructure should not become totally subservient to the problems related to the transfer of technology.

The combined effect of the simplistic scope of the first approach (limited to a strengthening of the research and scientific infrastructure) and the restrictive nature of the second (commercialization of technology) has introduced an erroneous and artificial distinction between scientific policy and technological policy. The former is restricted to general activities, such as the training of the necessary personnel, that strengthen and develop the research and scientific infrastructure. The latter, on the other hand, centres
its attention on the activities and regulations dealing with the selection, commercialization, adaptation, integration, and use of technology. Thus, the artificial distinction is a result of the separate actions to strengthen the national S&T infrastructure and to regulate the transfer of technology.

The Integrated Approach

Recently a third approach, based on a more comprehensive view of S&T development, has been designed. This approach is not limited to the indiscriminate strengthening of national research and scientific capacity, or to problems related to the commercialization and adaptation of foreign technology. Adopting an overall view, this new perspective considers science and technology inseparable and emphasizes the need for not only local production of S&T know-how, but also an analysis of the appropriate importation, adaptation, and assimilation of foreign technology.

This approach presents S&T development problems in the following terms: First, an analysis must be made of the economic and sociopolitical context in which the transfer of technology and the strengthening of the internal S&T system is to take place. One of the principal goals in strengthening the national infrastructure is to increase the decision-making capacity regarding the creation and adaptation of the S&T needed for national development. The analysis must take into consideration the constraints that regulate and limit this capacity (characteristics and nature of the technological market, S&T dependence, effects of these constraints on bargaining power, and factors that restrain the development of a demand for local S&T activities). Second, the efforts undertaken to develop local S&T capacity must be designed according to national needs, on the basis of an identification of specific national high-priority problems or well defined development goals. In other words, rather than limiting the activities to mere promotion of the indiscriminate growth of supply of the internal S&T infrastructure, this approach propounds the necessity for guiding S&T development according to critical national needs.

The principal tool for implementing this approach is the establishment of integrated S&T development projects in priority areas of national interest. Once national development goals and problems have been identified, the different contributions of science and technology toward their fulfillment or solution must be considered. This implies the consideration of a wide range of elements, from local research to the importation of foreign technology. Consequently, at the individual project level a variety of interrelated components must be analyzed, such as:

- Establishment of technological requirements and necessary information input.
- Nationally existing S&T know-how applicable to the solution of the identified problems.
- Strengthening of the national S&T infrastructure so as to analyze and propose solutions to these problems, including the identification of priority areas for research.
- Identification of technology importation requirements in terms of technological needs that cannot be satisfied locally, including the search for information and the identification of available technologies in the world market.
• Evaluation and selection of technology on the basis of national requirements, conditions, and characteristics.
• Creation of a demand for S&T activities and promotion of adaptive research, which contribute to the strengthening of the national S&T infrastructure and foster the local capacity for assimilating, modifying, and improving imported technology in order to reduce foreign dependence.

Thus, the comprehensive view of S&T development proposed in the third approach considers as complementary the problems of transfer of technology and the strengthening of the internal S&T system.

S&T Planning in Colombia

Colombia has not formally established an S&T policy, nor is this area explicitly treated within the national development plan. However, the national government has recognized in general terms the importance of S&T in the socioeconomic development of the country. Certain government organizations have been established to deal with problems related to S&T development, and official documents prepared by other central planning institutions have included S&T in their analysis of national problems. Nevertheless, a comprehensive system of S&T planning has not been developed to date.

Government efforts in the field of S&T have developed at both the national and the sectorial levels.

At the national level, several organizations have been established during recent years whose activities are directly related to S&T policy or to certain specific aspects of technological development in Colombia. These organizations can be grouped in two broad categories: institutions oriented to the overall design of a national S&T policy, and institutions having direct influence on specific aspects of technological development, especially in relation to the transfer of technology. Most of the latter were established to regulate foreign investment or financial transactions in foreign currency, but they have gradually included technological aspects as one of their prime concerns, owing to the importance of these aspects in the transactions they were regulating; hence, these institutions must be considered as belonging to the institutional network being created in the field of technological development.

At the sectorial level a series of government research centres have been established that function either as departments of the national ministries or as decentralized institutes (e.g. the Technological Research Institute and the Colombian Agricultural Institute). Funds are allocated directly through the budget of the respective ministry. Consequently, these research centres establish the research policy to be followed by the government in their respective sectors through the use of available financial resources in their research projects and activities.

Planning at the National Level

The effort to plan S&T development at the national level began formally in 1968. Before then, the efforts of the public sector in promoting
the development of scientific activities had been limited basically to the creation of centres of research in different economic sectors (such as the Colombian Agricultural Institute, which was created in 1962). These institutions establish their own explicit or implicit research policies.

In February 1968, at the First Seminar on Science and Technology for Development it was recommended that administrative structures be created to design and put into practice a policy that would vigorously stimulate S&T activities in Colombia according to the needs of the country and with the aims and objectives of the development plans. Welcoming this recommendation, the national government created the National Council for Science and Technology (CONCYT) as a consulting body responsible for advising about everything related to the policy of S&T development. At the same time it created the Francisco José de Caldas Colombia Fund for Scientific Research and Special Projects — (COLCIENCIAS) — as a decentralized institute dependent on the Ministry of Education and responsible for the stimulation, coordination, and financing of S&T development.

CONCYT is one of the four national councils at the level of the presidency of the republic (the other three being Economic and Social Policy, Security, and Population and Environment). It is made up of the following 18 members: the president of the republic, who presides over it; the ministers of education, agriculture, health, and development; seven representatives of the scientific community (rectors of universities, and directors of research institutes and of professional scientific associations); two representatives of industry; and four presidential advisers on S&T. The functions assigned to CONCYT by law are to:

- Advise the national government on the design and execution of the S&T policy.
- Give opinions on the plans and projects submitted for its consideration by the national government.
- Advise the government on its relations with international organizations and other countries.
- Suggest the measures necessary to ensure that the utmost use is made of the experts in Colombia and to promote the return home of Colombian scientists and technicians.
- Study the policy of Latin American integration in the field of S&T and present the pertinent recommendations to the government.

COLCIENCIAS is headed by a board of directors of seven members that is presided over by the minister of education and a manager. Although it functions as the executive secretariat of CONCYT and thus for the policies, plans, and programs of the government in S&T development, it does not do so for the S&T activities themselves, such as research. Its functions are to stimulate, coordinate, and finance such activities, not to put them into practice.

Among the various activities of COLCIENCIAS, two are of special importance: the financing of research projects, with the aim of stimulating such activities in Colombia; and the forming of a national S&T policy.

The work of COLCIENCIAS in the field of S&T planning has been
carried out at two levels. At an overall level an effort has been made to identify areas of high priority for the country with respect to research. The priorities and objectives outlined by the government in its policies and plans for socioeconomic development were taken into consideration as a starting point and have determined the areas of research considered important for the country in view of the government's development objectives.

There are two principal methods for the establishment of priorities in the field of research: the deductive method and the method of successive approximations. In the past COLCIENCIAS placed greater emphasis on the first method, but it has gradually ventured into the second. Given the existence in Colombia of important centres of research at a sectorial level, each determining its own research policy with a certain autonomy, a national planning strategy must be based on or take into consideration the method of successive approximations.

Similar planning efforts have been made at the sectorial level with "special projects." These programs have been structured around some problem or area of research considered to be of national importance, with the development priorities of the country taken into consideration.

The task of determining research priorities for the special projects has been carried out by technical advisory committees, in which representatives of the scientific community, other government institutions, and the production sector participate. Greater emphasis has recently been placed on the participation of the last group. The "indicative plans of research" formed at the sectorial level have proved much more influential than the general outlines of overall research priorities. This may be due to the nature of these programs, their greater stability and the greater participation of the various sectors in the technical advisory committees.

During its 6 years of existence, COLCIENCIAS has financed 350 S&T research projects with an approximate value of $50 million (almost U.S. $2 million).

This financial mechanism has, until now, been the main direct instrument COLCIENCIAS has had to implement and to which the research policies it has established could be applied. Because of its characteristics as a fund, COLCIENCIAS has been able to use the financial resources at its disposal in a strategic way to complement the funds of the different organizations carrying out research. Without such financial leverage, the power of a policymaking institution to influence such activities in the country would be minimal. Therefore, financing and the designing of national policy in this field are complementary and should be carried out in an integrated manner.

In determining what effects the financing of research projects has on the economic and social development of the country, two aspects must be distinguished. First, the financing of projects has certainly contributed to the strengthening of the research infrastructure and of the national S&T capacity simply by supporting research in the universities and other centres, contributing to the training of researchers, and increasing the facilities and resources for research in Colombia. But of what real use have the results of this research been, and what effective contribution has the research made to the development of the country?

Earlier in this chapter, I discussed the need for an integrated view of S&T development, beyond the mere strengthening of the national capacity
in this field or the increasing of the supply of this type of services and activities in Colombia. This implies, among other things, that the functions of COLCIENCIAS should not be limited to the financing of research projects but should also include the use of the results of these projects in the production sector, which would necessitate following up the results of each project. Despite the fact that most of the projects financed by COLCIENCIAS have been in the field of applied research, it is difficult to determine or even to estimate what proportion of them have been transformed into concrete technological innovations in the production sector and, therefore, into contributions to the development of the country.

Related to this issue is an important bottleneck in the financing of S&T activities in Colombia. The funds of COLCIENCIAS are generally used to finance basic and applied research as well as technological development efforts that suggest or describe a new technological process or a specific technological innovation. The financing activity of this institution is much more limited in the phase that immediately follows — that is, the transition between the obtaining of results and their effective use in the production sector; transition activities include, for example, basic and detailed engineering, and the building of prototypes and pilot plants.

The lack of a financial mechanism specifically oriented to the transition phase is a serious limitation to the transformation of the national research efforts into technological innovations that can contribute to the development of the country. COLCIENCIAS has been examining, in conjunction with the National Fund for Development Projects, the possibility of creating a fund specifically for financing activities of technological development that could ensure or facilitate the connection between basic and applied research and the effective use of the results of this research in the production sector. Given the nature of these activities the fund would have to consider the relatively high risks in the type of projects it would be financing.

Planning at the Sectoral Level

Important governmental research centres exist at the sectoral level that concentrate most of the research activities carried out in their respective areas.

Colombia has no mechanism to coordinate government funds that are allocated to research or to S&T activities in general; the assignment of financial resources to these institutions is done directly through the budget of the respective sector or ministry. As a consequence of this, the research centres determine the government’s research policy in each of these sectors on the basis of how they allocate funds among the research projects they are carrying out. This does not mean that these research institutes have an explicit, clearly defined research policy. In fact, in most cases they do not.

The institutional relationship between the establishment of research priorities at a sectoral level and the analogous process that COLCIENCIAS puts into effect at a national level has been very limited and sporadic. This is one of the important gaps in S&T development planning in Colombia. If no specific link is established between the two levels the policy in this field made at the national level will be condemned to be of no real significance.
In certain areas a link between the two levels has been partly achieved through the special projects. This link has been sought through the direct participation of research centres in the establishment of research priorities at a national level in specific fields. This mechanism of "participatory planning" may turn out to be much more efficient in linking these levels than the establishment of an institutional or formal relationship between them, especially in a fairly decentralized sociopolitical system such as there is in Colombia.

Conclusions

The efforts of the Colombian government with regard to overall S&T development have basically been limited to the creation of institutions concerned with the planning of S&T development or some specific aspect of it. However, these efforts have not been translated into an explicit national policy or national development plan for this field. Moreover, despite the institutional framework that has been created, no operational mechanism through which such a policy or plan could be established or implemented has been clearly defined.

At the sectorial level important government research centres exist to which funds are allocated directly through the ministries. The fact that these institutes invest considerable amounts of money in research in their respective fields implies that they are making and implementing a research "policy" in each sector. The level at which the designing and formalizing of such policies takes place varies from sector to sector; however, the policies are usually not explicit. It would be interesting to analyze the levels of formalization of the sectorial policies and the procedures used in policymaking. COLCIENCIAS and the Colombian Agricultural Institute are currently designing a joint project to analyze these matters in relation to agricultural research.

As a consequence, two complementary aspects should be mentioned. First, when formulating an S&T policy at a national or overall level one must take into account the fact that most of the research activities in the public sector are carried out in sectorial research centres according to the policies established by each institution. The existence of these sectorial policies cannot be ignored, although in most cases they have not been explicitly designed but are simply "resultant" policies that have emerged from the allocation of funds to ongoing research projects. Among other things, this raises the problem of the relations and coordination between the institutions responsible for establishing a national S&T policy and the large sectorial research centres. Furthermore, this implies that research priorities defined at the national level will have to follow a gradual method of "successive approximations," through which the priorities defined by the research centres and those defined by the policymaking institutions will gradually become more consistent.

The second aspect is that the allocation of funds to the sectorial research centres is made directly through the budgets of each sector or ministry, not through any coordinating body that allocates public financial resources to technological R&D activities. This dispersion of the government's allocation of funds to research activities represents an obstacle to the establishment 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 of these funds. With, for example, a national budget for S&T the allocations to research activities in the sectorial budgets could be clearly contemplated and analyzed. An interinstitutional body composed of various ministries, the National Planning Department, and others would probably have to be established to forge close relations with those responsible for drawing up the national budget.

The two groups of institutions reflected, in the initial phase of their activities, the different views on S&T development.

The first effort COLCIENCIAS made in relation to S&T development was oriented to strengthening the internal infrastructure of research, largely the scientific aspect. As it became conscious of the complexity of the process, COLCIENCIAS expanded its activities, becoming one of the first advocates of the integrated approach to S&T development. However, as an isolated institution, it is limited in its possible activities in this area.

On the other hand, the second group of institutions has tended to limit its activities to "economic problems" related to the commercialization of technology following the economic approach to S&T development. 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 S&T policy. As they have become more aware of the importance of the many aspects of technological development, the institutions have accorded these aspects more importance in their functioning.

The difference between the two groups of institutions is also reflected in their position in the government's administrative framework. Whereas COLCIENCIAS has its principal ties with CONCYT, the National Council for Science and Technology, the organizations of the second group are more directly associated with CONPES, the National Council for Economic and Social Policy, the highest planning institution in Colombia.

Since CONCYT has had only two meetings since it was created, it is difficult to judge the effectiveness of the division between the two national councils. However, the following general observations can be made: CONPES is responsible for developing general economic policy or "implicit policies," which may well be more important than the "explicit policies" in determining the S&T development of the country. Similarly, CONPES intervenes in specific decisions on important sectorial projects. It is through these projects that S&T is integrated into the economic development process and that the principal technological decisions about national S&T development are taken. If one accepts the integrated approach to S&T development, it is necessary to achieve greater interrelation between S&T planning and economic development planning. Thus, there are two alternatives: to encourage greater participation in CONCYT by the institutions of the second group and greater coordination of CONCYT with CONPES so as to integrate the two planning systems; or to reevaluate the reasons for the parallel existence of the two national councils.
The responsibility for making and implementing a national S&T policy is obviously too great for any single institution. On the contrary, one must think in terms of building and coordinating an institutional network made up by the principal organizations that take part in making the basic decisions that orient the S&T development of the country. Such a network has gradually been emerging in Colombia: several of the institutions participate in interinstitutional committees (such as the royalty committees) or are linked informally as a consequence of initiatives for interinstitutional meetings and projects that have often arisen through personal, informal contact between the people who work in the various institutions. What this informal network can do at the level of personal relations or small joint projects between institutions may be of vital importance in the progressive integration of the S&T planning system and may even be more important than the simple bureaucratic administrative definition of a planning system in this field. The main weakness of informal networks is their vulnerability to personnel turnover.
6. Science and Technology Policy and Planning in the Arab Republic of Egypt

Adel A. Sabet

National Science Policy

The great achievements in S&T, especially during the first half of the 20th century, have led governments to be much more conscious of the important role of scientific research and technological progress, their deep implications for national development plans, and their cultural and social effects on the lives of people in all parts of the world.

Development can be described as the product of two interrelated processes: growth and change. Both depend on the application of S&T and the beneficial use of their continued achievements. In economic growth S&T contributes basically to an improvement in productivity, both quantitative and qualitative. Yet, the most important effect of S&T lies in the change element. Accordingly, when governments draw up a national science policy they aim to influence all sorts of activities in which S&T achievements are or can potentially be used to accelerate national development and its social, economic, and cultural goals.

A national science policy comprises various legal and executive measures that the state carries out to organize and develop the national S&T potential, to promote technological innovation, and to use such innovations in the best interests of the country’s development and international prestige. It must be taken as an important political decision by the government and as an integral part of the overall policy of the country.

The developing countries need to lay down bases for their national science policy in the light of their limited resources and scientific and managerial capabilities. In fact, they have no choice but to plan their scientific activities in order to reach their short- and long-term targets. Their need for a national science policy is founded on the following factors:

- The increasing link between S&T research and the socioeconomic activities.
- The complex problems stemming from the rapid development of modern S&T.
- The large requirement for human and financial resources for S&T activities, which needs state support.
- The limited potential for R&D, which demands the establishment of national objectives and priorities.
- The growing role of international cooperation in S&T.
In Egypt, there has never been a national science policy and the awareness of the need for such a policy is very limited, though it is growing. Many official statements have explicitly emphasized the importance of science and the convenience of building a modern state based on science. The constitution refers to this, and since the 1952 revolution various statements from heads of state, prime ministers, political organizations, and parliamentary committees have expressed this conviction in one way or another. This has frequently been through official action, with the provision of moral and material support to scientific activities and organizations, and to the scientific community. However, a state proclamation or act on national science policy is very much desired.

In the absence of such a proclamation or act a number of policymaking bodies have been created over the last 25 years. They started with the first National Research Council, which began to function about the end of 1948; the Science Council was formed in 1956, the Ministry of Scientific Research in 1961, the Council for the Promotion of Scientific Research in 1964, the Council for Scientific Research (superseding the ministry) in 1965, the ministry again in 1968, the Academy of Scientific Research and Technology in 1971, and the Ministry of Scientific Research and Atomic Energy in 1975 (probably with the academy structure retained for national planning and coordination).

In addition to the effect of so many changes in the national policymaking bodies, several factors have deeply hampered their effectiveness, mainly:

- Instability and rapid changes in policy strategies and tactics.
- Inadequacy of the infrastructure, especially in the first stages, in terms of qualified personnel, applied research, laboratories, and supporting services.
- Shortage of funds most of the time, especially in terms of foreign exchange.
- Limitation of executive functions in some instances, and failure of evaluation and follow-up practices.
- Dominance of the "university ideology," whether in policy planning or evaluation, which stamped most of the research activity with academic attitudes; the real needs of the development plans were largely ignored.
- Isolation of the scientific community, with minimum linkage required between the research and applied sectors, which inevitably widened the gap between them.
- Separation between the sectors of research and socioeconomic planning at the national level.
- Shortage of managerial capabilities.

**S&T Planning**

Science policy is not an end in itself; it is a strategy for national action in the field of science and should serve a twofold purpose: the development of science and scientific capabilities, and the use of scientific activities for the benefit of development.
Because planning is a function of policy, there should be two kinds of integrated plans: a plan for science itself and a plan that uses science for development. In fact, the basing of the development plan upon science may be rightly argued.

Two important attempts at S&T planning have taken place in Egypt and will be briefly reviewed. They deserve more intensive study, however.

The Science Council Effort (1958–60)

The general atmosphere in Egypt after 1956 and the Suez War led to acceptance of the idea of planning in science in 1958, though with great opposition. However, the Science Council finally adopted a 5-year (1960–64) plan for scientific research that coincided with the first plan for national development. It had three main aims: to survey and assess the potential of existing resources; to recruit personnel for present and future development; and to draw up effective programs for meeting immediate and long-term needs, while depending mainly on state projects for national development.

Actual preparation started in 1958, when the objectives and contents of a scientific research plan for the country were defined as follows:

- Encouragement of basic or academic research as an important part of the plan.
- Selection of research topics entirely on the basis of individual initiative, with encouragement given free from all ties or restrictions.
- Procurement of appropriate financial support for the purchase of equipment, for assistance to libraries, and for scientists to attend international conferences or to study abroad.
- Applied research in the plan should help the national economy, directly or indirectly, and should solve social problems in fields such as health and education.

The work was divided into six sections: 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. A total of 117 topics bearing on the national economy and on scientific progress were selected, and 170 experts were commissioned to write detailed reports on relevant work being carried out in Egypt and the possible practical application of the results; institutions engaged in such activities or for which the studies would be of interest; scientific personnel having experience in the subject, including proposals for recruitment, improvement of qualifications, training abroad for new subjects, and foreign experts needed; present laboratory and library facilities, and requirements for supporting or establishing new ones; world trends and possible means of using new advances, and lists of relevant
world institutions for possible contact; and problems affecting the various fields of the national economy that needed a solution.

After coordination of the reports 58 planning conferences, attended by about 3,000 scientists, were held.

The following comprehensive preliminary reports were finally drafted:

- A general introduction to the present situation and an estimate of funds needed to finance the suggested projects.
- A list of research topics to be dealt with, in order of priority.
- A program for postgraduate scholarships and fellowships for studies and training at home and abroad.
- Proposals for invitations to foreign experts.
- An estimate of funds required for developing existing research laboratories and setting up new ones.
- General recommendations.

The total budgetary estimates for the science plan amounted to £19,673,250 (at the official rate then £1 = U.S. $2.35). About £8.5 million was finally approved in addition to about £3 million for a scholarship training program.

The plan called for action on a broad scope and envisaged the reform and strengthening of the scientific infrastructure through material support for existing laboratories and qualified personnel and for their expansion. But it was too broad and too ambitious, with a definite, though 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 power, 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 had started with the establishment of the Ministry of Scientific Research in 1961) involved new policy trends.

The Academy Effort (1972)

One of the main responsibilities of the Academy of Scientific Research and Technology was the design, coordination, and financing of research projects related to national problems, and the following up of their execution. The academy’s council entrusted its 14 specialized research councils — with representatives from the research community as producers of science, and from the production and services sectors as users of scientific results and technological progress — to identify important problems facing the national socioeconomic plans for which concerted research effort was needed to find practical solutions. A number of criteria were discussed for identification and for making priority decisions. Proposals were received from the Council of Ministers and from different government ministries, for ministers concerned attended many meetings of the specialized councils, explaining the respective policies and problems encountered by the production and services organizations represented in the councils, by research institutes, and by individual scientists. All were studied at length by the councils and their special subject committees, and at the annual specialized councils’ conferences and the general annual conference of the academy in 1972–73. Two main
types of problems were distinguished: national problems, which would concern the entire country, especially those related to the country’s economic development; and problems of a particular sector or subsector.

More than 70 important national research projects that would take an estimated 3 to 5 years were finally endorsed and recommended to be sponsored and financed by the academy. In 1974 £1.8 million was allocated in the academy budget for these projects (and was spent). In 1975 £1.2 million was also earmarked in the same way.

Each project was studied in detail and executed on the basis of a contractual system. A contract was signed between three parties: the academy, the principal investigator of the project team, and the main research organization in which most of the work was to be carried out. Progress reports were to be regularly submitted for examination by the pertinent subject committee. Material and other incentives were provided. Implementation procedures were freed from much of the bureaucratic burden. Additions to these projects were studied by the specialized councils and at their conferences, and by the academy’s governing council, which also ensured continuity and flexibility.

Accordingly, a program of research was worked out mainly as a practical plan of action aiming at solving some important and urgent problems that cut directly across national development plans. However, the academy’s council had approved the allocation of about 20% of the available funds to strengthen the base of science, especially in new and interdisciplinary areas.

Research institutes affiliated with the academy were also asked to reorient their activities and set up their programs to serve the respective sectors of application, a process that succeeded in some sectors and is still under way in others.

For the research institutes under construction a new policy was laid down that was based on active cooperation between the academy and the pertinent applied sector, whether in the field of industry (e.g., metallurgy and petroleum) or in the field of health (e.g., schistosomiasis), as a joint venture with respect to policy planning, management, and finance.

At the same time, the academy prepared inventories on existing scientific potential (scientific manpower, expensive scientific instruments, and libraries and their periodical acquisitions); designed plans and measures to strengthen and modernize the work of the National Information and Documentation Centre and its central science library, as well as the work of the Scientific Instruments Centre; examined the status of the research community, mainly to allow for valid norms and evaluation measures to encourage the orientation to applied and developmental work; intensified scientific relations on bilateral, regional, and international levels, with a specific bearing toward assisting the implementation of research programs and the intensification of the scientific infrastructure; and established a science policy studies unit.

Within the short life of the academy (3 years) one can observe a number of basic positive features:

- Concentration on the principle of participation, as indicated in the composition of all academy groups (equal proportions of producers and users of science) involved in planning and the setting up of criteria as well as in research.
• Concentration on the principle of links between the research community and the applied sectors, whether in designing research programs or constructing research institutions as joint ventures, or in seeking other means of ensuring and strengthening such bonds.

• Recognition of the social function of science. For the first time in the history of science organization in Egypt, the social sciences were included in the activities of the academy as the principal policymaking body in the country.

• Recognition of the principle of planning coordination as a function of the national science policy and as an approach that should be subjected to scientific study.

Final Remarks

The integration in Egypt of national planning in scientific and other areas is still far from being reached. This is a very conspicuous negative aspect, though the reasons may be mostly external to the academy. A crucial issue is the relation between scientific research and the application of modern technology. One of the prevailing trends of thought is that an orientation toward applied research may be the solution. This is certainly true for advanced countries, where science has deep roots and traditions, and where industry, as with other sectors, has grown in the presence of science and, in most countries, as a result of its achievements. Yet in less-developed countries the situation is different, and it may be necessary to reverse the pyramid of development. It may even be argued that we have introduced many industrial plants, but not industry.

For a developing country to become industrialized, technology almost always has to be imported. Without touching on the complex question of transfer of technology, it seems that the only way to introduce technology into such a country and to build up indigenous S&T capabilities is to ensure from the outset the full participation of local scientists, engineers, economists, and so forth in the importation of that technology. Participation should start with the preliminary plans and continue through feasibility studies, choice of technologies, contractual bargaining, adaptation techniques, design, construction, experimentation, and operations. After such intensive training and experience have been acquired, research activities can be developed inside the particular plant and outside it in the concerned research institutes; these activities would start with adaptive and developmental work, and progress to applied and oriented basic areas. This is the real challenge facing not only the main policymaking body of the country but also the government and the nation as a whole: to implant technological capabilities and reduce technological dependence.
7. Development of Science and Technology Planning in India

Anil K. Malhotra

India differs from many other developing countries in that it had a flourishing scientific tradition in the ancient and medieval periods. The development of modern science has, however, not been an extension of this tradition. Instead it has been the growth of an implant by the British in a language that was alien to the Indian people.

The main S&T events after India became independent, in 1947, were the creation of an extensive institutional network, a chain of research laboratories, and the expansion of university and technical education. The Council of Scientific and Industrial Research, which was established in 1942, was reorganized on the lines of the former British Department of Scientific and Industrial Research; an autonomous Atomic Energy Commission was formed in 1948; the University Grants Commission was set up in 1956; and the Defense Research and Development Organization was established in 1958.

Pandit Nehru, who deeply believed that S&T was a key factor in national development, was the main architect in the laying of the foundation for the important S&T developments in the country. He introduced in Parliament in 1958 a scientific policy resolution that indicated the government’s intent to support S&T to “secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.” Since the enunciation of the resolution, scientific activity has quickened and broadened, so that now there is a substantial infrastructure of institutions and capabilities in a variety of technologies covering several fields, including agriculture, industry, medicine, defence, and atomic energy.

This rapid development of scientific activity in India is reflected in the substantial increase since 1958 in the financial resources devoted to R&D and the number of people engaged in it. Between 1958–59 and 1971–72 the budgeted expenditure on R&D in the public and private sectors increased from 0.23% to 0.54% of the gross national product, and the total number of scientific and technical personnel employed in R&D establishments increased from 20,724 to 103,767.

From 1947 to 1955, decisions on the setting up of scientific institutions and their funding were arrived at through a relatively unstructured policy process. Later, the government’s Planning Commission was expanded and the responsibility for integrating science into development fell to it. The responsibility of the Planning Commission in the area of scientific research was spelled out in 1959 as the setting up of independent committees and
panels of scientists as needed, and taking their views and recommendations into consideration in the planning of economic development and the attainment of national aims.

But during the preparation of the second and third plans only one such panel was set up to devise schemes for the research activities of the Council of Scientific and Industrial Research and the scientific organizations associated with the Ministry of Education. None of the other scientific agencies of the government were brought into the framework of a national plan for science.

With a view to designing a mechanism for obtaining scientific advice at the highest level, the government set up the Scientific Advisory Committee to the Cabinet in 1956 with explicit and wide-ranging terms of reference. This committee had, however, no mandate for the preparation of a national science plan, but it set up ad hoc working groups that included some scientists and technologists for the study of specific scientific issues. This Committee was replaced by the Committee on Science and Technology (COST) in 1968, chaired by the Planning Commission's person in charge of science. The new committee comprised agency heads and a few scientists, an economist, and a technologist as members. The terms of reference of this committee were a little wider but did not include the preparation of an S&T plan. The committee did, however, set up a number of standing committees, working groups, and ad hoc committees that included a number of working scientists, technologists, and industrial personnel to study many of the areas it wished to examine.

The National Committee on Science and Technology was set up in 1971, and one of its main mandates was to prepare an S&T plan.

**Serious Deficiencies of the Indian Science Policy**

The first such deficiency is the absence of rational science policies or guiding principles for making decisions on the magnitude and distribution of funds for scientific research.

There has been in the past no explicit policy on the allocation of funds for S&T activity, well over 80% of which is funded from the central exchequer. Each agency has submitted its proposals to the Planning Commission; the commission has appraised them from primarily a financial point of view, endorsed the plans, largely without modification, and recommended their funding to the government. The government, in turn, has accepted these recommendations and taken them to Parliament, which has usually been generous with funds. In sum, the overall funding of scientific research has been decided more by the absorptive capacity of the agencies and institutions concerned than by the economic or social importance of the research.

The absorptive capacity of the agencies and institutions has varied widely, partly because of the complexity of the technology handled, but also, in no mean measure, because of factors external to the complexity of the technology and to whether the scientists were capable of doing good work. These reasons have often had to do with such things as the organizational flexibility within agencies and departments, the status of the heads of agencies, and other factors unrelated to the requirements of the national economy. The result of this essentially laissez-faire attitude to the
allocation of funds has been a growing mismatch between the distribution of funds for scientific activity and the economic and social importance of the areas of funding.

Thus, in 1970–71, whereas agriculture contributed roughly half the gross national product, the central and state R&D allocation for this sector was about 21% of the total. The atomic energy and space programs accounted for 20% of the total expenditure on R&D in the central sector; yet medical research, health care, and family planning accounted for only about 5%. Whereas the share of R&D funds for defence was 12% of the total expenditure on scientific activity in the central sector, that for natural resources (excluding oil) was less than 8% and that for irrigation and power was less than 2%.

The second serious deficiency of the Indian science policy is in the matching of the perceived demand for science with the available supply of science. The communication gap between industry and the industrial research laboratory remains large. When scientific institutions have had to interact with government departments, the latter have been unable to appreciate the imperatives of science and the requirements of scientists. Emphasis on financial trivia and a lack of appreciation of the cost of lost time are the chief characteristics of the existing situation.

The third such deficiency is the continued neglect of badly needed organizational and administrative reform of India's scientific institutions, including their personnel policies. When reforms have been recommended, they have not been fully implemented. The values and methods of decision-making in most of these institutions either continue to be feudal or tend to subordinate the role of the scientist to that of the bureaucrat.

The fourth important deficiency in the Indian science policy is the lack of adequate recognition that the indigenous scientific effort must be geared to complementing and, in time, displacing the imported technology. Also, there has not been a determined effort to use the capabilities already developed in the country. This lack of effort has largely been due to the absence of an agency that could actively promote indigenous technology.

The National Committee on Science and Technology

The scientific community in India was aware of the deficiencies in the country's science policy and its implementation. As a result, the Administrative Reforms Committee set up by the government recommended that a national council of science and technology be established as a high-level body to advise on greater aspects of the government's scientific research policy and the best means of developing and using national scientific resources and personnel. A conference of scientists, technologists and educators in December 1970 also recommended such a body. The conference participants proposed that it should be called the National Committee on Science and Technology, and that, among other things, it should prepare a continuously updated national science and technology plan identifying the projects of high priority. After the minister for planning took charge in 1971 he held discussions with scientists,
technologists, and educators around the country to determine the form and nature of the nation's scientific efforts.

In November 1971 the government appointed a 10-person National Committee on Science and Technology to advise the central cabinet on all S&T matters. Its functions were as follows:

- Preparing and continually updating national S&T plans, both as 5-year plans and as "perspective plans." This would have to be carried out in close association with the Planning Commission and be intimately associated, in terms of relative priorities of allocation of resources, to national socioeconomic development plans.
- Arranging for periodic discussion of the draft plan and other important issues of science policy by a fairly large representative group of scientists, educators, industrialists, and policymakers.
- Assessing the pattern of development of S&T research and of intersectorial resource allocation, and designing measures to correct imbalances.
- Orienting the pattern of development to further the use of the nation's S&T resources; in particular, designing measures to strike a balance between domestic capabilities and foreign assistance.
- Establishing cooperation and communication between government, semigovernment, and nongovernment S&T institutions and professional bodies in the country.
- Handling S&T matters.

The Organization

The 10-member committee, presided over by the minister for science and technology, consisted of working scientists from a number of disciplines. The heads of important scientific organizations in the country were excluded from the committee in an attempt to involve working scientists in decision-making and to prevent institutional loyalties from being projected onto the national scene. All the members worked part-time, but one of their first tasks was to set up a full-time secretariat of high-level scientists and technologists to assist in the design of the S&T plan.

The Planning Process

To design the S&T plan the committee adopted a combined sectorial and national approach. The plan was structured in terms of 24 socioeconomic sectors that would each be studied critically so that suitable programs of research, development, and design, with time-bound targets, could be established. Work in each sector was coordinated by a panel of committee members that, in turn, set up a number of planning groups and task forces as basic instruments for the design of the plan. To aid the planning groups in tasks a general project profile was designed.

In devising the methods for the preparation of the S&T plan the committee was guided by the following considerations:
• The preparation of the plan was to involve the participation of the largest possible number of scientists, technologists, administrators, economists, town planners, and so on, so that a broad spectrum of skills would be reflected and an interdisciplinary approach adopted.

• The composition of the planning groups was to reflect the entire "innovation chain," from the educational institutions, the research laboratories and the engineering design organizations, to the production sectors of the economy and the consumers.

• The scientists, technologists, and others invited to participate in the planning were to function in their individual capacities rather than as official representatives of the agencies or organizations to which they belonged. Thus, institutional constraints would not be imposed on the participants during the framing of the various options available to the country at the initial stages of planning.

• The S&T plan was to take as its starting point the development profile for each sector as formulated by the task forces and steering groups of the Planning Commission to ensure that the S&T projects included in the plan were derived from committed development programs.

Although the entire economy had been divided into 24 sectors for the purposes of planning, these methods were not followed in all sectors. Instead, the 24 sectors were divided into three broad categories for each of which a different method was adopted. First, for sectors in which the program was basically to be implemented by a single agency (for example, agriculture, defence, space, aeronautics, electronics, atomic energy, and meteorology), the respective committee panels depended primarily on the plan proposals outlined by the respective agencies and organizations. The committee attempted to ensure that the planning process followed by the agencies reflected the criteria just mentioned, and that the plans were appraised and coordinated with the other components of the S&T and economic systems of the country. Second, for sectors covered by a number of ministries and agencies, the respective committee panels developed the sectorial plans in close collaboration and cooperation with the respective agencies. Third, for areas in which no agencies existed, as in solar and geothermal energy, and cryogenics, the committee set up special task forces to prepare a sectorial plan and to recommend the organizational arrangement needed to implement it. In addition to the projects generated by the various planning groups and task forces a number of surveys, state of the art studies, technoeconomic feasibility reports, and so forth were commissioned by the committee.

In short, the planning process has been both democratic and interactive. It has directly involved more than 2,000 scientists, technologists, economists, administrators, and others, and has led to a basic plan for the S&T work that the country is capable of undertaking. Furthermore, by involving individuals from an entire innovation chain even in the definition of S&T projects, it has been possible to follow a systems approach in the development of the S&T plan. This has meant, for example, that the first step of identifying a process or product technology led to the spelling out of the technological skills involved in the entire spectrum of engineering design capability, material know-how, and production techniques that might be critical to the manufacture of the
equipment and machinery needed to commercialize that technology. Similarly, planning in the agricultural sector brought into consideration not only nonindustrial resources such as land and water, but also matters related to fertilizers, pesticides, post-harvest technology, and climatic control.

The Approach Paper

In January 1973 the committee issued a document that reflected its current thinking on the complex issue facing it in the preparation of the S&T plan, and enunciated the policy framework that it would follow in its deliberations. The reasons for issuing the document at this time were fourfold: (a) to indicate clearly that S&T policies must be an integral part of the country’s socioeconomic plans, and that they have to derive their mandate from the national plans; (b) to ensure that all S&T activities in the country would come within the S&T plan under preparation; (c) to develop a progressive consensus of the policy framework for S&T planning (for example, to indicate to both scientists and politicians that S&T planning is more than a collection of R&D project proposals, and that the extent and pace at which S&T can contribute to national development depend in large measure on the policies evolved and the actions taken outside the S&T system); and (d) to generate discussion and debate among scientists and technologists (to elicit their participation in the preparation and the implementation of the plan and, indeed, in the reinterpretation of their roles in national life), managers and administrators (to make explicit to them the interdependence and interrelatedness of the S&T system and socioeconomic decision-making), and journalists and politicians (to create a consensus and an environment conducive to the implementation of the S&T plan).

To generate greater consensus the committee organized seven seminars in different parts of the country at which the S&T approach paper was discussed by scientists, technologists, and economists. Then, in August 1973, the final plan was presented to the cabinet.

The S&T Plan

The 5-year S&T plan indicated the strategy being followed by the planners and its objectives, and the details of the plan for the 24 sectors. Each of the sectorial plans was outlined in terms of the specific projects to be carried out by specified organizations and agencies.

Much of the extent to which S&T can contribute to national development depends on the policies evolved and the actions taken outside the S&T system. The maximum use of S&T in achieving the country’s socioeconomic objectives requires not only investment and changes in the S&T system but also suitable adjustment in fiscal policies, lending policies of public financial institutions, foreign exchange allocation policies, industrial regulatory and import policies, and foreign investment policies. The following considerations, as pointed out in the fifth plan, are relevant:

... The import of technology does not necessarily have to be linked with the availability of aids or credits. Secondly, institutional arrange-
ments 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 to learning, adapting, improving, and then displacing, imported technology.

There must be simultaneously a national commitment to increase substantially the total expenditure on S&T so that, for example, by the end of the fifth plan’s period approximately 1% of the gross national product would be continually available for investment in S&T. The S&T plan attempted to reorder the financial allocations among the sectors to be more in tune with the declared national objectives. In this it may not always have completely succeeded, but it did avoid advocating investment at subcritical levels. Furthermore, radical reallocation of resources cannot realistically be done overnight, for not only will this be difficult organizationally, but also it could lead to avoidable waste of resources and talent. The directions to be followed for matching the allocation of resources committed to national S&T efforts with the enunciated national socioeconomic objectives were clearly stated in the S&T plan. It will be the task in the days ahead to move the S&T system even closer to the priorities inherent in the national socioeconomic plans.

The S&T plan was prepared in close collaboration with the pertinent administrative ministries as well as the Planning Commission. Once the plan had been submitted to the cabinet and accepted, the ministries were left to implement it by asking for allocations to the programs from their annual allocations budget. Shortly after the budget allocations for 1974–75 were presented by the administrative ministries to the Planning Commission, it was discovered that the allocations bore little relation to the 5-year S&T plan. There could be a number of reasons for this. Most important must have been that the annual plans of the ministries were drawn up at a time of acute financial stringency. The resources available even for completing the projects in hand were scarce, and any additional investments requested for the S&T plan would have been pared down mercilessly. It was at this stage that the committee, having noted that the resources being allocated to the various sectors were at great variance with those they had proposed in the S&T plan, sought an intercession with the political leaders. The case was presented to the Standing Council of Ministers for Science and Technology that the annual reallocation of funds would have a long-term deleterious effect on the national scientific, technological, and industrial fronts, and that it was necessary to ensure not only that adequate resources were made available but also that the funds were distributed among sectors in a reasonable and consistent manner. As a result of this intercession it was decided that annual S&T plans would be drawn up by the committee, who would keep in mind the stringent financial picture and select areas for investment.

This S&T planning exercise was the first of its kind in India. The formation of an S&T plan is, however, only the first step in the effective use of S&T for development. Although the plan charted a course for the future, its success would lie only in its effective implementation. And it is this difficult task that lay ahead in 1973.
8. Integrating Science and Technology Planning with Economic Development Planning

Kyu Bok Whang

The emergence of S&T planning has created the question of how it is integrated into the economic development planning. Such integration is considered inevitable because industrial production requires technological input in addition to labour and raw materials. Modern production systems require a labour force with specific skills, capital that includes S&T knowledge, and raw materials that are preprocessed by related suppliers. S&T planning is intended to influence the productive capacity of an economy through promotion of S&T activities, which therefore require enhanced funding.

Since the establishment of the Ministry of Science and Technology in South Korea the S&T policy has been oriented to fostering the technical capacity of the nation and directing the S&T activities toward the set goal. Specific technological needs of industry have been delineated, and technology has been supplied through research institutes in the country, but the supply of technology has not been adequate for the industrial needs.

It is traditional for the establishing of an S&T policy to lag behind that of an economic policy. The result seems to be underachievement with the economic development plan owing to lack of technical input. This is partially due to the lack of analysis and of a translation of economic development into specific technological needs. More appropriate timing of S&T planning can provide better integration of the S&T plan with the economic development plan.

Framework of the Integration

Information about the economic development plan can be fed to an S&T planning group for review. This group can, in turn, feed its own information to the economic development planning group. This exchange of information can be repeated to perfect a workable plan. The economic planning group has traditionally been composed of economists, mathematicians, statisticians, and planners in various disciplines, whereas the S&T planning group is largely composed of scientists and engineers within the government. S&T planning is less extensive than economic planning and can be independent from the latter, but in view of the consequences of S&T planning and the resources required for research, it seems advisable to have the two types of planning coordinated.
For the preparation of South Korea's fourth 5-year economic
development plan, the Economic Planning Board formed 21 sectorial
planning groups, each of which was expected to draw up a preliminary
plan and submit it to a coordinating group. The sectorial groups reflected
the existing ministerial organization, so that the top planners at the
ministries had to participate in the planning. The participation of planners
from research organizations, trade associations, and academic com-
monities was also expected. Intense involvement was expected of S&T
planners in the sectors of heavy and chemical industries, light industries,
transportation, natural resources, energy, and employment and personnel.
Although S&T planning may be extended beyond these six sectors, the
current involvement of S&T planners was, for practical reasons, to be
contained in the sectors predominantly oriented toward "hardware"
technology. At least in these six sectors, interaction between economic
planners and S&T planners was ensured for the period of that economic
development plan.

All sectorial planners were to be versed in the goals of the economic
development plan: development of agricultural and energy resources;
enhancement of domestic earnings through exports; a proper structure for
development of heavy and chemical industries; development of science
and management of business, and of personnel; development of land
resources and maximum expansion of employment opportunities; price
stabilization, improvement of the taxation situation, and amelioration
of banking conditions; dispersion of population and industries to nonurban
areas; enhancement of investment for social development; improvement
of working conditions; expansion of cultural facilities and of nonurban
welfare, and social security systems; and improvement of efficiency in the
administration of development planning.

The participation of S&T planners in the sectorial groups ensured the
integration of S&T planning with economic development planning. At the
time this chapter was written the S&T planning group was subdivided into
metals, shipbuilding, textile, machinery, electronics, petrochemicals, and
energy groups. Each subgroup was expected to design a project to be
evaluated in terms of technology constraints, technology alternatives, and
required resources for the development and importation of technology.

The economist in each planning sector was to estimate a feasible
output of the sector on the basis of overall growth, investment, resources,
employment, and other discernible economic variables. The S&T planners
would then be able to determine the technical requirements for meeting
the output: the current capacity of production (capital goods and labour),
the current requirement for raw materials, the technical requirement for
skilled labour, the investment requirement for a new product, the
investment requirement for additional capacity, the extent of importation
of technology, a plan for domestic technology, and alternatives for a better
mixture of products.

The output requirements of each industrial sector are critical infor-
mation for the S&T group. The figures can be tentative until technical
feasibility is ascertained. The feasible output of each sector can be adjusted
across the other industrial sectors by the coordinating group.
The Product—Technology Matrix

The product—technology matrix, which was published in 1969 by the Korean Ministry of Science and Technology, is used to assess the value of technology in relation to specific products in each of 16 industrial sectors. On the matrix form, the products are listed vertically and classified in one of three levels; 100 products, on the average, are listed for each sector. The required technologies are listed horizontally and also classified in three levels; 70 technologies, on the average, are listed for each sector. In each cell of the matrix the technology required to produce each product is identified and classified as to whether it is minor, major, or not available in the country. The matrix form also has space for indicating the priority of a technology's development and the feasibility of producing a specific product.

Because of the difficulties in assessing the monetary value of a technology, or of an element of the technology, one has to resort to the monetary value of the equipment or production facilities containing the technology to estimate the relative monetary value of each technology or element and its availability. The relative importance of technologies or their elements can be assessed by applying the value of capital goods to each product and the volume of output.

This index will show not only the relative value of the technical element but also the total effect on other products. However, the index is not particularly applicable to a technology developed by a corporation for the exclusive use of that corporation. When the development of a technology is funded by a public organization, such as the government or an industrial association, the index is more applicable.

Even though the priority of technology development has been established, a strategy for the process has yet to be developed. Advanced countries have a large reservoir of primary sources of technology. Importation of technology from such countries must be treated by discriminatory principles.

Concluding Remarks

The integration of S&T planning with economic development planning in South Korea is expected to permit both the systematic integration of S&T activities with industrial production and the enhancement of S&T funding.

Planners in South Korea appear to be ready to accept the systematic treatment of S&T. However, owing to the complexity of and difficulties in evaluating technology, and the vast requirement of personnel for S&T activities, deliberate efforts are required to find a workable practice. This needs to be done soon to minimize subjective judgment of the planning.

The product—technology matrix is to be used in the systematic assessment of S&T requirements for promoting economic activities. This tool has limited value in that it deals with current requirements and existing knowledge. Problems such as the need for energy technology for the future cannot possibly be solved or even guided by the current static product—technology relation. Likewise, we have to seek a supplementary method dealing with the dynamic nature of technology.
9. Science and Technology Planning in Mexico and its Relevance to Other Developing Countries

Miguel S. Wionczek

More than half a century after the 1910 revolution, Mexico still belongs to the underdeveloped world, with most of its rapidly growing population subsisting in precarious conditions. For years, historians, sociologists, political scientists, and economists have been trying to explain why the country has remained underdeveloped, but most existing general explanations are at best incomplete or partial, and at worst based on unverified assumptions.

For a long time it was claimed by many that the slowness of socially acceptable development in Mexico was due to limited natural resources, a relatively small population dispersed over an extensive territory, and a per capita income too low to generate sufficient savings to finance growth. However, more and more evidence is available that Mexico is not at all poor in natural resources but, rather, only a small part of these resources has been surveyed and an even smaller portion has been exploited. Nor can one speak of a shortage of human resources in a country with one of the highest birth rates in the world and a labour force that is increasing by about 1 million people a year. Moreover, with the present average annual income of about U.S. $1 000, and with the high income concentration, it cannot be assumed that Mexico's potential savings are low.

Thus, the explanation for the persistence of Mexico's economic and social underdevelopment must be sought elsewhere. Without considering the difficulties of international economic relations between developed and developing countries, it is possible to claim that among the most important causes of Mexico's relatively slow development are the absence of political modernization, the severely deficient social organization, the poorly designed education system, and S&T backwardness. Together, these factors result in inadequate and inefficient management of the country's most important problems.

The weakness of domestic S&T activities reflects the backwardness and dependence of the Mexican economy. Mexico's rapid economic expansion, accelerated industrialization, and enhanced S&T development date only from the 1930s, when university education was given a high priority and there was official support for industrialization; the conditions were propitious for some scientific research — unaccompanied, however, by similar efforts in technology.

As a result, whereas scientific activities in the larger universities progressed in the next few decades, applied R&D advanced slowly because of the country's dependent and imitative industrialization.
response to the local technological backwardness the technology embodied in machinery or available through the licencing of industrial know-how was imported massively, even though the imports did not often meet the needs of a country short of capital and with a relative abundance of unskilled labour. Not only were the technological imports demanded by industry and services linked to the production structure serving mainly the urban groups whose preferences were patterned after those of high-income countries, but also the imported technology often required intermediate input not produced in Mexico, and at times it even hindered the exploitation of some widely available renewable resources. The technological links with the outside world changed little after World War II, when Mexico's industrial structure expanded with the establishment of many industries producing intermediate goods and with the appearance of the capital goods sector.

Thus, Mexico's scientific and, in particular, technological dependence upon the outside world increased instead of diminishing. Isolated attempts to rectify the situation by promoting R&D activities at the universities and in the public sector were not accompanied by the elaboration of a national S&T policy until very recently. Only with the setting up of the National Council for Science and Technology at the beginning of the 1970s, which coincided with the worldwide recognition of the interrelations between S&T efforts and the patterns and pace of economic and social growth, was the need for an S&T policy perceived. Consequently, the council, in close cooperation with the scientific community, leading universities, and representatives of the public and private sectors drew up in 1975–76 the first S&T Plan. Although the plan covered basically the period 1976–82, it was within the framework of the longer-term R&D strategy. The contents of the plan will be reviewed here at some length because they may throw some light on the problems arising from the S&T backwardness of practically all developing countries.

The detailed survey of S&T activities revealed that Mexico's R&D system, although having accelerated its growth in the 1970s, faced many formidable difficulties:

- Mexico's R&D system was excessively dependent on S&T development in more advanced countries; thus, its output was often limited to purely imitative, quasi-research activities in fields in which serious indigenous R&D was badly needed, if only because many of the problems arising from underdevelopment were different from those facing developed societies.
- The financial resources available domestically for R&D were inadequate not only in comparison with those provided by industrialized countries, but also in comparison with R&D expenditures in some countries with a similar level of development, such as the other larger Latin American republics.
- The S&T system had neither the quantity nor the quality of human resources required, both in absolute terms and in comparison with those of many other countries with a similar level of development.

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• The geographic and institutional concentration of S&T institutions was excessive. In 1973 the research institutions in or around Mexico City accounted for more than 80% of the total R&D expenditures and personnel, and five institutions spent 45% of the funds provided by the national R&D budget.

• The functional distribution of R&D expenditures was deficient. Almost 70% of the financial resources was being spent on salaries and wages, while less than 15% was available for purchasing equipment indispensable for serious research.

• Most R&D institutions lacked a sufficient number of researchers. Only 3.5% of the 400 research institutions each were employing more than 20 people, the minimum number for relevant research in most fields.

• S&T development was highly unbalanced sectorially and by discipline, with the consequent neglect of important areas of research. Resources for basic research were scarce, and applied R&D was concentrated in the few sectors in which the presence of the state was particularly great. Petroleum and energy, modern agriculture, medicine and health, and the industries producing intermediate goods were absorbing half of the available financial resources. Even in these fields the research was inadequate for the country’s specific S&T needs. Furthermore, R&D was neglected in such areas of great importance as subsistence agriculture, nonrenewable resources, capital goods, transportation and communications, and urban development and housing.

• There were no permanent links between the R&D efforts and the education and production systems. Moreover, the structure of the S&T system was fostering the gap between R&D and dynamic and technically complex production activities. The weakness of technical diffusion and extension services was obstructing the transmission of knowledge to the production system, especially in noncommercial agriculture and the consumer goods industries. These deficiencies were common to most of the Latin American S&T systems.

The contrast between the existing situation and the country’s probable R&D needs indicated that the S&T system should expand its activities considerably. Moreover, the growth of the system and the relevance of R&D would depend largely on the formation of a long-term overall development program, which had been missing in Mexico for sui generis political reasons. In other words, the future of S&T in Mexico seemed to be contingent not only on an increase in financial resources for R&D and on the more rapid training of personnel, but also on the integration of these efforts into a general planning framework. Given the nature of S&T activities, the characteristics of the Mexican economy, and the official ideology, such planning could only be indicative and participative. S&T planning had to foster not only the expansion of R&D but also the demand for domestically produced S&T knowledge, which was then practically nonexistent. The work on the Mexican S&T plan demonstrated beyond doubt that in developing countries the mere supply of know-how does not create a demand for it.
The Mexican S&T Plan

The Mexican S&T plan was based on two premises: first, that the importance of S&T for socioeconomic development makes its long-term planning urgent for any country; and, second, that the need for S&T planning is even more pressing in countries such as Mexico owing to the persistence of underdevelopment, the relative scarcity of the government's financial resources, and the magnitude of the still unsatisfied basic needs of most of the population.

The main objectives of the S&T plan were defined as nonimitative 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 functions and participate in 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 progressively reoriented toward local sources of technical knowledge, that would rationalize purchases of foreign technology, and that would help to assimilate and to adapt the imported know-how for the internal generation of technology.

Inherent in S&T policy required to attain these objectives were the following postulates:

• The S&T policy must be thoroughly integrated with the country's general development policy.
• The model of S&T advancement must be adapted to the country's long-term social and economic objectives.
• The adoption of an autonomous model for the advancement of S&T in no way implies the abandonment of the selective use of externally generated S&T knowledge.
• In the absence of a well integrated S&T system the task of overcoming the present state of scientific backwardness requires a joint, sustained effort by the government, R&D institutions, institutions of higher learning, and the production system.
• S&T advancement demands an environment that acknowledges its social value and particularly, its contribution to the achievement of long-term national objectives.
• Excellence is badly needed in certain scientific fields that until now have been little explored and developed but are of great importance to the solution of the problems of underdevelopment.
• Technological advances are needed in selected areas of conventional R&D practiced in advanced countries, in appropriate "primitive" technologies of local origin, and in some specific fields in which early technological breakthroughs would be of great social importance.
• The S&T system must have close links with the educational system and the economy.

Because of the state of underdevelopment of most R&D supporting
activities and the urgent need to transmit R&D results to the society for educational and productive purposes the plan devoted considerable attention to the problems facing the S&T infrastructure, including the training of high-level personnel, the diffusion and distribution of knowledge, information and statistics, engineering and consultant services, the production and maintenance of scientific equipment and instruments, and international S&T cooperation. For each of these components of the system's infrastructure and its external links the plan provided long-term objectives and medium-term policy guidelines.

With respect to R&D, the plan defined objectives and set guidelines for problem-oriented research in exact and natural sciences and in social disciplines. For applied R&D it set forth technological policy guidelines for nutrition, agriculture and forestry, communications, urban development, industry, energy, renewable resources, construction and housing, medicine and health, educational techniques, and research into natural phenomena. The plan emphasized that scientific advancement must be based not only on the recognition of university autonomy but also on the state's commitment to guarantee the academic and research freedom necessary for scientific creativity. The specific S&T policy guidelines were expected to be translated into institutional and sectorial programs with the aid of some relatively simple interinstitutional mechanisms designed for programming and implementation that would be indicative, participative, and flexible.

The plan postulated that by 1982, the annual expenditure on S&T in Mexico should reach 16 200 million pesos (U.S. $1 300 million at 1975 prices) — almost three times the 1976 spending and slightly more than 1% of the gross national product. The annual outlay for R&D alone should rise from 3 090 million pesos (U.S. $250 million) in 1976 to 9 200 million pesos (U.S. $735 million) by 1982. A slight reduction in the government's share of the total expenditure from the current 80% to 75%, was assumed, along with a proportional increase in private sector spending. Furthermore, the plan offered medium-term targets for R&D supporting activities and a package of S&T policy instruments aimed at increasing the productivity of R&D. Finally, the setting up of mechanisms to evaluate the progress of the plan's implementation was considered.

The plan proposed that policymaking be institutionalized through a permanent national scientific and technological planning commission, to be composed of high-level representatives of the federal government, decentralized agencies and public enterprises, institutions for higher education, and S&T users in the production sector. The commission would, first, coordinate and guide the preparation and the periodic revision of S&T policies, and of successive S&T plans, and, second, guarantee serious involvement in these tasks by the government, institutions for higher education, the private sector, and the S&T community.

It was proposed that the planning commission be supported by an interinstitutional science and technology committee, to be composed of the National Council for Science and Technology and various ministries in charge of allocating financial resources and of controlling their use. The main function of the committee would be to integrate the annual federal budgets for S&T into the framework of financial targets and R&D
guidelines set by successive S&T plans. Together the planning commission and the interinstitutional committee would form the basis of the permanent plan for the S&T system, a plan that would be closely interlinked with the socioeconomic development strategy to be established by the federal executive.

The permanent planning process would have four phases:

- The designing of a strategy for S&T development in the country with a long-term perspective (20 to 25 years).
- The defining of a medium-term (10-year) S&T policy.
- The drawing up of successive indicative 6-year S&T plans.
- The designing of institutional and sectorial programs for general R&D activities and for R&D supporting activities for the duration of each plan.

Implications of the Plan

Given the current underdevelopment of S&T in Mexico and the long period required for S&T efforts to produce tangible results, unless an S&T plan has a long-term strategy, it runs the risk of being reduced to an insignificant exercise with extremely limited effects. The need to define S&T policies for 10-year periods only and to redefine them periodically was determined by the nature of scientific progress and technological change. Their speed the world over is so great that S&T objectives and policy guidelines must be revised from time to time, though not too frequently. Successive 6-year plans were chosen for Mexico because of the political and administrative cycle of the country. Lastly, it is important that institutional and sectorial R&D programs be worked out by the S&T community so that continuity is ensured, the productivity is improved, and the infrastructure facilities and the financial and human resources are used more rationally.

The S&T Plan left the S&T institutions free to define their short- and medium-term programs within the framework of the policy guidelines and priorities established in the plan. Institutional programs were expected to contain eventually not only research and related activities for the duration of each plan, but also a general and preliminary outline of problem-oriented priority research areas for longer periods.

Institutional programs would have to be coordinated by the sectors not to meet formal requirements of planning, but because the S&T policy guidelines presented in the plan strongly indicated that the Mexican S&T system would have to undertake in the coming years many multidisciplinary R&D activities that would exceed the capabilities of any single institution. Linking institutional and sectorial programing with the federal annual budget for S&T was meant to permit a more efficient allocation of financial resources by the government and to ensure their use in accordance with the policy guidelines of the plan.

Although the nature of S&T planning requires it be indicative, various groups of participants in the S&T system would have different degrees of commitment to the implementation of the plan's national and sectorial guidelines.
The plan would be mandatory for the National Council for Science and Technology, which would act as a technical adviser to S&T institutions at their request and would have to design its own R&D support program for fields that could not be covered by other institutions because of insufficient resources, the lack of an infrastructure, and so forth. The council's priority activities would continue to be the training of high-level personnel, the setting up of research centres in sectors lacking such institutions, and the selective promotion of mechanisms for linking the S&T system with the educational and production systems.

Government S&T research centres would also have to make a relatively strong commitment to the plan's objectives, targets, and policy guidelines. The argument in favour of this commitment is simple: the plan amounts to a federal program, and the federal government is the direct source of funds for R&D activities undertaken in the public sector.

Although the state and its enterprises account for some 60% of the national R&D expenditure, in many instances the productivity of S&T research directly financed by the government is very low, mainly because of two factors. First, although there are a few large research centres, such as the National Institute for Agricultural Research and the Mexican Petroleum Institute, whose contributions to national S&T are unquestionably outstanding, there are also many small research units that because of size, budget, personnel, and bureaucratic problems, cannot be expected to make any important advances. (There are some 300 public sector R&D units with three researchers or fewer each.) Second, many of the small units have no formal research program and lack coordination both with the institution they are attached to and with other institutions carrying out similar research. If these small units are to increase their productivity and undertake more relevant research, the government must create the conditions that would permit these units to establish their programs with a view toward participating in sectorial R&D planning.

All these deficiencies are less frequent in most of the R&D centres belonging to the larger institutions for higher education. Consequently, and in response to the idea of university autonomy, the S&T plan would be indicative for these research centres. Moreover, because the S&T community, most of whose members work at the institutions for higher learning, helped to draw up the plan's broad policy guidelines for research, it should be relatively easy for university R&D centres to devise research programs that fall within the plan's general framework.

There remains the question of the private sector's participation in R&D. In view of the general lack of interest of business firms in R&D, the property structure of industry (that is, the strong participation of foreign capital in the technologically dynamic sectors), and the marked preference of both foreign and local businesses for foreign technology, it is highly unlikely that the private sector will substantially modify its technological conduct in the short term. Consequently the S&T plan proposed that the government implement fiscal, financial, and other mechanisms to stimulate private companies to develop their technological capacity, use research originating in the country, and augment their contribution to the domestic S&T efforts. It would also be necessary to design instruments that encourage large foreign-owned companies to adapt their technology to local conditions and requirements so that they need not remain completely dependent on foreign technology.
Nevertheless, even the best planning and implementation of S&T programs at the institutional, sectorial, and national levels cannot guarantee the system's contribution to Mexico's development. The main limitation — contrary to the recent contention of the industrialized world — is that S&T by itself cannot solve the main problems of underdevelopment although it may provide many elements essential to their solution.

In other words, to take full advantage of the S&T potential to help reach the nation's goals, the S&T policies have to be coordinated with overall development policies. This means the creation of a number of direct S&T policy instruments and the readjustment of the existing economic policies that indirectly affect the functioning and development of the S&T system.

One of the particularly urgent problems in this area is the evaluation of the impact of industrialization policies on S&T. In the past, these policies, together with the supporting fiscal, monetary, and foreign trade policies, had not taken adequate account of the need to accelerate scientific development and to promote technological self-determination. In fact, many of these policies have had a negative impact on S&T objectives. The gap between the important economic policy instruments in force and the proposed S&T policy instruments originated mainly in the fact that the design of the latter followed that of most of the economic policies that were elaborated when the relation between S&T activities and socioeconomic development was not clearly understood. In summary, as with many other developing countries, Mexico is facing the difficult and complicated task of integrating these two policy areas into a coherent whole.

**Lessons to be Drawn from the Planning Exercise**

Apart from the degree of success Mexico may have with the implementation of its S&T plan, the planning exercise offers to other underdeveloped countries many lessons, five of which are particularly important.

The first lesson is the need to recognize that S&T problems in generally underdeveloped countries differ basically from those in developed countries. Thus, advancement in this field in underdeveloped countries cannot be achieved by methods more or less successfully applied in the world's industrial centres. Since S&T backwardness is part of overall underdevelopment, S&T policies must be integrated with the general development policies. The absence of a general development framework limits severely the relevance of any attempt to build up the domestic S&T capacity.

The second lesson is that one of the main obstacles to the advancement of S&T in a country like Mexico is the gap between local R&D activities and the education and production systems. Consequently, knowledge that is produced domestically is used neither for improving the quality of education nor for production purposes. The Mexican experience strongly suggests 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 S&T in a developing country depends more upon the effort to establish links between the R&D system and the education system and the economy than upon the simple increase in human and financial resources allocated to R&D. Acceptance of this proposition makes it easier to understand why the S&T strategy proposed for underdeveloped countries by advanced countries, which proposes that local modern scientific institutes be established more or less at random and that applied R&D efforts be left to traditional international mechanisms, just cannot work. In the absence of a demand for their output, modern scientific institutes set up in underdeveloped societies wither away and become focal points of "brain drain". At the same time, the dependence on traditional mechanisms for technology transfer leads to the emergence of enclaves of advanced technology that perpetuate themselves in the context of general technological backwardness. The question is not whether such transfer of technology (for example, through foreign-owned enterprises) is of any use. It may be useful or useless, depending on the presence or absence of other vehicles for transfer and propagation of technical know-how in a developing society. Only the technological strategy designed to establish permanent links between technological importation and the domestic R&D system on the one hand, and the local R&D output and the education and production systems on the other hand, can ensure long-term meaningful technological modernization of a backward country.

The third lesson is that the domestic S&T system in a developing country must be thought of not just as the sum of the local centres of R&D activities, but as the sum of all the units dedicated to R&D and supporting activities as well as those intermediating between the R&D centres and institutions for higher learning and the production system. The intermediation is not unidirectional — from those who produce knowledge to those who use it — but is a two-directional triangular relationship. If S&T policymakers in the advanced countries seem to forget this, it is because they lack historical perspective. In all the advanced societies this triangular relationship between S&T, education, and production, which has been absent in backward societies, was built up slowly and without planning over the last two centuries. This statement also covers socialist societies. Contrary to widespread belief these societies were not scientifically or technologically backward in their presocialist times, particularly when compared with most of today's underdeveloped countries. The Soviet Union before 1917, Poland before 1945, and China before 1948 were advanced in all possible respects in comparison with most of Latin America, Africa, and Asia in the middle of the 20th century. Thus, if one wants to advance S&T in the underdeveloped world, one faces the difficult task of devising policy instruments that will affect the broad R&D system and revise the educational and economic policies in the light of the S&T effort.

The fourth lesson is that we know little about the relations, particularly in the context of underdevelopment, within 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 in turn is needed for technological development) is open to criticism on logical, structural, and historical grounds. Only by accepting our ignorance of the
relations within R&D, agreeing that social functions of different parts of the R&D continuum vary considerably, and relating the production of knowledge to some overall view of long-term social, economic, and national objectives of a given society, can we arrive at a broad vision of the national S&T strategy for an underdeveloped country or region.

Finally, S&T policy problems cannot be meaningfully handled just by scientists and technologists, if only because S&T is not a specialized sector but affects every phase of social, economic, cultural, and even political life. If we accept, furthermore, the proposition that S&T is not socially neutral, we may arrive at the conclusion that S&T planning is a 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 underdeveloped countries, where the S&T elite, though sometimes highly educated, may be in other respects as backward as the societies in which they function.
10. The Interactions between Socioeconomic Policy and Scientific and Technological Planning in Venezuela

Luis Matos Azocar

Analysis of an S&T policy separate from a socioeconomic policy can only be justified to facilitate a study of the more important elements of cause and effect. The interactions of the two types of policy are so complex that S&T development is an objective of the socioeconomic development policy, yet it accounts for restrictions in that policy.

The planning of unified development requires simultaneous and coordinated analysis of all factors that contribute to a country's progress. Yet assessing the contribution of S&T to that progress has involved such methodological difficulties that even the most advanced countries have postponed the explicit consideration of S&T in defining their economic and social policies.

In technologically dependent countries, where accelerated economic expansion is the central concern of the development plans, the lack of technology is seen exclusively as a restriction to be overcome through massive importation, and an S&T policy is regarded as external to the socioeconomic policy and a separate consideration in the definition of national plans.

This attitude of the planners in underdeveloped countries encounters a favourable climate in the liberal philosophy of the main groups directing investigation, and thus a barrier is created between the bodies defining economic and social policies and the newly established organs of S&T policy. For this reason national S&T councils in Latin America appear and die out in barely 5 years. This was the atmosphere in Venezuela when the fifth national development plan began to be formed.

The Place of S&T in the Venezuelan National Development Plan

The national development plan is the instrument with which the state tries to redirect the economic and social activities of Venezuela. It establishes objectives and requirements for the S&T system, and the S&T infrastructure must offer solutions that permit the selection of one or other type of economic and social development. Because of the incipient S&T development of underdeveloped countries, it is difficult to imagine that they might offer solutions that would effectively direct the national development, but it is certainly true that if investigation is to be coupled to production, the broad outlines of S&T development must be planned
according to the socioeconomic orientation. In countries whose economy
is not planned, the main factor producing this coupling is the market,
which imposes the need for innovation to maintain competitiveness.

This relation is fostered by the state through a variety of mechanisms
designed to stimulate research into activities such as the movement of
personnel between companies, antimonopoly laws, the reduction of
research costs, and managerial training.

Research that falls outside the competitive framework of business,
generally that carried out in universities, is controlled by the availability of
funds from the state, which depends on whether the proposed research
reflects the main concerns of the nation.

For underdeveloped countries the need to plan S&T activities is
rooted in political and economic factors. From the political point of view it
is clear that there tend to be triangles of coexistence between countries
rich in technology and wielding political power, countries producing raw
materials, and countries offering financial and energy resources.

The principle of S&T interdependence is relevant only to countries
that have sufficient capacity to initiate the flow of technology in both
directions, wide local participation in the absorption and modification of
the imported knowledge, and sufficient determination to define the
conditions of transfer. With underdeveloped countries, which tend to be
disorganized in this respect and to have little capacity for negotiation, the
sale of technology by advanced countries is monopolistic, so as to permit
maximum profits for the sellers. There is also a trend toward unequal
distribution of income as a result of the commercialization of technology,
and toward the use of technological power to reduce the political power of
underdeveloped countries.

From the economic point of view it is impossible for a developing
country to allow market forces to define the status of S&T research,
because the priorities would be determined not by realistic social needs
but rather by the interests of higher income groups or the multinational
companies that dominate the economies of these parts of the world. There
is, besides, a risk that the companies operating in captive markets might
not assign funds to research, or that when they did, they might neglect
research that would not yield short-term gains.

On the other hand, because in underdeveloped countries researchers
and creators of technology are scarce there is a tendency to concentrate
research — and its system of promotion and stimulus — on energy,
defence, space, and nuclear problems. How is it possible to justify the use
of state resources to support this type of research when there are other
problems that, for political and social reasons, ought to take first priority?

The intervention of the state by means of planning is indispensable,
both to obtain better distribution of scarce resources, and to effect the
structural changes necessary to eliminate attitudes that hinder the action of
S&T in relation to the needs of most of the people.

The Fifth National Venezuelan Development Plan

The fifth national plan envisaged the enhanced well-being of the
population through accelerated growth in the areas of nutrition, education,
technical assistance, housing, production, ecology, and investment,
with the following medium-term objectives: diversification of the economy, full employment, supply of essential input for the large groups with poor economic resources, deconcentration of economic activity, exportation of nontraditional goods, protection of natural resources, and reduction of the economy's vulnerability to external forces.

These objectives necessitated the following demands upon the local S&T infrastructure:

- Generation of new methods to increase agricultural and industrial productivity, with emphasis on full employment.
- Production of technology that would permit the rational use of nonrenewable natural resources and an increase in the local aggregate value of the basic products.
- Changes in the nutritional composition of mass-consumption food products without a reduction in the purchasing capacity of the low-income groups.
- Rational selection of technologies and creation of the capacity to use imported technology to induce the development of local technology.
- Development of design engineering capabilities and of the technology of capital goods production as indispensable links between laboratory activity and commercialization of the results.
- Evaluation of technology in view of the goals of generating full employment and preserving the ecological balance.
- Production of technology to permit the construction of housing adapted to the climate and culture of each region.
- Production of teaching systems that are better adapted to the nature of Venezuelan students and would permit greater access to education and improvements in its quality.
- Increase in basic research in universities to guarantee a better calibre of higher education and to accelerate by means of better qualified personnel the innovative capacity of the production sector.

The objectives of the fifth plan, in which the state, controlling more than 50% of the investments, played an important part, offered excellent prospects for the S&T development of the country. However, it remained necessary to establish an institutional structure that would permit systematic and continuous consultation with the main decision-making centres — those making the policies or consuming large amounts of technology. In addition, research centres would have to change their attitude and organization toward 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.

Proposals for S&T Development

The fifth plan, because of the accelerated investment involved, carried the risk of strengthening rather than reducing the country's technological dependence. The investment plan was made without taking into account the savings that can result if the time sequence is adjusted so as to permit greater participation of local technology or its production; such savings are
sometimes greater than those resulting from accelerated investment to avoid the increasing costs due to world inflation.

In addition to the national S&T provisions that linked the fifth plan to the plan elaborated by the National Council for Scientific and Technological Research, there were S&T provisions for each economic sector that, though they did not define a precise strategy, reflected the desire to consider S&T development as an explicit objective.

On the other hand, the guidelines governing the acquisition of technology by state companies should have stimulated the demand for technological development as well. The fact that state companies were obliged to seek to diversify their sources of technology, with emphasis on local sources rather than the traditional foreign sources, represented a potential demand for engineering and research that would stimulate interrelations, lead to efforts to redirect activities, and increase the research potential.

A permanent source of finances for R&D activities was guaranteed by the provision that companies owned or partly financed by the state would have to create a fund destined exclusively to cover S&T expenses. These companies were to contribute each year between 1% and 2%, at a minimum, of their sales income. Although the R&D activities would fundamentally be directed toward the specific problems of the companies, they would also increase the flow of resources to such an extent that other institutions would be able to devote their efforts to the high-risk research areas traditionally neglected by the production sector. The decision to centralize the government’s funds allocated to S&T development revealed the desire for more effective coordination between the bodies that promote, direct, finance, and carry out S&T research. This centralization of funding was also likely to stimulate research in the private sector, either through direct action by companies or through the financing of research centres.

Another new feature of the fifth plan was the linking of state incentives (credit and protection) to the use of domestically produced technology. This constituted the first explicit manifestation of a technology import substitution policy. Similarly, protective and credit schemes were designed to stimulate capital goods production in Venezuela. These schemes included protection barriers without time limitation, subsidized capital, and use of the state enterprises’ purchasing power. They reflected the will to base economic growth upon improvement in the technological level of the country.

Another aspect of importance in the development of the country’s S&T capacity, and contemplated in the general policies, was the definition of guidelines governing the acceptance of foreign capital and the transfer of technology. These guidelines restricted the traditional channels whereby technology was imported into the country and had the effect of obtaining the incorporation of national technology through local investors.

The other parts of the plan that explicitly dealt with S&T constituted a link with the S&T strategy elaborated in greater detail by the National Council for Scientific and Technological Research.

The requirements for S&T research were set forth in the first national S&T plan as follows:
• Creation of an S&T planning system within the national planning system, which would permit rationalization of the S&T activities then being carried out. The system would operate within an institutional framework to permit greater differentiation by priority, complementation, and coherence of the S&T activities, and to avoid the bureaucratic aspects that stifle activity. Aims of the system would include the participation of the entire chain of technological innovation and scientific support in the definition of policy, and the centralization of all financial resources to stimulate S&T.

• Development of a critical body of researchers and scientists to harness the creative capacity of the country to social priorities and open options for the medium-term creation of an infrastructure able to generate workable technology.

• Definition of priority research areas in relation to the plans and projects of the production sector. The aim was to reorient the demand for S&T toward local production and real needs.

• Pursuit of an integrated view of all the components of the S&T system. Emphasis would not be placed exclusively on the generation of new knowledge, but would take into account the possibility of incorporating research results, with the contribution of design engineering, into the machinery of production. The system would also incorporate aspects of quality control and other technical support services, such as information and technical assistance, which should develop harmoniously along with the capacity for generation of new knowledge.

• Pursuit of a double policy of, first, increasing the internal infrastructure in sectors that, because of the specific characteristics of the country, need to solve their problems by generating their own technology, and, second, defining the desirability of relegating the importation of technology to the local research centres, with the aim of having the elements required for innovation absorbed in the medium term. Hence, provision was made to dismember technological packages and to obligate state companies to break turn-key contracts.

• Creation of research or technological development groups within state enterprises to make the plan more workable in view of the characteristics of the national economy, with the state enterprises controlling the main goods-producing units and the most dynamic sectors of the economy.

• Creation of technology closely associated with problems falling within the area of influence of the different research centres, in the hope that their development would generate centres for the promotion of small- and medium-sized industry.

• Creation and support of special programs to popularize the principles of science and thus increase the national awareness of S&T matters. These programs would be aimed at improving the teaching of science. Likewise, a program would be created to promote the main values and principles of S&T in all the social strata of the country.

• A guaranteed flow of funds for basic research that would be free of all priorities and restrictions except those related to quality. Directed basic research would be stimulated to maintain harmony and close contact with applied and technological research projects. The aim would be to locate the projects in universities.
• Modification of the education system to meet the requirements of the new phase of development.

Institutional Structure

Development of the national S&T system would require a number of substantial modifications in the institutional framework. These modifications would have the following fundamental aims:

• To insert the S&T policy into the general development strategy, which would require compatibility of the S&T policy with the various sectorial policies.
• To coordinate all bodies concerned with the elaboration and execution of the S&T policy.
• To create conditions whereby the S&T policy might generate the obligation of the Venezuelan state to the public sector.

These aims, to be put into practice, would require the adoption of the following measures:

• The creation of an institutional network integrated by the National Council for Scientific and Technological Research, the Superintendency of Foreign Investment, the Evaluation Office, the Industrial Projects Register, the Industrial Property Register Office, the Technology Bank, Comision Venezolana de Normas Industriales, R&D institutions, and others that would need to be created, such as a coordinating office of Venezuelan state negotiations and a national engineering office. It would be possible through this network to coordinate the action of these institutions, whose part in the promotion and regulation of S&T activities is decisive.
• Modification in both the location and the legal attributes of the national council. This modification should ratify this body's role in the planning and coordination of the S&T activities undertaken in the country, situate it in the axis of the institutional network, and grant it the ability to establish permanent links with the bodies that contribute indirectly to determining the S&T behaviour of the country (organs of fiscal policy, of financial policy, and so forth), and to establish channels of communication with the private sector and with the research centres.
• The creation of a national register of R&D projects, in which should be recorded all such projects generated in the public sector and those generated in the private sector that make claim to any form of public help. The aim of the register would be to permit the national council to coordinate and plan for the creation of knowledge and to contribute to the observation of established priorities and the more rational use of available resources.
• The creation within state companies and sectorial bodies of technological and research policy nuclei that could receive resources once they had become compatible with the national S&T plan.

The main components of the national S&T planning system should function within the following broad outlines:
• The national council should be the axis organ of the institutional network.
• The Superintendency of Foreign Investment and the Industrial Projects Register should be merged, and the General Projects Office and the Industrial Property Register Office should be obligated to maintain close communication with the superintendency, with which they might even merge.
• The national council, the superintendency, the General Evaluation Office, the Industrial Projects Register, the Industrial Property Register Office, the Comision Venezolana de Normas Industriales, and the R&D institutions should be obliged to maintain permanent relations with a series of auxiliary bodies that fulfill special functions in the control of technology transfer: a national engineering office, essential for the technical evaluation of projects and for adapting, improving, and negotiating for foreign technology; a coordinating office of Venezuelan state negotiations, which would tend to centralize the acquisition of technology on behalf of the public sector; and a national information network.
• The specific function of the Technology Bank would be to provide risk capital required in the development of local technology that is used by the local production system. This body would serve as a link with the private sector.
• The sectorial planning and promotion bodies would make and promote plans and programs in their respective sectors that would fall within the provisions of the S&T development strategy.
• The action centres would work on multi-institutional R&D projects and programs, avoiding the dispersion of resources, and coordinating efforts within the objectives established by the S&T development strategy.

Notes on the Development of the First National S&T Plan

A number of key decisions were taken in the definition of the plan.

First, the plan had to be operative: in other words, it had to be implemented sufficiently to permit the mobilization of resources toward specific objectives. This decision was restricted by the fact that the National Council for Scientific and Technological Research lacked the instruments required for a correct appreciation of reality and the institutional channels that would allow for the precise assessment of the different parts of the system. Nor could it be accepted as valid, given the separation between the production sector and the research centres, that groups of council scientists and technicians should, in an isolated fashion, define the image pursued by the S&T system.

Second, internal support for the planning process would be provided by several projects, on instruments and technology transfer, for example.

The partial reports on the instruments project provided means of assessing institutional aspects of the S&T policy and the interactions between economy policy and S&T policy that revealed the weight of the implicit policy. The pilot project, which lasted 2 years, concentrated basically on operative aspects of technology transfer (internal and external), revealing that among the main obstacles to redirecting the local...
production of technology toward the requirements of the production system was the user's inability to identify his needs and the lack of managerial training of the local operator. These projects gave sufficient information on external aspects of the S&T system to demonstrate that any plan that does not have the support of the economic and political decision-making centres will be converted into a simple academic exercise.

In view of this, a promotional strategy was organized to give to the planning process a technical-political nature. It sought the participation of the highest political authorities of the country, who were given the responsibility of coordinating each working group during the first S&T congress.

To overcome these restrictions the third key decision was made: to mobilize principal sectors of the economy by means of regional meetings of impresarios, researchers, science promoters, planners, and government leaders. Each event was like an open forum, with the national council employees acting as technical secretaries, with the most flexible work-guides possible, to harvest expectations and recommendations. Fifteen sectorial meetings were held in areas such as metallurgy, health, food, technology, and agriculture. These events had three aims: to define objectives that, though they might not be ideal, would emerge from the decisions made in consensus by the participants of each panel; to broaden the base of support for the plan; and to obtain information as to the real requirements of the production sector and on socioeconomic matters, the last being possible because the development of the national S&T plan began a year after the establishment of the socioeconomic plans, on which the S&T plan was thus able to draw. After each meeting the participants were grouped to prepare documents for presentation at the first S&T congress.

All these activities created the climate required to convert the planning process into a great national project overrun by values that were at times in conflict and at times in perfect harmony: technology as a foundation for the autonomous political position to which Venezuela aspired, technological policy defined by market forces or directed by the state toward the solution of high-priority social problems, the definition of a political hierarchy in S&T planning, the definition of specific areas of research, and so forth.

This aspect of planning, which consists in defining the hierarchy of preferences, was effected at the first S&T congress, which was attended by 2,000 participants, 60% of them from the research sector. The congress confirmed the national council as the guiding organ of S&T policy, discarded the possibility of liberal S&T development, and accepted the need to reorganize S&T in relation to the objectives of development. The national council saw that in order to act as the guiding organ of the system it had to turn toward political decision-making and understand not only research promotion problems but all the aspects of a balanced development system.

The first S&T congress ratified the following: the need to invert the proportion of effort devoted to basic research, applied research, and

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20 The cost of not doing so with surveys was compensated by the quality of the data spontaneously put forward.
experimental development research; the high political status of S&T planning; and the priority of research areas. The last were grouped as regards their contribution to the stimulation of social variables (nutrition, housing, and health), the modernization of the economy, the raising of the value of nonrenewable resources, and the domination of technology. A collective aspiration was to define a coherent body of provisions to cover the system's behaviour over the next 5 years.

The president of the republic and his ministers committed themselves, at the opening and the closing of the congress, to executing the recommendations defined at the plenary session.

The national council, as the axis of implementation of the recommendations and in relation to the main objectives of the congress, had to assume a new organizational structure based on its new responsibility to make a coordinated plan, and it began its activities with the elaboration of the plan. Relying on its new weight in decision-making bodies, the national council obtained a reformulation of the S&T aspects of the socioeconomic plan and introduced elements of policy, such as the obligation of state companies to open technological packages and the guarantee of financial support for research activities within these companies.

The most important characteristics of this process were the following:

- Mobilization of resources was begun even before the plan was elaborated, which made the process dynamic.
- From the start the process was identified as a technical-political action, which eliminated the possibility of generation of negative results.
- The plan was participatory, for at each meeting the basic document presented was transformed and enriched by the opinions of the participants.
- A support basis was obtained; each participant played a part in activities after the congress.
- The plan emerged as a requirement of the community, not something imposed by a group of intellectuals. Besides, it had political support even before it was launched.
- The institution entrusted with the definition and supervision of the plan was to be supported informally as well as legally and institutionally.
- The dispersed decision-making centres were to seek coordination in order to fulfill the congress's directions and provide a certain coherence to the system.

In summary, the most important aspect from an internal point of view is that this process constituted experience in "learning on the job" and in the planning of technological independence. Its main fault lay in the fact that the close attention paid to external planning aspects implied the neglect of internal methodological aspects, such as the consideration of objectives and diminished distribution of resources. Throughout the plan, efforts were systematically made to adjust this phase of the process.
11. Integration of Technology in Development Planning: a Normative View

Ignacy Sachs and Krystyna Vinaver

The failure of the development models that have more or less spontaneously emerged over the last 2 decades is beginning to be openly recognized. The development crisis is being discussed everywhere. International organizations responsible for dealing with development problems are proposing that new styles of development and new paradigms for planning be sought. This is the background of the work undertaken, for example, by the United Nations Planning Committee and, more recently, at the symposium on patterns of resource use and development strategies, held at Cocoyoc, Mexico, in October 1974, which resulted in the Cocoyoc Declaration.

This study follows the same lines. We explore the conceptual framework for long-term planning modeled on the logic of needs and focus on the role of technology. One objective of our approach is to match social and economic development with rational management of resources and the environment so as to guard against ecological crises. Although we do not believe that the apocalypse is just around the corner, neither do we think that one can put off reckoning with ecological constraints on the pretense that efforts must be concentrated first of all on the fight against poverty. For if ecological limits were to be neglected, various dangers would arise; corrective action is often very costly (usually more costly than preventive action), and certain acts of destruction could even prove to be irreversible. A worldwide ecological crisis may appear remote, but local ecological crises happen every day. Colonial history is full of examples of irreversible destruction caused by thoughtless exploitation of natural resources; deserts and soil erosion are spreading fast as a result of inadequate land structures and use of rash techniques. The Stockholm Conference established that the environment is a dimension separate from development. The environment should not be considered solely as a constraint or an additional cost; more imaginative analysis of its potential might lead to new opportunities for development and to the more complete meeting of special needs. Ecodevelopment constitutes an attempt to tackle the range of problems posed by the environment in this positive manner; technology is one, if not the sole, governing element in this concept.

Our study is in three parts: first we describe the general conceptual framework of long-term planning and the place in it of technology; then we propose a few analytic procedures, an institutional framework, and instruments to ensure the transition from the normative values of a chosen
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technological style to the choice of appropriate products and technologies; and last we attempt to evaluate the place of the approach proposed in relation to a few concrete experiences with technological policy in Eastern Europe, India, and Latin America.

We have endeavoured to summarize in the study the results of research projects on ecodevelopment and S&T policy conducted over the last 3 years by the Centre International de Recherches sur l’Environnement et le Développement, Paris.

The General Conceptual Framework of Long-Term Planning

The System of Social Production and the Forms of Its Operating Logic

It is useful, as a starting point for our analysis, to define the system of social production (P) as the purposive system and to subdivide its environment — solely for analytic ends — into three subsets: resources, space, and the state of the environment. These subsets are not separate entities but different ways of viewing the environment.

We shall distinguish — and this is the basic feature of our approach — two forms of logic that may be at the basis of the operating of the system of social production and may determine the differences in the objectives of such systems. We shall speak of a narrowly productivist system of production and of a system of production governed by the logic of needs. The distinction between the two systems constitutes a tool of analysis rather than a method of classifying countries; the real situations, particularly as regards certain mixed economies, are characterized by the coexistence of, or conflicts between, different systems of production.

Table 3 sums up the characteristics of the two systems that are relevant to our purposes. The table calls for a few comments:

First, we do not deny the profound differences between capitalist economies and peoples’ democracies with regard to the distribution of income and the greater share of the wealth reserved by the latter for collective consumption and nonmarket industries. But the implicit acceptance of a unilinear concept of history that is reflected in a rivalry with the capitalist industrialized countries in terms of growth rates and the hold of the demonstration effect upon their populations has led the peoples’ democracies to forgo the opportunity they had to give themselves civilization projects (and thereby structures of consumption) different from those of the developed capitalist economies.

Second, the extending of the time frame constitutes an important characteristic of the transition from the productivist logic to the logic of needs. An enterprise can only take a long-term view when it is forced to. The same is true for social costs, which it has a tendency to externalize while internalizing profits.

Third, wastefulness, which has an increasingly important role in the redefining of strategies, takes on its true meaning only in the system governed by the logic of needs; from the point of view of the productivist logic, financial profit is the only criterion of wastefulness. The word wastefulness is then to be used when a product is made to be sold or when the quantity of material incorporated into it could have been reduced without adverse effects on the product or on profit. Both instances
represent mismanagement. The degree of satisfaction of social needs derived from products counts only in so far as some form of satisfaction (even if artificial) is necessary for a product to be sold. Destruction of the product is perfectly acceptable if the seller profits from it by way of some price variation.

Fourth, the negative effects on the environment (pollution, destruction of resources, crowding) within the productivist system are taken into consideration only in so far as they affect production, and only in order to maintain them at a level deemed acceptable. When this happens, antipollution activities are incorporated into the system as new sources of profit.

Finally, we think it necessary to clarify the concept of social missions. The planning process envisaged takes as its starting point the social needs of the population and, in particular, of its most unfavoured classes. The first priority consists in ensuring for everyone the goods and services necessary for a decent existence: food, housing, standard industrial consumer goods, and access to health services and to education. Security of employment is a central element of this strategy, which sets the elimination of poverty as its first main goal. It in no way follows that production should be limited to essential goods and services; a large place should be arranged for "enhancement goods" — to the exclusion, at least initially, of luxury goods.

It may be useful to analyze other methods of satisfying basic needs in terms of social missions to be fulfilled so as to show clearly that such needs can be satisfied only by means of systems of services and goods, the structure and form of which should not be determined in advance. This idea is commonly accepted with respect to certain services (for instance, alternative transportation services and health care delivery systems). There is no reason for it not to be extended to instances in which meeting a need involves the consumption of certain goods or a combination of goods and services.

Emphasis should be laid on the analysis of possible and desirable substitutions, taking into account the availability of resources, the choice of techniques, and cultural preferences.

Planners consequently have to concern themselves with two essential questions: What importance should be attributed to each mission? and How should each mission be implemented?

We do not believe that a formal planning system can supply unequivocal and optimal answers to these questions; hence the importance of participatory procedures in planning. It will nevertheless be up to the planners to single out societal preferences and to identify and study alternative systems so as to carry out successfully the different missions and organize the continual debate between decision-makers, producers, and users.

The systems of satisfaction constituted by social missions always amount to triads of goods and services, the technologies used, and the location of production and consumer activities. For this reason it is convenient to speak of life and consumption styles, technological styles, and styles of space management as three aspects of development style. The attempt to make these three styles consistent constitutes the basic problem of all planning.
Life and consumption style

What is at issue is not merely determining tasks for the production system in terms of goods and services structures, but also identifying the forms of distribution deemed appropriate and the mode of consumption of goods and services.

We do not believe in the sovereignty of the consumers who would reveal their preferences through “money votes” (effective demand). Even in the case of an ideally egalitarian income distribution (in which everyone’s vote would consequently have the same weight) consumers would not be able to vote for foods and services they could not find on the market. Even in a socialist economy (not to mention a capitalist one) the market is not a good indicator of social and individual preferences.

What, then, are the basic problems to be tackled by the planners in this approach?

The structure of income distribution and its dynamics

Problems in these areas are principally linked to the postulate of full employment (and the security of such employment) and to wage policy; for instance, in this framework the role that one wishes to attribute to the different types of individual and collective economic incentives should be classified.

The relative shares of nonmarket and market goods and services in national consumption

What should be the volume and the content of the basket of goods and services that one wishes to be ensured for everyone or for certain groups in society (nonmarket consumption)? Care should be taken that the quantity and quality of these goods and services, and the forms of access to them, truly help to meet the needs of the unfavoured classes. For example, a nonmarket health care system that is concentrated in the large cities and is too limited to cope with total demand better serves those who are already privileged by their place of residence or by their social position because both of these factors give them easier access to the system.

The same applies to rationing systems. In order for them not to give rise to a black market the rations should be effectively distributed; this makes for a system that is difficult to handle in practice but is also effective and equitable when the industrial conditions and social disciplines are accepted.

Nonmarket distribution may be a fairly effective instrument for making consumption habits more socially desirable (for instance, free public transport) or for introducing new products or services (for instance, nonconventional foods).

The relative shares of collective and individual consumption (and services)

In this area the planners’ analyses would hinge to a great extent on ideological, cultural, social, and economic factors, both present and past, and on societal forecasting because the system chosen to perform a societal mission will have a great influence on lifestyle and on the characteristics of social relations (level of conviviality, etc). For instance, one of the most important factors in the decline of the kibbutzim in Israel is the conflict between the postulate of community life and the individual forms of certain types of consumption (television viewing, for example).
The choice of individual means of transportation has effects on the forms of human settlements and their networks, the forms and uses of leisure time (holidays, for instance), and so on.

The distribution of consumption between services and material goods
This is an ill-defined problem because goods and services are simply the vehicles of a particular use, and we are seeking alternative systems for the fulfillment of different social missions. These systems always consist of combinations of goods and services. The consumption pattern of industrial societies is characterized by underdevelopment of social services and overconsumption of material goods. Dissemination of this pattern by way of demonstration should be eliminated.

One must begin by posing the problem of the priority of certain social missions over others. Is it really necessary to attain first of all a high national per capita income (by means of the development of industry and agriculture) in order to be able to develop mass social services, as was the case in the industrialized countries? We deny this thesis, which issued from a unilinear concept of history; there is no reason for alternative technological systems capable of fulfilling social missions as deserving of priority as education and health not to be set in motion in the shortest possible time, even in countries with a very low per capita income.

Time management
The choice of a formula for allocating time between work, education, social activities, and personal life is fundamental to a development project. There exist alternatives to the management of the daytime — that of the week, the year, or the whole human life (length of compulsory school attendance, retirement age, retirement "at will," the staggering of education, university courses for mature students, etc.).

These choices should naturally be backed by cultural, social, and economic considerations. The styles of time and space management are closely linked.

These five groups of problems are at the basis of a coherent concept of the life and consumption style. The identification of a desired future necessitates exploration into social and individual preferences and values, with the widest participation of those concerned.

Technological Style
Technology will be considered as the set of technical, economic, and institutional means whereby material and human resources may be mobilized for a mission to be effected. Alongside the goods and services whose creation is the ultimate goal of production, technology also creates waste. The broadest criteria for the choice of appropriate technologies consonant with consumption and space management styles are the following:

Making the most of plentiful resources
Manpower constitutes the greatest resource of the Third World countries and, for both social and economic reasons, it is urgent that it be turned to account. Economists have closely studied the microeconomic functions of production; their research has confirmed the hypothesis that there exists in certain branches a wide range of alternative techniques more labour-intensive than those currently applied.
The criterion of the creation of employment is surely fundamental in the search for appropriate technologies, but one should not conclude from this that modern capital-intensive technologies should be banned. Although the concept of intermediate technologies seems useful to us to guide research and to promote technological progress using available means, it seems, however, too restrictive for it to become synonymous with appropriate technologies for the Third World.

Any discussion of the issue in terms of a dichotomy comprising mutually exclusive poles (modern capital-intensive or traditional labour-intensive technologies) should be rejected. The two should be incorporated into a dynamic view of development on the condition that a minimum productivity level be respected, warranting remuneration that would allow the enhancement of the labour force, because in order for any country to develop it must pass through a period of technological pluralism. The pluralism must be accepted and the idea must be advanced that it has to be consciously managed by dint of a planning process that accords complementary roles to sectors with different technological levels; this would wipe out the effects of unequal income distribution caused by great divergences in labour productivity.21

In addition, the macroeconomic concept of technological pluralism should be transposed to the microeconomic level with the help of the concept of combined technologies, which describes a situation in which the production line becomes more productive, or results in more acceptable products, because of the insertion of a modern unit without any change in the potential for manpower absorption (and the use of local materials) in all the other units in the line. It may be convenient to distinguish three instances: splitting up a production process at the level of an industrial or an agricultural branch (including all the peripheral operations) with a view to changing the technology of the process; adding modern units or operations, with the object of changing the technology of the product; and combining the technologies of a system of goods and services, with a view to fulfilling a social mission. The paradigm of combined technology possesses above all a heuristic value.

A second aspect of the effort to make the most of plentiful resources is the development of local natural resources and the possible use of waste.

The concept of resource has a cultural and therefore a historical and changing character; indeed, a resource is all that we are able to use as such, given a level of technology and a production target deemed useful either because it fulfills a need or because, in a market economy, it may be sold. This observation opens up the possibility of profiting to the utmost from the specificity and variability of each ecosystem, consciously shaking off the cultural prejudices of industrial societies. The different social missions may be effected by other systems of goods and services, which may be derived from the processing of the most diverse resources. From this standpoint, through recovering and recycling, waste becomes a resource.

21 China has applied a highly developed and diversified policy for the management of technological pluralism: “walking on two legs,” decentralized development, management of the rate of obsolescence of equipment, and, above all, removal of the link between workers' wage and their individual productivity.
This is a far cry from gratuitously seeking to fashion reality to fit in with our desires while turning a blind eye to the material constraints of production. But, as is shown by the numerous accounts of anthropologists, historians, and geographers who have studied "primitive" techniques and by the increasingly numerous results of research undertaken outside the dominant paradigm, prompted by recent discussions on ecology, it is possible to arrive at solutions different from those put into effect by the industrialized countries with respect to the production of food, human settlements, energy, and many other vital products. Many more such solutions could be found by resolving even further to direct research along new lines.

An appropriate technology is one that contributes to improved and more complete use of the potential of the specific resources of each ecosystem instead of dictating environmental change on the basis of the requirements of an imported technology that has proved itself in other ecological and cultural contexts.

It should not be concluded from this that we advocate thoughtless exploitation of natural resources; we propose, on the contrary, that these resources be managed on a forward-looking basis keyed to a sense of community and solidarity with future generations. And perhaps, somewhat paradoxically, the poorer a country is in the traditional sense of the word, the more it must set its hopes on the creation of new resources by means of the imaginative use of elements in its natural environment.

**Using scant resources sparingly**

The pressing need for the careful management of scant resources is felt at the economic level as well as at the ecological and social levels. To the customary criterion of the saving of foreign currencies (through, for instance, the minimization of foreign input) should be added the postulate of a campaign against waste in all forms. Regulating the rate of obsolescence of equipment and finished goods is an important policy instrument for the management of resources. The prolongation of the useful life of machines and durable goods makes it possible for the aim of the careful management of scant resources (by economizing on the material in these products) to coincide with that of improving the quality of the product and developing employment in the sectors of maintenance and repair. The obsolescence rate should be regulated in the light of both the type of resources involved and the value of the product; it is desirable for certain products to be short-lived (syringes, for instance).

A particularly important aspect of the careful management of resources is the saving of energy. The search for, and promotion of, technology low in energy consumption should become a characteristic of all new technological styles. Apart from the quantitative aspects of the energy demand, it is important in long-term planning to focus on diversifying the present energy pattern and searching for nonconventional sources. The advanced technologies used today in the developed countries are perhaps not sufficiently advanced for the Third World. The question arises as to whether it would be possible to bank on solar energy, in a technological leap over nuclear energy, the inconveniences and risks of which are known.
Minimizing negative social effects

The criterion of the minimization of negative social effects will be clarified in the light of the demographic and social structure, the distribution of population between urban and rural areas, and the characteristics of the system of production. At this general level it is possible for us to contend only that, apart from the considerations already presented concerning employment and income distribution, the technologies used should not be an alienating factor on account of their incompatibility with local cultural values, the organization of labour, and an excessive concentration of production, capital and spatial.

Reducing the dependence on foreign technology

The problem of dependence on foreign technology is twofold: First, the hinging of technological dependence on the source of the technology and the cost of the technological package analyzed together synchronically; and, second, evaluation of the contribution of S & T to the consolidation of the country’s capacity for decision-making and innovation. This postulate is closely linked to the national research capacity, which should be geared to the search for technologies that are not too difficult to master and that will strengthen the local potential supply of technology (research, as well as plant design and construction, the construction of equipment, and the training of research workers and engineers).

Finally, a place must be made for the concept of soft technologies, which purport to involve low consumption of scant resources; to be economical at the level of commercial energy; to be ecologically workable provided that production cycles are modeled on ecological cycles, that waste products are turned to account, and that pollution is minimized; to be labour-intensive; and to be applicable on a small scale.

All this is certainly desirable. However, if the criterion of minimum productivity is applied, the use of soft technologies seems to be extremely restricted for a long time to come. If, then, efforts must be made to develop them, care should be taken not to be exclusively attached to them and not to apply too rigidly all the criteria previously mentioned at the same time. These are important social missions that cannot be performed simply by means of soft technologies, either because they are lacking or because they do not ensure minimum productivity. We should therefore handle the concept of appropriate technologies more flexibly. Sometimes, as in the oil-producing countries where capital is plentiful, it is possible to consider as appropriate capital-intensive technologies capable, for instance, of making the desert bloom.

This line of reasoning may create the idea that the choice of products is made in advance; this is not correct. The choice of products and of technologies is made at two levels that do not constitute successive stages but different aspects of the same process.

First, in accordance with our approach in which the logic of production is subordinated to that of needs, the choice of priorities in the implementation of social missions is made in principle on the basis of considerations other than technological and economic. However, when one has to decide between two requirements deserving equal priority, and when this choice relates to a relatively narrow margin (that is, one must determine which of the two needs will be accorded slightly greater attention), the availability of appropriate technological systems for a
mission may favour the choice of one over the other. In this case the
technological style may influence the life and consumption style. This
situation is different from that predominating in market economies, where
currently the technological style has a decisive hold upon the life and
consumption style.

Second, for certain missions (or components thereof) there may be
little or no room for maneuvering in terms of the choice of products for
their fulfillment because of the nature of the needs, the rigidity of the
structure of consumption, or constraints introduced by previous choices.
All that remains to be done is to choose production techniques. Here the
consumption style has a direct hold upon the technological style. The
situation is different when there are alternative technological systems
composed of different products and different technologies able to fulfill a
particular mission; the identification of a system particularly in line with the
criteria of technological style will precede and influence the choice of
consumption pattern. In particular, the planning of the product should
play a far more explicit role within the planning of the system of fulfillment
of a mission in connection with the latter’s requisites; a television set, for
instance, conceived for an educational mission need not be equipped to
receive several channels but merely one, and its price should be lowered
as far as possible. The technological and consumption styles are therefore
closely interconnected.

If foreign trade is taken into consideration, this line of reasoning may
be extended. If certain needs that are deemed to be high priority are not
matched with appropriate technologies, recourse could be had to
imported goods or services, or both, considered to be necessary.
Financing could be through exportation, the structure of which would be
governed by technological preferences, assuming that a foreign outlet for
the exports is found.

Style of Space Management

Defining a style of space management is tantamount to seeking a way
in which space can be used for different social purposes proposed in the
development strategy in accord with the societal values incorporated in the
development style. The study of strategies for the management of space
requires that a very long time frame be envisaged, usually by means of the
method of alternative scenarios.

Management of multipurpose spaces and the guarding of options for
the future

Space is a resource that is particularly limited. It offers much potential
but involves decisions that are often irreversible. How can its uses be
structured while options are preserved for the future? Studies on the use of
coastal areas, to give only one example, reveal a complex problem: space
must simultaneously serve tourism, industry, and aquaculture. In addition,
there is the risk of a static view of incompatibilities that relate to a given
state of technology.

The harmonizing of the many purposes served by space and the
guarding of options for the future make it necessary for irreversible
decisions about land use and development to be kept to a minimum. This
often entails deciding against immediate local interests in favour of the
long term and general ones. There cannot be any formal method of decision-making but, rather, arbitration, with as full a discussion as possible and the participation of all concerned.

The principle of preserving rural spaces (protection of the landscape by the peasant) and nature (for reasons of climatic requirements and conservation of the genetic pool) is to be viewed in a similar manner.

*The network of human settlements*

It is necessary to go beyond the traditional standpoint, according to which urban and rural areas have opposite roles, by viewing the functional and dynamic network of interdependent human settlements; this makes it possible to tackle the problems of centralization and decentralization in a new light. The technological factor comes into play at several levels: the evaluation of the positive and negative external effects of the main built-up areas, the choice of transportation systems to serve these areas and the network, and the evaluation of the possibilities opened up by recent progress in communication techniques that will eventually make possible far-ranging deconcentration and render obsolete the model of the industrial and commercial megalopolis, the roots of which reach back to the 19th century. This is a field where another technological leap could occur, sparing some Third World countries the urbanization process, which has such serious effects on social and ecological systems.

*Strategies for the development of new economic frontiers*

Developing untouched territories is an increasingly rare opportunity. It seems to us that what should be proposed is an ecodevelopment strategy that stresses the development of specific resources of the ecosystem while respecting the overall ecological equilibrium; this involves choosing not only products and technologies, but also suitable forms of spatial organization, transportation, and housing.

It is impossible to conceive a style of space management without simultaneously giving thought to a life and consumption style and to a technological style. For most of the options noted concerning life and consumption style, we matched by forms of space management and, in particular, collective or individual forms of consumption (the example of the transportation system is the most obvious one) the effects of the different patterns of time management, the organization of leisure, forms of housing, forms of social participation and organization, and so forth.

The same is true of technological styles, in which the criteria of appropriate technologies and the conception and operating of technological systems directly support a chosen mode of space management and influence certain choices with respect to such management: this is true in particular for alternative transportation and communications systems, forms of organization of the social services, the technologies of human settlements, and appropriate technologies and settings with a view to harmonizing the many purposes for space to serve (housing, industry, leisure, etc.).

*Consistency of Development Style*

As we have seen, three development styles are many-sided and are interconnected. To be consistent in development style, planning should
focus on clarifying and taking into account these interdependencies by means of a transdisciplinary participative approach. Institutional aspects play a basic role in the search for such consistency. There would be no point in establishing a bureaucratic system that would impose perfectly consistent decisions. The social process of planning has at least as much importance as its results — the plan. The institutional pattern of decision-making should then make it possible to notice and eliminate inconsistencies between the three styles by means of wide participation of representatives of the different social and professional groups involved, of experts in various fields, and of representatives of different administrations.

The technological style in which we are particularly interested in this study owes its importance to its multidimensionality, but because of this feature technological choices are difficult to make, though they may and should become a favoured instrument for ensuring the harmonizing of the different development goals.

The Implementation of Technological Planning

Determining Appropriate Technological and Research Priorities

In this framework, two lines of approach must be pursued. On the one hand, social missions must be evaluated in terms of their content and alternative means of implementation, be they available or desired, to identify the resources required; on the other hand, fields of resources should be evaluated in terms of their potential and the technological means required to develop them, so that it is possible to identify social missions that may be fulfilled through the development of these fields. The potential that might be found in resources depends on their characteristics and on the necessities created by societal activities, and, thus, on the conditions of fulfillment of the different missions.

The main stages in the evaluation of the social mission are as follows:

- Definition of the mission and contextual analysis, in comparison with the other missions. To define the mission, a close analysis of the lifestyle of the society and clarification of the values of the society are necessary. The mission and its general relations with the other missions can then be defined within the social development process.

- Evaluation of the available technological means (in a broad sense: technologies of products, technologies of processes, instruments of technological policies, and institutional means). This evaluation would take into account the criteria defined by the postulated development style, which are conveyed by the technological style and emphasize the economic, social, and ecological impacts considered relevant. The fundamental values of the development style, expressed in general (but still precise) terms, are clarified by the dimensions considered relevant — the life and consumption styles, the technological style, and the style of space management — and the social preferences linked to each of these dimensions. Thus, for instance, the postulate of social equality is related to several dimensions of the technological style, such as job creation, the
possibility of decentralized uses of technique, the preservation of the conditions of production for future generations, and so forth.

• Definition of the main lines of the research. In the light of the criteria chosen and the results of evaluation of the available technologies, what is involved is identifying the characteristics of new technologies more in conformity with the technological style proposed. The definition of priorities for research requires at this stage recourse to technological forecasting. It is necessary to pinpoint the probability of and the time frame for the breakthrough of such S&T knowledge, which will influence the application of the desired new technologies, and to identify the necessary stages that must be passed through by science to arrive at the desired results. In the light of the results obtained at this stage it may prove necessary to go back to the previous stages or to the lines of approach for reasons relating to the feasibility of the technologies desired.

The purpose of evaluating a field of resources is to identify the socially desirable potential of the field and the means necessary, particularly in S&T, to turn the potential to account. Doubtless, a certain amount of potential is not exploited for reasons that have nothing to do with the inadequacy of technological assets or scientific knowledge. Often, however, what is lacking are the technological processes or knowledge.

This potential may be considered along several lines, which may be combined:

• Increasing the level of real resource availability.
• Finding new uses for the resources in the field examined.
• Stepping up the quality of the resources so that they better coincide with the requirements of the various uses; this change in the character of the resources may take place prior or subsequent to production.

The evaluation of a field of resources should entail an appraisal of the overall management of resources and, in accord with the postulate of an evolving sense of solidarity with future generations, an evaluation of the system of production in the framework of which the resources will be exploited and processed. An important part of this evaluation is the analysis of what would be called the internal and external compatibility of the potential uses in a long-term view (preservation of the options for the future): the exploitation of a field of resources usually has, at one time or another, a spatial or geographic dimension, and the links between various potential uses and between these uses and the other activities, present or potential, in the region, must be considered. For instance, the development of agriculture in a bay has important effects on the leisure and industrial activities in the region; a total incompatibility is possible.

The main logical stages to be passed through in this evaluation are as follows:

• Definition of the field of resources and its components, and a survey of current ways of using the resources in the field, with analysis of the effects of such uses.
• A systematic search for the potential of the resources in the field in terms of new uses and alteration of the character of the resources. This search may be carried out with a long-term perspective or with a more immediate perspective. It will necessarily be accompanied by appraisal of S&T knowledge centred on the implementation of the various current or potential uses of the resources in the field and by the pointing out of research priorities.

• Prospective analysis of the impact linked with the exploitation of the potential that is at first glance desirable and feasible. This analysis should accord an important place to the evaluation of the compatibilities of the potential uses with the postulates of the development style.

• Identification of the main lines of research.

These two approaches to determining technological and research priorities are complementary and overlapping; thus, they allow the identification of existing appropriate technologies as well as of gaps in research and therefore priorities that may give rise to interdisciplinary programs. These programs must be problem-oriented rather than keyed to the traditional divisions between the sector of production and the scientific disciplines. The ultimate objective must be the development of systems for the fulfillment of social missions; emphasis is laid on the word systems, which presupposes internal consistency and rejection of any preconception with regard to the choices of specific goods and services.

The evaluation of important development projects occupies an important place in any planning system in view of the scale of resources involved and the structural changes of the kinds to which such projects give rise.

The choice of appropriate technologies and, in certain cases, the definition of a program of research necessary for the implementation of the project cannot be made without resorting to expanded procedures for technological evaluation. We shall not dwell on this subject, which has been dealt with in detail in numerous studies, but shall merely point out that, in comparison with the subjects previously tackled, this evaluation brings to the forefront the question of land use and development.

Institutional Levels of Technological Planning

The proposed approach calls for radical reorientation of the institutional framework of planning, aimed at decentralization of the socioeconomic organization, with a large share given to participation, and the establishment of a horizontal development authority at all levels (local as well as national), with a corresponding reduction in the role of sectorial administrations (to an executive one).

Consequently, the functions of the central, regional, enterprise, and the sector levels of planning appear to be as follows:

The central level is responsible for the following planning and policymaking in the sphere of S&T:

• Conception, in normative terms, of the development style and the underlying technological style, in collaboration with the regional and local levels through recurrent and participatory planning. The identifica-
tion of technological style is governed by the study and clarification of social values, and entails an analysis of the interrelations between the life and consumption style, the technological style, and the style of space management.

- Definition of guidelines for technological evaluation and the search for appropriate technologies.
- Institutional planning: the setting up of establishments capable of initiating the transition to the new development style.
- Organization and management of the research program.
- Evaluation of important development projects.
- Framing and implementation of policies to ensure the search for and use of appropriate technologies for enterprises in the public sector (offices responsible for plant design and construction, direct control of investments, technological transfer and importation, etc.);
- Framing and management of contextual policies to guide the preferences of the private sector.

Because of the emphasis on the variety of solutions and the integration of the spatial variable in socioeconomic planning, great weight has been given to regional development plans, and the way has been laid for the redefinition of regions so as to take into account their ecological homogeneity, whenever this does not fly too much in the face of historical and cultural factors.

As to the role of the enterprise, the public sector and the private sector must clearly be distinguished. With regard to the latter, it is up to the contextual policies of the central and regional levels to ensure conformity of choice within the range of existing technologies having regard to the requirements of development style. On the other hand, public enterprises should become a direct instrument of the state in the fulfillment of its goals, which implies stricter supervision, as is the case in most Third World countries.

The sector's role is reduced to essentially executive functions. All the same, it is possible to draw up sectorial research programs to be carried out within the framework of a scientific infrastructure under the authority of the relevant ministry, which would also have the task of ensuring the presence of specialists in the field; the latter would be coordinated by the horizontal development authority.

Seeking Technological Policy Instruments to Create a Technological Style Within a Mixed Economy

Creating a technological style means promoting the use of the technologies most adequate to the country's preferences as well as promoting the research that is to support the chosen style; this action should take place in a consistent institutional context. In a system that is partly government owned, the instruments available to the state make it possible to control demand and induce an adequate supply of relevant national technologies and selective transfers. This control takes the form of direct action of the state through its own enterprises and through modifications of the environment of private enterprises meant to persuade and oblige them to take the required decision. To create efficient control the state is likely to use two types of instruments — direct and indirect.
Some instruments are directly used in the management of state-controlled enterprises or in the form of administrative decisions regarding private enterprises. The decisions of the public sector bearing on the choice of products and techniques, the choice of local or foreign suppliers, the allocation of intermediary scarce products, and on tariffs affect the activities of private enterprises both before and after they affect public enterprises and organizations.

The instruments of direct control of private enterprises include particularly the control of investment and the control of exterior trade. This control takes the form of compulsory licences for private national and foreign investment whose financial volume goes beyond a fixed limit; import controls (licences to obtain currency); and the control public development banks are likely to have on the characteristics of private projects when they request preferential loans. But the decision to grant such loans should be influenced by consideration of social assessment criteria. Such mechanisms may turn out to be totally insufficient if the assessment is based on inadequate criteria (owing, for instance, to the weighting system), so that there is little actual control over the projects.

Provided the direct controls are limited to projects of a certain scale, it is possible to scrutinize not only the nature of the production but also the location and choice of techniques. As to less important projects, only the control of importation can be considered capable of influencing directly the choices of techniques and products. Apart from this control, only indirect incitements are possible in the fields of scattered activity.

Indirect instruments are used in the management of all activities not subject to the direct instruments of control of investment and choice of technique. An essential part is to be given to the establishing of relative prices of the factors expressing social preferences.

In many Third World countries the situation of modern enterprises is different from that of traditional enterprises. The latter fight against a shortage of capital, which they can obtain only at very high rates; and as a result they have to pay their employees poorly. In contrast, modern enterprises have funds available from public sources as well as currency at preferential rates. They therefore tend to make an excessive use of capital and imported equipment. In addition, the cost of manpower is increased by social insurance contributions, which are sometimes very high. A situation is thus created in which restrictive, corporatist social institutions eventually provoke adverse social effects, because high wages are made possible only by the limitation of jobs. Certain social laws may also induce adverse social effects.

Therefore, guaranteeing a minimum salary can only be considered an adequate policy to fight manpower overexploitation in traditional activities in so far as the state is able to enforce it in a field where trade unions' supervision and control are nonexistent; the same is true for all social laws on age, labour hours, security, and hygiene.

Because the financial and monetary system is mostly managed by governmental institutions, it is relatively easier to act on loan rates. A financial policy aimed at supporting traditional activities seems necessary, as is a more selective approach in the allowance of preferential loans to modern enterprises. However, in oligopolistic situations a higher interest rate is not to be expected to prevent the use of highly capital-intensive
techniques, at least in the rather frequent instances in which the demand for their products is little influenced by prices.

This is why in economies with an unequal distribution of income and a high concentration of industries in fields producing, directly or indirectly, for small but rich markets — the wealthy classes — we do not think it conceivable to rely only on indirect instruments to determine the choice of techniques.

Having different rates of indirect taxes may be another way of discouraging the use of mechanized methods (e.g. cigarettes manufacturing and bottling of drinks) when the considered techniques can be explicitly described and when means to control them are available.

As for exchange rates, the remarks made about loan rates are relevant. The taxes on imported equipment could differ depending on whether the equipment originated in an industrialized country or in another developing country. A similar rate difference could apply to second-hand equipment, provided buyers were protected against irregularities in experts' appraisements.

An effort in research and engineering is necessary for reasons linked to the balance of payments and to establish an adequate technological style. This could not be done without support from the national S&T infrastructure.

The selection of imported technology is the first stage in the protection of local supplies. It means the evaluation of projects and the selective granting of currency and loans. The ability required to appraise the requests for equipment imports would certainly make it necessary to create a special (if not independent) department to take care of external operations. The negotiating of technology transfer contracts in particular should be entrusted to highly qualified economists able to realize the importance of the varied clauses because such actions can eventually lead to obliging the demanders of technology (especially in government-controlled enterprises) to make an effort toward national autonomy, and this can only be done if the person in charge is given the status of a minister or the equivalent. The establishing of a data-collecting centre on technology is necessary to the working of the institution in charge of selecting technology import requests. Since there can only be direct control on large investments, this institution should also take part in the definition of indirect control measures.

The creation and development of national engineering offices able to draw up projects is an indispensable step toward the establishment of an institutional system that would make it possible not merely to choose between importing and going without technology, but also to obtain information on better adapted foreign sources, to combine imported elements and local elements, and even to conceive locally.

To create a stable market for local applied research a progressive process can be considered: first, forcing foreign agencies and enterprises to subcontract certain activities in the country (especially with public contracts); and, second, giving preference to local engineering in public or even private contracts (provided the additional estimated cost to the customer is limited). At the same time, the state should make sure that planning and engineering offices work in connection with local research centres.
The strengthening of the autonomic capacity of Third World countries in the drawing up of projects is urgently needed because there is a demand for technology at this level now, and because these offices may have decisive effects on the national supply of technology.

A Few Comparisons

How does the proposed approach figure in relation to experiences in technological planning?

In the Soviet Union and the peoples’ democracies of Eastern Europe as well as in most of the Third World countries and in the industrialized countries, systems of production operate and are planned, where planning exists, according to the rules of productivist logic.

The two relevant questions that would consequently be raised are:

• Is planning on the basis of the logic of needs practicable?
• To what extent can the tasks we have ascribed chiefly to technological planning (management of technological pluralism, conceptualization, and definition and application of appropriate technologies) be taken up within the framework of productivist systems, and with what effectiveness?

Institutionally any collectivist economy could provide itself with an autonomous development style aimed at fulfilling its societal objectives. And yet neither in the Soviet Union nor in the peoples’ democracies of Eastern Europe has a development project emerged that is fundamentally different from those in the industrialized countries. We consider that there are three main reasons for this deadlock:

First, in the middle of the 1950s the difficulties in gaining access to world markets were attributed to the technological gap between the socialist countries and the Western ones. As a result, the tasks assigned to technological research were those that would permit the socialist countries to catch up with the levels of Western technology. The socialist countries also purchased Western technologies by means of which they hoped to achieve a breakthrough on the world market. This result is slow in coming about despite certain progress. On the other hand, certain harmful effects seem to us more notable. What took place was a phenomenon with which most of the Third World countries are familiar: the technology transfer reinforced the demonstration effect of the Western consumer pattern, especially because the priority long accorded to the sector of production goods created a situation in which attractive industrial consumer goods were in short supply, and because in the long run it proved impossible to maintain in the population the illusion that the working class in the Western countries were at a disadvantage as regards levels of consumption in comparison with their Eastern counterparts. As a result, there was a trend in public opinion toward catching up with the West, not solely at the technological level, but also at the level of consumption style.

Second, the demonstration effect acted in conjunction with the importance attached to made-to-measure economic incentives to encourage a raising of labour productivity. In our opinion this phenomenon constitutes a basic ideological turning point. Moreover, the generalization
of economic incentives has had consequences that would have been
difficult to avoid: the accentuation of the rule of individual consumption to
the detriment of collective consumption; the increased importance of
goods and services obtained through the market compared with nonmar­
et goods and services; and a certain accentuation of inequalities of
income distribution (especially if one takes into account the different
advantages enjoyed by the upper echelons of the state and party
apparatus).

All this has strongly reinforced the demand not only for the
"enhancement goods" but also, and more markedly, for the luxury articles
specific to the Western capitalist system. The symbols of this entire trend
and the deadlock are, it seems to us, the encouragement to purchase
private accommodation (whereas immediately after World War II, housing
was considered a nonmarket social service) and the development of an
automobile civilization modeled on that of the West at a time when it is
beginning to be challenged in the West and in conditions that are much
more difficult as regards the volume of investment necessary to ensure a
satisfactory road system.

The third reason for the deadlock is what seems to have been the
dominant perspective in technological planning — the sectorial perspec­
tive, which has lacked any serious search for alternative systems of fulfilling
missions.

On the other hand, several Third World countries, while pursuing
productivist logic in their planning, have, in their technological policy,
taken into account concerns we regard as fundamental: the management
of technological pluralism, and the definition and implementation of
appropriate technologies.

The case of India is very often quoted as one in which the contextual
policy for the support of traditional village industries on the one hand and
the establishment of a heavy industrial base on the other has been more
developed. The two sectors were intended to play complementary roles in
the creation of jobs, the creation of a demand for consumer goods with
capital spared, and the creation of a demand for intermediate goods
(including equipment) with the country less dependent on its imports.
Within the very wide range of intervention instruments, public powers can
control the growth of these sectors.

The evaluation of the Indian experience is far from being solely
positive: the instruments put into effect have had only a limited
effectiveness in protecting the traditional sector in the area of nonpriority
activities (in particular, luxury industries) and inequalities of income
distribution.

Although the practical results are slight, in Latin America there has
come to be an awareness of the role of technology during the last decade.
This is evident from legislative measures, the national effort to create a
capacity for the domestic supply of technology, the explicit contextual
policies put into effect to influence the private sector, and a substantial
body of literature. All this has resulted in greater selectivity of imported
technology and capital, at least for certain countries.

The examples of India and Latin America seem to indicate that even
within a system guided by productivist logic it is possible, with the help of
an array of direct and indirect instruments, to orient choices to some
extent, in favour of appropriate technologies, and to gauge the stakes, which should make it possible gradually to establish increasingly effective technological policies — on the understanding, of course, that the public authorities have the will to do so.

Conclusion

The definition of an appropriate technological style cannot be arrived at without reference to a development style that makes explicit the society's values and its fundamental objectives: employment, equity, and self-reliance. Moreover, all the normative arguments concerning the role of technological policy in a new development style are influenced by political will, without which they would be dead issues.

An important role imparted to the state — that of a mixed economy far removed from the free play of domestic and foreign market forces — constitutes a minimum framework for the development envisaged.

Some are discouraged and irritated by the situation to which we seem condemned: developing a normative alternative for current practices that we find unacceptable. We need to define an alternative that goes beyond the errors of the present system and includes the interests of minorities.

Without denying the importance of the political prerequisites a normative approach leading, according to circumstances, to the design of plans or counterplans none the less seems important to us to shed light on the debate, specify the actions that should be combined to carry out the political desire for real development, and promote awareness of the fact that the current development crisis in no way rules out the possibility of development.
12. Methods Used to Design a Scientific and Technological Policy with Respect to Research and Development Activities

Fernando Chaparro

Designing an R&D Policy or Plan at the National Level

The methods used by different countries in designing an R&D policy or plan are of two dominant types: the deductive method and the successive approximations method. Because the methods are complementary, some countries combine elements of both, but the degree to which each country stresses one of the two approaches varies, so that different limitations are faced. I will discuss each of these methods in its ideal or pure form.

Deductive Method

The point of departure of this approach is the identification of the problems, needs, and priorities of the country, as well as the overall objectives of its process of national development. These factors are usually derived from three sources: the national development plan or policy of the government, the image or characteristics of the future society one wishes to have, and direct personal knowledge of the country's problems and needs.

The first source reflects the fact that policymaking and planning in S&T are part of the overall planning for the development of any country and cannot be considered an isolated process. Therefore, the objectives and priorities established in the government's national development plan or policy have to be taken into consideration, especially in the short term.

The second and third sources give S&T planning a certain flexibility, so that it, in turn, can influence the direction and future characteristics of the country in the medium and the long term. These two sources have been used in two ways: for unilateral identification of objectives, needs, and priorities by the policymaking body or through the assistance of advisory committees or working groups set up for this purpose; and for a systematic effort to develop a consensus among different groups and sectors of the society.

Once the socioeconomic problems and needs of the country have been identified, they must be expressed in terms of questions and problems suitable for S&T treatment. Thus, the potential demand for R&D activities is translated into an explicit one through identification of contributions R&D can make to the solution of the country's problems.
The most common pattern has been to set up advisory committees to analyze the problems identified. The committees address themselves to the question of what S&T can do to solve or help solve those problems.

Traditionally, these committees have been largely composed of members of the scientific community. Nevertheless, their composition is being drastically redefined by some national science councils so as to have greater representation from the production sector and from other potential users of S&T knowledge. This change is part of the evolution from a scientific view of S&T development to an integrated view of this process.

The result of these efforts is the formation of an indicative plan at either the national or the sectorial level related to specific issues or problem areas. The plan identifies possible R&D or technological development programs and projects that should be carried out because they are closely related to national problems and needs.

Some planning efforts have stopped at this stage. The limitation of an indicative plan is that it does not consider the following: the feasibility of the proposed projects, what specific activities will be carried out during a given period (the "duration" of the plan), what institution is going to carry them out, and with what funds and scientific personnel they are going to be carried out.

An indicative plan may provide a useful framework within which decision-making (for example, the allocation of research funds) may take place, but it is not really a plan. If the deductive method is carried to its logical conclusion, funds and other types of resources should be allocated to the different programs and projects identified in the previous stage; this would convert an indicative plan into an action plan. The deductive method has basically been limited to the design of indicative plans. Attempts to form specific action plans have incorporated, to various degrees, elements of the successive approximations method.

The deductive approach to policymaking and planning has several potential limitations:

- The first stage of the process may fail to identify certain basic needs of the country because of, among other things, implicit views of socioeconomic development and of the role S&T may play in it. A case in point is the concentration of R&D in the "modern" sector of the society as opposed to the "traditional" one, where many of the problems are.
- In setting up the advisory committees that analyze each issue or problem too much weight may be given to the scientific community, so that there is little representation of the production sector and other users of S&T knowledge. Thus, the indicative plans or action plans drawn up by these committees may have a strong academic orientation and pay little attention to the solution of existing problems or to the application of S&T knowledge to production.
- This method follows a strictly deductive approach that goes from general development objectives and national needs to specific R&D or technological development projects. Although this approach is intellectually coherent and theoretically integrated, it may have serious practical weaknesses if one wishes to go beyond a mere indicative plan to an action plan. One of these weaknesses is that it is hard to imagine how a
detailed research program could be imposed "from above" on the existing research institutions unless the sociopolitical system were highly centralized. The priorities and research programs thus derived do not take into consideration the research and other S&T activities being carried out by the existing institutions, as well as their future programs of work. Because there is a substantial discrepancy between the theoretical programs and priorities derived through the deductive method and those that are actually being carried out, the problem of implementing the former may be great, depending on the implementing power of the policymaking body.

The first two limitations are not inherent to the deductive method. They are, rather, due to problems in the use or application of the method and therefore can, in principle, be corrected once they are identified. On the other hand, the third limitation is much more basic since it is a consequence of the deductive nature of the approach. As such it is a more serious limitation to the overall process and its results.

An important question is raised by the second limitation: What social sectors or groups should be represented in the policymaking process? Technological development affects not only the scientific community and the production sector but also other interest groups and classes in the society (such as industrial workers, peasants, etc.). Therefore one must consider what groups should be represented in the policymaking process, and through what means this participation can be achieved.

This issue places the S&T policy of a country in the sociopolitical context in which it is designed and implemented, for it takes into consideration the effects of technological development on different groups in the society as well as the relations between these groups.

Successive Approximations Method

This approach does not take as a point of departure the identification of national objectives, problems, and needs, nor does it attempt to deduce systematically an indicative plan or an action plan for R&D at the national or the sectorial level. On the contrary, the point of departure is the R&D and other scientific activities that are presently being carried out or are expected to be carried out by specific institutions. This information is usually collected in one of two ways: through specific requests for funds to carry out certain R&D projects or other scientific activities that are presented by research institutions to the policymaking body; or through systematic collection of information on R&D and other scientific activities that are being carried out by different ministries or governmental agencies, as well as the programs and projects they expect to carry out in the next financial year.

Once this information is collected or made available, an attempt is made to "progressively adjust" the R&D and other scientific activities that are being carried out, or are supposed to be carried out in the near future, to the priorities and needs of the country. This adjustment is carried out through an evaluation that may have successive stages at different institutional levels. The evaluation has two important functions: it eliminates overlapping and repetition of projects; and it confronts the intended programs and projects with the needs of the country and on this
basis suggests modifications that should be introduced to make the R&D effort more compatible with national needs.

The evaluation is usually related to some funding mechanism or to a formal process of drawing up and approving the governmental S&T budget. Some countries have established an interministerial or interinstitutional mechanism to draw up the governmental S&T budget. Generally, this involves a central policymaking body or an interinstitutional committee that evaluates and approves the R&D programs and other S&T activities that are being or will be carried out by government agencies.

In contrast to the deductive method, in which one starts with what should be done, the successive approximations method starts with what is being done and tries to progressively adjust this to the needs of the country. Thus, this approach does not have the same type of limitations as the deductive method. However, the limitations that this process does have are no less important. Because of its pragmatic character, this approach is more concerned with defining the mechanism by which funds are allocated or approved, as well as with designing limited strategies for improving what is being done. There is, therefore, the risk of not defining clearly the national objectives, needs, and priorities that provide the guidelines necessary to orient R&D activities toward the needs of the country.

Simplifying to a great extent, we may say that with the deductive method one runs the risk of designing a coherent policy or general view of the problem without creating the instruments to implement it, so that the plan remains theoretical. With the successive approximations method, however, one runs the risk of creating a series of mechanisms and instruments without having an overall policy that defines the problems and objectives toward which R&D efforts should be directed.

The two methods are not mutually exclusive; on the contrary, they may be complementary. The simultaneous use of the two methods for policymaking may help to avoid to a great extent their respective limitations. Nevertheless, countries differ in the degree to which they emphasize one of the two approaches. Colombia and Venezuela have emphasized the deductive approach, whereas Brazil has emphasized the successive approximations approach.

Designing an R&D Policy or Plan at the Sectorial Level: a Case Study

Technical advisory committees have been mentioned as one of the principal mechanisms or institutional instruments that have been used to identify and define research priorities at a sectorial level or at the level of certain problems of importance for national development. In the case of Colombia, COLCIENCIAS has created a series of special programs structured around these areas or problems of national interest. At present, special programs are being carried out in the following areas: national system of information; normalization, metrology, and quality control; national program of metallurgy; retention and return of scientists; food technology and nutrition; marine and continental waters research; improvement in the teaching of science; housing and building materials; technical assistance to small and medium-sized industry; and population and environment.
In these programs an effort has been made to define the priorities in the respective area through the use of the technical advisory committees. These committees have two basic characteristics: they have wide interinstitutional and interdisciplinary participation; and representatives of the scientific community, the production sector, and the government participate in them.

To illustrate the process, I will now analyze the methods used to define research priorities in the special program of food technology and nutrition.

**Background to the Program**

Studies carried out by various institutions had underlined that the main problems of nutrition in Colombia were protein and energy in infants, malnutrition and undernourishment and anemia through lack of iron in adults. The low income of the population and the lack of access to food were the outstanding causes of malnutrition. A study carried out by the Technological Research Institute found that nearly 40% of urban families did not have a sufficient total income to acquire the minimum diet. In addition, the balance sheet on food of the nutrition board of the Colombian Institute of Family Welfare showed that the local production of food was insufficient to satisfy the minimum requirements of the population.

Therefore the objective of the R&D program in this sector was basically to increase the availability of food for people of low income. This meant the generation and adaptation of production technologies that could provide a balanced diet at a low cost.

**Elaboration of the Program**

Planning of the program included the following stages, which will be discussed in detail:

- Choice of objectives.
- Study of the restrictions within which the possible solutions must be chosen.
- Choice of means to reach the objectives.
- Identification of the problems related to application of the means.
- Identification of the main problems that could be tackled by research programs, and their breakdown into specific projects.
- Establishment of priorities through the application of previously set criteria.

**Objectives**

On the basis of the overall socioeconomic objective — increasing the availability of food for people of low income — the program was directed toward the development of protein-rich foods of high nutritional content. Foods derived from cereals, especially wheat, were given a high priority.

**Restrictions**

When looking for solutions to the food problem through the application of food technology, one must take into account not only the
availability of nutritionally adequate food but also other factors, such as the
low income, the current level and the possibility for development of the
food industry, the impact that industrialization has on the cost of the
product to the consumer, the educational level and food consumption
patterns of the groups toward which the program is directed, the resources
available, the existing government programs, and the degree of develop-
ment of the R&D system in technology.

Means of reaching the objectives

Taking into consideration that there is no single solution to the
problem of protein deficiency, various options were considered simulta-
aneously:

• Adequate production, preservation, distribution, and industriali-
   zation of conventional sources of protein (meat, milk, fish, vegetables,
   oleaginous products, and cereals). Colombia must make the most of its
capacity to produce protein of animal and vegetable origin. However,
despite all its efforts, it is believed that the supply of animal protein and
its consumption by the groups in need will not be sufficient. For this
reason, balanced products containing vegetable protein and substitute
animal protein should be designed and their consumption promoted.
• Production of processed food with higher protein quality and low
cost.
• Selection, adaptation, and use of new means to supply protein —
  for example, sugared products, starch, and sugared fruit juices.
• Use of new or unconventional sources of protein.

In general there is a low level of industrialization of food production in
Colombia, and the application of the second and third options requires the
existence of at least a first stage of industrialization, to make possible the
implementation of a policy of protein enrichment. Of the available sources
of protein and food energy in the country, 55% are animal, and the high
cost of animal protein limits the possibility of its consumption. One could
try to reduce this cost through the application of technology and use
vegetable and cereal protein (cereals are, on average, 32% protein).

Whatever the option chosen, it is necessary for technology to be
 capable of transforming a substance that is merely nutritious into the
superior one of an acceptable food product whose costs and means of
distribution permit it to reach the groups of the population most lacking in
nutrition.

Problems related to application of the means

To identify these problems a format was used in which the problems
that limit or affect the availability of a given source of protein were pointed
out. Each type of problem in agriculture, economics, food technology, etc.
was then classified and accorded first, second, or third priority. The
priorities were initially set according to criteria established from studies
carried out in the country or abroad that have since been revised, and in
some cases modified. Two criteria were taken into account: the size of the
effort necessary, and its order in the sequence of problems that must be
resolved.

Research required

A study of the problems pointed out permitted the identification of
research projects that required organizing and promoting to reach the
program's objective. The research in nutrition would support and direct
research into food technology. The agricultural, economic, and education-
al problems were remitted to the pertinent bodies or institutions for
management.

Establishment of priorities

One of the methods for the study of strategies of research,
classification, and assignation of priorities to projects consists of evaluating
the relative impact that different programs can have on the most pressing
needs of society. This method also requires the establishment of criteria.
Moreover, guidelines must be selected for measuring the impact that the
application of the project may have on the objective implied by each
criterion — in other words, for grading the criteria.

The technical advisory committee selected the criteria and weighted
them according to relative social, economic, and operative importance,
taking into account the most outstanding causes of malnutrition identified
up to then, such as the low income of the population and the lack of
availability of foods in relation to minimum requirements. Also taken into
account were the facts that certain factors have influenced the experience
of other countries, that the introduction of enriched products could have
very little success, that the product must be compatible with the national
eating habits, and that the necessary natural resources must be obtainable
locally.

If one considers that 40% of the urban families in Colombia do not
have a sufficient total income to acquire a minimum-cost diet, the
production of inexpensive but highly nutritious products takes on great
importance. If one also takes into account the magnitude and intensity of
the problem of malnutrition in the country, the possibility of short-term
benefit to the population also takes on great importance. The criteria of
foreign currency and investment are also important, given the limited
economic resources in the country.

In the course of grading the projects according to these criteria, no
exact figures were available to permit assessment of the impact a given
project might have on the achievement of an objective, but approximations
were made on the basis of the information available to the working group.
The multidisciplinary, multi-institutional committee tried to make this
information as correct as possible for the social and economic categories.
The criteria were graded on a scale of 1 to 5. Inapplicable criteria were not
graded. For each project an overall grade was calculated by adding up the
grades of each criterion.

The projects were graded by the committee as a whole because it was
necessary that the evaluation be done simultaneously by a multidiscipli-
nary group that would reach agreement on the grading through discussion.

Once the grades were obtained, the projects were classified into four
groups according to priority. The projects with the highest grades were
considered more likely to be successful in reaching their objectives.
However, the grading was a relative, not a specific indicator. Thus, the
project with the highest grading was not necessarily better than the second
or third project of the first priority, but was probably much better than
those of third or fourth priority.
13. A Framework and Format for Sectorial Science and Technology Plans

Ashok Parthasarathi

The first step in preparing a sectorial plan for S&T development is to analyze the broad social and economic setting of the sector concerned. This is necessary because large-scale application of S&T has been shown in the highly industrialized countries to be related to the structure and organization of their economic and social systems. This step has two components: analyzing the development of the sector, looking at the way its structure and organization have evolved and have influenced the pattern of development; and analyzing the investment, employment, pricing, import-export, industrial, and similar socioeconomic policies that have been applied to the sector.

Against this background one should ask the following question: How do the prevailing structure and organization of the sector and the socioeconomic policies being followed affect the demand for S&T and the capacity of the production and service systems of the sectors to use effectively the output, particularly indigenous, of S&T?

This question should be applied policy by policy, and the changes in the policies (including legislation) that would permit intensification of the use of S&T should be identified. Although redefinition of development policy is very important, attention could also be valuably drawn to the parts of the sector in which structural and organizational changes and socioeconomic policies favourable to the use of S&T already prevail.

Demand for S&T Input

In the Existing Production and Service Systems

In these systems R&D input is needed in the following areas:

- Substitution of domestically produced process and product know-how for imported, so as to limit the dependence on technical collaboration agreements.
- Substitution of domestic raw and intermediate materials for imported, whether these are used in production based on indigenous technology or production based on imported technology.

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22 This essay is based on a document prepared for the National Committee on Science and Technology of India.
- Substitution of domestically produced capital goods for imported.
- Improvement of yield, conversion efficiency, and other technological factors involved in production, extraction, and utilization processes — for example, improvement in the percentage recovery in coal mining, and improvement in machinery efficiency through increased cutting speed of the tools.
- Waste utilization and byproduct recovery.
- Environmental control.

Import substitution efforts must involve not merely “one-to-one” substitution, but also adaptation of the imported know-how to suit Indian conditions of production and use, and improvement of the know-how to an extent consistent with available lead times. The starting point for such planning is most likely to be compiling a comprehensive list of foreign collaboration agreements in force, with their expiry dates, the nature and scope of the technology transferred, and so forth.

The areas in which it is worthwhile to commit indigenous R&D resources to the substitution of domestically produced know-how for imported must be chosen carefully. If, for instance, it is judged, with reference to either international trends or India’s needs, that ferrite should be replaced by semiconductor magnetic devices in all electronic equipment that is to be made starting 2 years from now, then even if equipment containing ferrite is being manufactured now with imported know-how, no effort should be committed to the replacement of that know-how with domestically produced know-how.

S&T input into productivity enhancement and regulatory activity (PERA) would be directed toward improving plant maintenance and operation, plant utilization, cost reduction at all points, safety, standardization, and environmental control.

In the Expansion and Diversification of Production and Service Activities of the Sector

Forecasting of the demand 5 and 10 years from now for each product to be produced, each facility to be set up, each service to be provided, and quality control must be done primarily by the Planning Commission and an administrative ministry, but with important input of the National Committee on Science and Technology, particularly in relation to the choice of technology. Should the most advanced technology, which is likely to be highly capital-intensive and to demand a sophisticated infrastructure and often a large market, be used, or should less sophisticated technology involving higher labour content, use of local materials, and suitability to the relatively smaller market in India be used? What is the range of options available and what are the costs and benefits of each?

Policy preferences (social, economic, and political) should be applied to decide which elements in the demand forecast should be met and which should be deemphasized. For example, the development of electrical power generation resources should be regionally balanced even if this involves higher costs of generation and supply in certain instances; and products and services causing substantial environmental problems should
be replaced by those with less severe environmental adverse effects even if this means higher production and selling costs at the start. This again is a task to be undertaken by the Planning Commission in cooperation with the National Committee on Science and Technology and the National Committee on Environmental Planning and Co-ordination, under the direction and control of the cabinet.

"Policy legitimized" forecasted demand can be separated into that related to existing products, facilities, and services, and that related to new products, facilities, and services. Meeting the former would largely involve expansion of the existing production system, whereas meeting the latter would call for new investment.

The S&T tasks to be tackled to meet this demand for existing products, facilities, and services would largely have been taken into account in the exercise described earlier for existing production and services systems. As to the demand for new products, facilities, and services, some would require R&D efforts and others PERA; examples are the development of specifications and configurations of facilities, the development of process and product know-how, the development of trial and testing centres, the development of design engineering for each category of process or product, the development of production plant and equipment fabrication, the development of instrumentation, and determination of the nature and extent of extension and demonstration services to be provided and how they should be provided.

**Supply of S&T Input**

S&T input can currently be supplied by all central and state government laboratories, central and state public sector companies, private sector companies, and universities and other institutions for higher education that are pertinent to the sector.

Institution-specific sectorial plan reports should include at least the following:

- Goals of individual tasks that are being worked on or have been completed, and the funds committed to them during the last 3 years, including foreign.
- Manpower resources deployed on each project during the last 3 years, in terms of level and number.
- Present status.
- Expected date of completion.
- Nature of output to be provided — for example, technical report or laboratory scale know-how, pilot plan sponsorship (if any), proven know-how, test procedures, standards, and so forth.

The report should conclude with a summary statement that consists of two main sections (process and product development, and PERA), each of which is broken down into two categories: completed tasks, and ongoing tasks. The tasks should be categorized in terms of the goals of the demand statement for S&T input into the existing production and services systems.
Changes Necessary in the S & T Effort to Match Supply to Demand

R & D

Domestic effort

• Identifying, in consultation with R&D agencies, production agencies, and others concerned, the goals in the demand statement for which R&D input had already been generated, whether in government laboratories or laboratories (or other installations) of public or private sector industry, and working out the means for commercialization.

• Identifying, in consultation with the concerned R&D agencies, production agencies and users, the R&D projects under way in government laboratories or laboratories of public or private sector industry that are directed at meeting one or other of the goals in the demand statement.

• Determining, in consultation with the concerned R&D agencies, the projects under way in existing institutions that should be terminated because their goals are at variance with those contained in the demand statement.

• Assessing, in consultation with the concerned R&D agencies and companies, whether the R&D resources (personnel, equipment, money) released as a result of such termination are adequate to meet all the requirements of the remaining goals in the demand statement.

• If it is found that the redeployable R&D resources are inadequate, determining the manner in which they should be augmented so as to meet the requirements of the remaining demand. For instance, specific groups in existing laboratories might be expanded, new groups in existing laboratories might be set up, or new laboratories might be set up.

• Establishing as a result the optimum mix of such supply-augmenting measures for the sector concerned in terms of the tasks now assigned to named groups and institutions. An important aspect of this activity should be identifying and meeting the internal requirements for success of the augmented S & T effort, such as concentration of the R&D effort so as to create research groups of a practical size, creation of points of contact between basic, applied, and developmental research, and coordination of R&D activities with PERA as well as extension activities, survey activities, and so on.

Foreign input

Tasks for which it is felt that production-worthy know-how cannot be generated in the available lead time, even with augmentation of the supply of R&D input, should be indicated as needing imported S & T. This should be done on a process- or product-specific basis. In each case either a government laboratory should be assigned the task of building on the imported technology (which requires the company that imports the technology to provide the laboratory with access to what it imports) or the importing company should be required to indicate, at the time of import, what measures it is taking to assimilate and build on the technology.

Organizational and managerial reform

It may often be found that supply-augmenting measures in terms of
personnel, equipment, materials, and so forth may not be enough; certain organizational and managerial changes may also have to be made in at least some of the R&D institutions in the sector. These changes should therefore be spelled out at this stage of the sectorial plan report.

Furthermore, new institutions of many kinds may also have to be set up. The nature of these institutions, a broad indication of their goals, and, when possible, the agency that should be responsible for setting them up should be indicated. If the plan is sufficiently well worked out, it may be possible to mention these institutions in the task assignment statement.

**Design Engineering**

**Domestic effort**

- Identifying the processes and products for which the involvement of design engineering is necessary to commercialize either existing technology or the technology that is to result from R&D efforts under way or to be initiated.
- Determining in each case a design engineering company that would be willing and able to take over the know-how and commercialize it on a turn-key basis if needed.
- Establishing the design engineering lead time in each case, and the amount of design and engineering effort required in terms of personnel and money.
- When suitable design engineering organizations do not exist, as in the shipping industry, determining the amount of money and time required to set up such a company.

**Foreign input**

When it is felt that the design engineering capability is inadequate and that it cannot be generated through measures such as the preceding in the available lead time, even with augmentation of supply of design engineering input, these services should be imported. At the same time, however, the best existing design engineering company in the country should be assigned the task of being fully associated with such imported services and building on them.

**Organizational and managerial reform**

It may often be found that supply-augmenting measures in terms of personnel, equipment, materials, and so forth may not be enough; certain organizational and managerial changes may also have to be made in at least some of the design engineering and other institutions in the sector. These changes should therefore be spelled out at this stage of the sectorial plan report.

Furthermore, new institutions of many kinds may have to be set up. The nature of these institutions, a broad indication of their goals, and, when possible, the agency that should be responsible for setting them up should be indicated. If the plan is sufficiently well worked out, it may be possible to mention those institutions in the task assignment statement.

**Plant and equipment fabrication**

The plant and equipment needed may be itemized, with as many specifications as possible, and then passed on to special groups, such as those concerned with machine tools, heavy engineering, or instrumentation.
**Domestic effort**

- Identifying, in consultation with PERA agencies, production agencies, and others concerned, the goals in the demand statement for which PERA input has already been generated, whether in government laboratories or laboratories (or other installations) of public or private sector industry, and working out the means for commercialization.
- Identifying, in consultation with the concerned PERA agencies, production agencies and users, the PERA projects under way in government laboratories or laboratories of public or private sector industry that are directed at meeting one or other of the goals in the demand statement.
- Determining the manner in which PERA resources should be augmented so as to meet the requirements of the remaining goals in the demand statement. For instance, specific groups in existing laboratories might be expanded, new groups in existing laboratories might be set up, or new laboratories might be set up.
- Establishing as a result the optimum mix of such supply-augmenting measures for the sector concerned in terms of the tasks now assigned to named groups and institutions.

**Foreign input**

Tasks for which it is felt that better maintenance practices or new service facilities cannot be generated in the available lead time, even with augmentation of the supply of PERA input, should be indicated as needing imported S&T. This should be done on a service- or facility-specific basis. In each case either a government laboratory should be assigned the task of building on the imported technology or the agency that imports the technology should be required to indicate, at the time of import, what measures it is taking to assimilate and build on the technology.

**Organizational and managerial reform**

It may often be found that supply-augmentation measures in terms of personnel, equipment, materials, and so forth may not be enough; certain organizational and managerial changes may also have to be made in at least some of the PERA and other institutions in the sector. These changes should therefore be spelled out at this stage of the sectorial plan report.

Furthermore, new institutions of many kinds may have to be set up. The nature of these institutions, a broad indication of their goals, and, when possible, the agency that should be responsible for setting them up should be indicated. If the plan is sufficiently well worked out, it may be possible to mention these institutions in the task assignment statement.

**Research and Personnel Training in Academic Institutions**

An important aspect of S&T planning must be how to ensure that the academic institutions train the right kind of personnel and that the research done in universities is related to the priority social and economic problems of the nation. Ensuring the former calls for review of curricula and teaching methods, provision of teaching facilities and equipment, and many related aspects of university education. Ensuring the latter calls for a
system in which a large part of the research done by the universities is basic research needed for government and industrial laboratories to make progress in their applied and developmental work. A possible way of establishing such a system would seem to be to ensure that a large part (say two-thirds) of the funds allocated to university research were committed to projects designed by university faculty in consultation with project leaders in mission-oriented government laboratories. Such an approach would require the mission-oriented agencies to work out appropriate policies and practices regarding the funds granted to university training and research. At least one agency is known to be working on such policies and practices.

There would also be a need to ensure that the rest of university research was undertaken on an open-ended basis, where the criterion of choice for financial and institutional support was the quality of the research worker or the importance of the problem from a long-range point of view.

It would be valuable if part of the output of this part of the sectorial plan was a list of themes for long-range, forward-looking scientific and engineering research, based on technological forecasting when possible. The output of these analyses should be finally presentable in the form of a task assignment statement.
14. The Categories of Anticipatory Decisions Involved in Scientific and Technological Planning²³

Francisco R. Sagasti

As long as anticipatory decisions are the building blocks of planning, planning methods should be developed that take into account the different types of anticipatory decisions that have to be made, for each of these may require a different planning procedure. In planning for S&T development there are five categories of such decisions: first, the definition of long-term ideals; second, the pattern of interactions with related systems; third, decisions about the institutions within the system; fourth, the scope and nature of the activities of the system; and, fifth, the allocation of resources. These five categories may be described as stylistic, contextual, institutional, activity, and resource planning respectively.

Although planning activities can be divided into these five types, the five are not independent, and they cannot be dealt with separately and individually. Planners would like to be able to identify the combination of activities, institutions, and resource allocation that would enable the system to approach its ideal. Unfortunately, it is unlikely that such a method could be developed in the near future. The most workable alternative appears to be procedures that would construct for each category of decisions a provisional plan to be revised in the light of anticipatory decisions made in the other areas.

Planning concepts, procedures, and methods appropriate for one planning category cannot be expected to be appropriate for any of the others, as all five categories differ in almost every respect. For example, the problems of resource allocation have little in common with those of building institutions, coordinating policies and plans, and designing the ideal future. Hence, it becomes necessary to discard old thinking habits when moving from one category of planning to another. Thus, we arrive at the principle: in planning for S&T development we should consider the different categories of planning decisions that have to be made and develop methods appropriate for each.

Current planning methods apply only to activity and resource planning; there are no methods specifically designed for anticipatory decision-making in any of the three other categories.

The different characteristics of the five types of anticipatory decisions suggest that they may fall within the domain of different planning

Table 4. Characteristics of the different categories of planning.

<table>
<thead>
<tr>
<th></th>
<th>Stylistic</th>
<th>Contextual</th>
<th>Institutional</th>
<th>Activity</th>
<th>Resource</th>
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</thead>
<tbody>
<tr>
<td>Conditioned by</td>
<td>Value systems and preferences (stylistic constraints), and long-term possibilities</td>
<td>Environmental constraints and interdependencies with other systems</td>
<td>Institutional constraints and possibilities for development, and organizational ecology</td>
<td>Existing and potential capabilities, and dynamics of processes</td>
<td>Availability of resources and possibilities for directing allocations</td>
</tr>
<tr>
<td>Emphasis on</td>
<td>Alternative futures, Desired image (willed future), and clarification of values</td>
<td>Convergence of different policies and plans, and attaining overall coherence in plans and policies</td>
<td>Establishing appropriate organizational structure (channels and clusters)</td>
<td>Defining areas for concentration of activities, and evaluation of past performance</td>
<td>Influencing resource allocation</td>
</tr>
<tr>
<td>Type of process</td>
<td>Exploratory, consultative, and multiple-loop</td>
<td>Coordinating and negotiative</td>
<td>Structuring and texturing (setting the organizational fabric)</td>
<td>Diagnosing, target-setting, balancing, and learning</td>
<td>Allocative, distributive, and experimental</td>
</tr>
<tr>
<td>Procedures followed</td>
<td>Establishing ideal standards, proposing broad directions, and establishing dialogue with interest groups</td>
<td>Making explicit relevant implicit policies, resolving contradictions, and using indirect instruments to implement plans and policies</td>
<td>Institution building and renewal (creation and modification of institutions), defining performance measures, and setting the “rules of the game”</td>
<td>Establishing objectives, defining orientation, and setting up operational procedures</td>
<td>Acquiring and distributing resources, establishing priorities for resource allocation, defining specific aims and goals, and generating a data base</td>
</tr>
<tr>
<td>Made by</td>
<td>Planning agency and interest groups</td>
<td>Planning agency and agencies in other systems</td>
<td>Planning agency and other organizations in the system</td>
<td>Planning agency and other organizations in the system</td>
<td>Planning organization and other organizations in the system</td>
</tr>
<tr>
<td>Dominant time frame</td>
<td>Long-range</td>
<td>Medium-range</td>
<td>Medium-range</td>
<td>Medium-range</td>
<td>Short-range</td>
</tr>
</tbody>
</table>
organizations. If we assume the existence of a central agency in charge of S&T planning, then stylistic planning would be performed by the planning agency and the interest groups affected by the anticipatory decisions to be taken, contextual planning would be performed by the planning agency in conjunction with planning agencies in other related systems, and institutional, activity, and resource planning would be carried out by the planning agency and the other institutions in the system.

Stylistic planning is essentially long-range. Contextual, institutional, and activity planning are primarily medium-range, although the planning of ideal patterns of interaction, institutional structures, and patterns of activities would be stylistic and thus part of a long-range exercise. Short-term planning appears to be less important for these three categories. Finally, resource planning, much of which concerns budgets, is primarily short-range, although occasionally long- and medium-term commitments have to be made.

The main characteristics of the five types of planning activities are summarized in Table 4.

Stylistic Planning

The objectives in stylistic planning are to project an image of the S&T system as an ideal to be approached, and to involve the groups affected by planning, exposing their values and preferences. The stylistic plan evolves into a common perspective of the future. It is this, rather than the planning documents, that should be the main outcome of stylistic planning.

Trist (1968), commenting on Crozier’s analysis of French economic planning, has asserted that the learning process that takes place during the preparation of a plan is far more important than the plan itself. Recently Caroll (1971), has suggested that this learning process and the involvement in planning, particularly in technological matters, need not be confined to the immediately interested parties, such as the government and scientists, but can also spread to ordinary citizens.

Stylistic planning is an exploratory multiple-loop process, conditioned primarily by value structures and preferences. It specifies alternative futures and defines a desired image or a “willed future.”

In defining an ideal future, stylistic planners must consider the system’s relations with others. What, for example, might be the contribution of S&T to economic and educational development and the use of natural resources? The stylistic plan should also describe what institutions there would ideally be, what they would do, and how resources would be acquired and allocated.

The image of the desired future would consist of statements about the characteristics of the system and its interrelations with the environment at a certain time. Proposals for a strategy to attain this ideal would also be necessary. The statements need not be detailed; as the interactions in the continuous process of stylistic planning take place, these scenarios would be refined.

Stylistic planning should be over a long enough time that the present situation and its dynamics do not significantly condition the future situation. This does not imply, however, that feasibility should be ignored.
The design of ideals is not a recent development. Plato, St. Augustine, Sir Thomas More, and others put forward their ideals. Perhaps one of the most coherent early descriptions of the possible use of ideal schemes for taking action was given by Kropotkin (1970), who, in 1873, in an essay titled “Must we occupy ourselves with an examination of the ideal of a future system?”, said:

... I believe that we must. In the first place, in the ideal we can express our hopes, aspirations and goals, regardless of practical limitations, regardless of the degree of realization which we may attain; for this degree of realization is determined purely by external causes.

In the second place, the ideal can make clear how much we are infected with old prejudices and inclinations. If some aspects of everyday life seem to us so sacred that we dare not touch them even in an analysis of the ideal, then how great will our daring be in the actual abolishment of these everyday features? In other words, although daring in thought is not at all a guarantee of daring in practice, mental timidity in constructing an ideal is certainly a criterion of mental timidity in practice.

Kropotkin stressed the benefits of freeing the imagination from questions of feasibility to uncover latent value structures and preferences. However, to be of real benefit, ideal future images should be tempered by consideration of the possible.

Stylistic planning designs a future rather than extrapolating current trends or projecting the most likely developments from extrapolations and probable reactions. An extrapolation says: “If present trends continue and no action is taken, the future will look like this.” The “most likely” view says: “Given current trends, and the fact that this or that action will probably be taken in reaction, the future is most likely to look like this.”

The stylistic view designs the future as we would like it to be, and then devises a strategy for reaching it. Feasibility should initially be ignored for the reasons Kropotkin gave — namely, it should not inhibit new ideas that embody preferences and values; when modifying the desired image and devising a strategy for attaining it, however, one must consider feasibility. At later stages the extrapolated and most likely futures should be compared with the desired future. The planners are then confronted with a void between the projected and desired futures that has to be filled in through purposeful action.

The injection of reality precludes the stylistic planner from embracing the elements of a purely wishful desired future, elaborating on them, and then assuming the desired image to be an accomplished fact. This tendency, called “proyectismo,” has been identified in much of the planning in Mexico. Gross (1967) suggested that this is a feature common to planning in many underdeveloped countries, where “dreams are easy to concoct but the conflicts and obstacles to achievement are tremendous.” According to him:

... proyectismo is based upon utopian commitments to a desired situation that are simply impossible to obtain. In this latter case, the elaboration of presumed methods of attaining the unattainable may serve to make the plan more plausible, even though not a bit more
feasible. Yet the fact that a plan may be utopian need not prevent its reaching the stage of central decision and commitment. National political leaders often make “pie in the sky” promises as the only way to distract attention from current suffering.

Therefore, by identifying existing and potential S&T capabilities and incorporating technological forecasting, it may be possible to avoid the pitfalls of utopian thinking in the design of a desired future S&T image. There are reasons to believe that in building a planning capability, particularly in S&T, stylistic planning should have priority. Stylistic planning is relatively independent from the other types of planning. Being long-range, it affects the other types of planning more than they affect it. Furthermore, planners, policymakers, and other interested groups find it easier to agree on long-term ideals than on short-term problems of resource allocation or medium-term problems of defining activities, building institutions, and coordinating with other systems. Stylistic planning may thus provide a basis for agreement that would otherwise be difficult to obtain.

**Contextual Planning**

The second category of planning decisions is concerned with interaction between the S&T system and other systems. Contextual planning seeks coherence among these interacting systems and explores the use of indirect instruments and mechanisms for implementing planning decisions. It is influenced by its environment and emphasizes convergence of the policies and plans of different systems through coordination and negotiation. It makes explicit the consequences of other systems’ policies and plans, resolves contradictions that may appear among them, and analyzes the implementation of S&T plans through other systems.

Contextual planning deals with the context, or the environment, of the S&T system, the context being the systems and their components that affect the behaviour and performance of the S&T system, but over which they have no direct control. However, the S&T system can influence the behaviour of its environment through negotiation and coordination. Because of their importance for contextual planning, the characteristics of the environment merit further analysis.

Trist (1969) proposed a differentiation between task and contextual environments:

... It is necessary to distinguish between the immediate, operational or task environment and the more remote general or contextual environment. The task environment consists of all organizations, groups and people with whom the organization has specific relations, on both the input and output sides, even though it may not be aware of their complete range. The contextual environment consists of the relations which the entities included in the task environment have to each and to other systems not directly entering the world of the organization's own transactions. Events in the contextual environment may at any time obtrude into this world, constructively or destructively, predictably or unpredictably.
For a system to deal effectively with its environment it must do more than pay attention to the task environment. It must also assess the potential influence of the contextual environment, seeking to anticipate changes that may affect the system. It may be that some aspects and components of the contextual environment, particularly those that affect the system, need to be made part of the task environment through direct links between them and the system.

The policies of the systems within the environment constitute, in fact, a set of implicit policies for S&T. Government economic and educational policies, in particular, contain an array of consequences or implicit policies that indirectly regulate the behaviour of the S&T system. These implicit policies must be made explicit if planning for S&T development is to be effective. The process of making them explicit is likely to demonstrate inconsistencies between overt objectives and policies and those forced on the system by its environment. The ways in which those contradictions are resolved will decisively influence S&T developments.

There will be value conflicts. Contradictory policies are not made congruent simply by their demonstration. These value conflicts must be resolved, usually through coordination or negotiation, but in extreme cases by an open fight.

**Institutional Planning**

Anticipatory decisions on institutional structure concern the organizational network through which activities are to be carried out and resources channeled and the rules and regulations that govern the behaviour of the institutions. Institutional planning is influenced primarily by organizational constraints and the possibilities for institutional development. This type of planning activity includes creating and modifying institutions and setting codes of behaviour.

The development of an institutional infrastructure is necessary for the development of S&T in underdeveloped countries. As René Maheu (1965), former director general of the United Nations Educational, Scientific and Cultural Organization, said:

... 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 these countries 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 underdeveloped countries to imitate these structures. This has been the case in Peru, where such imitation has been responsible for several deficiencies in Peruvian institutions, particu-
larly in health care, higher education, industrial development, and even S&T.

A strategy of institutional imitation is likely to fail for the following reasons: first, the context in which institutions operate in a developed country is very different from the context in underdeveloped countries, 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 often prefer to develop institutional structures different from the ones they have, which are being copied; and third, the underdeveloped country may provide social and historical conditions for the development of new institutional patterns that are better suited to local conditions and could eventually become a model for other countries, underdeveloped and developed.

In underdeveloped countries the evolution of institutions in the S&T system has been slow. Research organizations, universities, research councils, and service organizations have lacked money and qualified personnel; in some countries, particularly in Latin America, there has been little demand for the knowledge and services such institutions produce.

A well organized institutional structure, particularly at the national level, cannot quickly be developed from scratch. However inadequate, a core of institutions usually exists in underdeveloped countries, even if only on paper, from which the building of an organizational fabric can begin. Institutional planning takes the existing structure as a basis, examines it critically, and proposes changes. Once proposals are implemented, they should be left to evolve without being changed too soon. A certain lead time is required for the institutions to stabilize after important modifications have been introduced, and frequent radical changes may retard the development of the institutional structure.

I know of no criteria for optimal institutional design, particularly for the S&T system in underdeveloped countries. One strategy for choosing among alternatives may be to establish minimal conditions for an acceptable institutional structure. The selection among such designs would not be part of institutional planning.

This strategy could be improved with a second set of criteria based on the institutional design's capability for adjusting to changes in the system or its environment. However, it may not always be possible to define the adaptability criteria in addition to the minimal standards.

**Activity Planning**

Activity planning concerns decisions about the scope and nature of activities to be performed by the system. It is influenced by the capabilities of the system and the processes that take place within it. Activity planning defines priorities for activities and evaluates past performance to guide the definition of these areas. The procedures include defining the objectives, defining the orientation the system should take, and providing operational procedures. Activity planning must propose controls on the flow of knowledge from abroad.

Thus, the tasks in activity planning can be divided into two: deciding which S&T activities should be carried out in the country, and specifying what S&T knowledge will be acquired from foreign sources.
S&T autarky is practically impossible and even undesirable in the modern world, particularly for the underdeveloped countries of Latin America. The strategy proposed for S&T development is one of selective interdependence with other countries and their S&T systems. This implies that the underdeveloped country will concentrate its efforts in areas in which it has competence, or can quickly acquire it, and in areas in which knowledge cannot or should not be imported. The local scientific community would attempt to transform itself into a world centre for knowledge in which it has decided to concentrate its efforts. The selective interdependence strategy also implies that the country may import know-how, process it, and then export it. Therefore, the selection of domains for S&T activities is crucial.

It is also necessary to ensure that, in the areas in which the country will be dependent on foreign knowledge, the best possible conditions are obtained, as the bitter experience of Latin American countries has shown.

The concept of selective interdependence is based on the work of Emery (1967) and Emery and Trist (1965). Gilpin (1970) has argued that strategies for determining priorities should be closely related to the strategy of selective interdependence. Gilpin identified three strategies for selecting priorities for S&T development:

...The first [strategy] is to support scientific and technological development across the broadest front possible...The second strategy is scientific and technological specialization. The essence of this strategy is to support specific areas of science and technology, usually of commercial utility and concentrate one's resources upon them...In contrast to the first two strategies, the third is an importation strategy. Emphasis is placed on importing foreign technology by the purchase of licenses...Although this strategy, like the second, implies specialization, it differs in that relatively little basic research is carried out. Instead...resources are concentrated on improving and redesigning imported technologies, specially for subsequent export.

The selective interdependence strategy proposed for S&T activity planning in Latin America encompasses Gilpin's second and third strategies. The existence of unused natural resources, for which the technical knowledge needed for exploitation is not available elsewhere, imposes the need for the specialization strategy, and the heavy reliance on foreign technology imposes the need for an importation strategy. The lack of human and financial resources precludes underdeveloped countries from following the first of Gilpin's strategies, which has been followed only by the Soviet Union and the United States.

Determining domains and priorities for S&T activities should be based on a comparison of the S&T capabilities of the country with the requirements of the economic, educational, physicoecological, and other systems in the nation. Using this method, planners examine the functioning of these demand-generation systems and clarify their needs for knowledge. The comparison demonstrates imbalances between demand for and supply of knowledge. This process may replace the market mechanisms for S&T knowledge that operate in countries with well-developed institutional structures.
However, it has been found necessary to modify and extend this method, particularly by refining the concept of requirements, so that the needs of economic, educational, cultural, and other activities are projected onto the S&T system. The possibility that S&T capabilities may give rise to demand-generating activities that, in turn, would create further S&T requirements is usually not considered.

The S&T and demand-generating activities can be classified into several categories, each with different requirements. Among the demand-generating activities (economic, natural resources, social, cultural, and so forth) there are existing and planned activities, which generate requirements for S&T that may be satisfied or unsatisfied, depending on whether or not the relevant S&T activities are being carried out. Satisfied requirements find S&T activities that correspond to the needs they create; unsatisfied requirements generate a need for new S&T activities. Unsatisfied requirements may be identified at different levels. At an aggregate level, priorities for S&T could be established for general problems of national importance or for economic sectors. At the level of production units and specific technology, research projects could be identified and priorities attached to them. Different methods will have to be used for selecting areas of concentration and for determining priorities at each of these levels.

On the other hand, there are S&T activities that have no counterpart in demand-generating activities. They could induce or promote economic, educational, social, and cultural activities that would, in turn, generate requirements for S&T.

Many countries have capabilities in some areas of fundamental or even applied research that have had little direct application. For example, it is common to find competence in electronics, physics, and chemistry for which there is no corresponding economic activity and therefore no effective demand. These S&T capabilities could promote or induce economic activities that would, in turn, require the research services the S&T system could provide. These induced requirements could play an important role, not only in the development of economic and social activities, but also in S&T progress.

Finally, we can define another category of requirements for which neither S&T nor demand-generating activities exist or are planned. These possible requirements would arise from a development strategy different from the one pursued by the country, and from a critical examination of the role of S&T in advancing economic growth under different models of development. This category of requirements is particularly important in a consideration of the possibility of skipping stages and pursuing different styles of economic development.

**Resource Planning**

This type of planning deals with the allocation of resources. It is influenced by the availability of resources and by the possibility of directing their allocation. Procedures followed include acquiring and distributing resources, defining goals to be achieved with given resources, establishing priorities, and generating a data base.
Planning agencies themselves seldom control much of the total resources allocated to S&T. Institutions such as private research organizations, universities, and government agencies are also engaged in resource planning, although they may not realize it. The planning agency should therefore aim at allocating its own resources efficiently, as well as at influencing the way in which other institutions in the S&T system allocate their resources.

S&T planning agencies in Latin America have little direct control over the training of highly qualified personnel. This training is, instead, a function of universities and other institutes of higher education. The agency in charge of S&T planning can only propose policies, coordinate efforts, and try to relate educational plans with S&T development. For instance, the agency could point out to educational planners the need for highly qualified research and technical personnel and suggest policies for retraining scientists whose skills appear to be irrelevant. It could also promote meetings to increase communication in the scientific community, as well as devise means for enhancing the prestige of S&T activities that relate to development.

The planning agency may directly control the administration of fellowships and scholarships and the training of personnel for S&T planning and supporting activities. Through the administration of fellowships, particularly those to study abroad, the planning agency could influence the volume and composition of qualified personnel and, therefore, exert some control over their orientation. The preparation of personnel for S&T planning and for supporting activities (documentation specialists and librarians, for example) is an additional task the planning agency could handle directly.

Different procedures for the allocation of funds may be followed, depending on whether the funds are controlled directly by the planning agency or by other institutions. In the first case, money available to the planning agency should be allocated to the general areas defined in activity planning. If research activities in these areas can be performed directly by the planning agency or one of its dependencies, the problem becomes one of generating and selecting the projects to which funds should be allocated. If projects are to be performed by other organizations, the planning agency should request proposals in the areas given priority. The problem then becomes one of selecting among research proposals submitted to the planning agency. Procedures such as cost–benefit analysis are available for this purpose.

For the funds not directly under its control, the planning agency should propose allocation methods and criteria to other institutions, suggest uniform budgeting procedures that would allow interinstitutional comparisons, and initiate an annual consolidated S&T budget. This would show how national resources are being allocated. Resource planning would include generation of information that would help in the construction of mathematical models for the allocation of funds and in the interpretation of allocation decisions.

Also included in resource planning should be the use of buildings, laboratory equipment, instruments, computers, libraries, and documentation centres, among others. The planning agency's functions should include proposing policies for more efficient use of physical resources.
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15. Allocation of Resources in Science and Technology Planning: Creation of Capacity and Use of Installed Capacity

Alberto Aráoz

In S&T planning in less-developed countries it is important to distinguish resources applied to the installation of new capacity in S&T from those that support current S&T activities.

With economic activities it is normal to consider investment and production as separate categories in the allocation of resources. In S&T matters, the two parallel categories are often confused, perhaps because it is felt that expenditure in R&D — and sometimes in other S&T activities — is an investment that will some day bear fruit.

The installation of capacity in S&T requires the creating, training, and perfecting of human resources and the development of a network of information, communication, and links with other social systems. These are structural aspects, to which true investment resources should be allocated.

Installed capacity in S&T should be used according to the demands and priorities of scheduled activities. Expenditure in this category should be budgeted as current operating costs, and will sometimes be supplemented by special funds from the national treasury.

S&T planning should not confuse these two aspects of the use of resources though certain complex programs may combine the two. The main problem in many less-developed countries is still how to get S&T capacity installed. This has often taken place haphazardly, guided by intuition, pressure from groups, and the imitation of S&T development patterns elsewhere. We believe some rationality needs to be introduced.

Our attention here will centre on institutions that primarily perform R&D and other S&T activities. These institutions make up the S&T infrastructure or system. In many developing countries S&T systems are weak, inefficient, poorly connected with the productive system, and largely marginal to development needs. Among the principal objectives of S&T policymaking and planning are the expansion of the S&T system according to long-term national needs, the orientation of activities toward the needs of production and government, and the increase of efficiency.

Suppose a country is interested in having installed S&T capacity in several fields, such as agriculture, manufacturing industry, housing, petroleum and petrochemicals, natural sciences, and social sciences. Each field may be divided into specific areas, or axes. Within an axis, lines of work may be identified. Once there exists S&T capacity (human and
material resources installed in axes and their lines), the following output is provided:

- New knowledge, through R&D projects, undertaken by people working along a line (several lines of the same axis or different axes may be coordinated in a single complex project).
- S&T services, such as testing, surveys, quality control, trouble-shooting, and feasibility studies, that rearrange existing knowledge and transmit it to users.

The installation of capacity in an axis is a long-term proposition; once resources are transformed into installed capacity they cannot easily be converted to a different axis. The creation of new lines within an existing axis is a medium-term task; periodic reviews are required. Decisions about R&D projects are short-term. New projects may quickly be started when the corresponding axis and lines already exist.

Installation or increase of capacity in major fields, axes, and lines should be planned concurrently with the preparation of an economic and social development plan. Long-term requirements may be compared with existing capacity to find out where new or increased capacity is needed. Decisions about the creation of new S&T capacity should go beyond a 5-year planning period. When capacity is installed in an axis and its lines, the resources committed may require 3 to 4 years for installation. To this should be added the period (which will vary according to the axis) for the institution to acquire new knowledge and experience and mature to a steady state in which it performs as originally designed. The time for installation and maturation may not be short (for instance, for the metallurgical laboratory of the Atomic Energy Commission of Argentina it was about 10 years) and, although in the meantime the institution may provide new knowledge and services, much of its energies are tied up with growth and the improvement of intellectual quality.

It is important to explain this 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 the economic infrastructure, where output depends principally on physical assets and equipment, and where skilled people to run new installations usually can readily be hired and quickly trained to do a good job. In the case of science, output depends principally on the number and quality of the people rather than on the buildings and equipment. It takes time to develop the usual bachelor of science graduate with only general training into the type of researcher that will produce good results. Moreover, a collection of mediocre scientists will produce mediocre results, so that an eye must be kept on scientific excellence. The fact that scientific institutions are basically composed of people means that they are vulnerable; an institution can be destroyed through the loss of its top scientists much more quickly than it can be built up.

Installing S&T Capacity

A first task in S&T planning is the establishment of the capacity in human and physical resources in axes of high priority. Those who plan
investment in S&T may choose from a number of projects to be implemented over several years, as resources become available. Investment may be in new S&T units or expansion of existing units.

Cost–benefit is difficult to assess here. The benefits of producing knowledge are not easy to estimate, nor is it usually possible to state what knowledge will be produced when the investment matures, because it is not known which research projects will be undertaken so many years hence. This double uncertainty precludes a quantitative cost–benefit approach. A primarily qualitative approach may be used to guide decisions in this situation. This approach is based on the assumption that the priority of an investment project depends on its expected contribution to national objectives and on the efficiency expected from it. This utility–efficiency approach may be applied through expert committees.

For each S&T axis the evaluation should consider how desirable such work promises to be. Thus, it should show relevance to national objectives, particularly those pertaining to long-range social and economic development; each investment should carry an assurance of useful results in not too long a period, to discourage “technological adventures” that may be left for richer countries.

In basic science the country should attempt to cover a large part of the scientific spectrum to gain access to what goes on in the scientific world and to impart a good level of education to young people. Such coverage of the science spectrum would normally be attained in institutions for higher education. If a survey of installed capacity showed large gaps in basic science, there would be strong prima facie reasons for filling them, probably through professorships or university institutes.

Should coverage of the spectrum already be adequate there may be a need for reinforcing capacity in basic science in a certain field to meet the requirements of an applied axis. Such an investment would be justified through its indirect relevance to national objectives. A good example in Argentina is basic research in plant nutrition, which is important for applied research on fertilizers and similar subjects.

Investment projects in axes that show high usefulness should be designed to ensure conditions for high efficiency. Items that should be checked include the qualifications of the leader of the scientific group, the size and structure of this group, the training program of the scientists, the buildings and equipment (taking into account that the first priority is human resources), and the annual operating budget, which should be large enough to permit smooth operation at least during the maturation period. It is not worthwhile setting up a new group or institute in S&T if conditions are not right for good scientific productivity.

The building up of S&T capacity is a gradual process that should be carefully planned many years ahead. The bottleneck for such an expansion lies in human resources, and this underlines the importance of good

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24 One of the advantages of close cooperation between small countries (such as those in Central America or the Caribbean) is that a common S&T policy at the subregional level may complement national efforts and attain a complete spectrum. A good example is the University of the West Indies, which has four campuses that between them cover the scientific fields of relevance for the four English-speaking countries in which they are located.
coordination between S&T policy and education policy; it is desirable to produce able and creative scientists and engineers at home in strong academic institutions rather than to depend on training overseas. Insistence on usefulness should not play down the role of basic research. Basic research 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 new knowledge or competent advice; it opens a window to the outer world of science, without which local scientists may either fall behind, unaware of new developments useful to their activities, or do research on topics already explored elsewhere.

Orienting the Activities of the S&T System

Capacity in S&T should be installed to produce new knowledge through research and development, a flow of S&T services, and a contribution to the quality of higher education. The last is a natural result of introducing basic research in universities. The provision of services such as testing, analysis, quality control, troubleshooting, survey of resources, computing, and S&T information would meet the demands of various sectors in government and industry. The S&T system may search for customers for these services, possibly with government help through persuasion, publicity, and subsidy.

R&D projects are oriented toward supply, demand, or requirements. Supply-oriented research is academic, generally basic, and directed toward supporting education and adding to basic knowledge. The topics to be researched are usually chosen by the researchers. Issues worthy of study can possibly be pointed out to the researchers, with the idea of transforming unoriented into oriented basic research that may prove to be important for further applied research. This would require good communication between the scientists and the planners.

Demand-oriented research is applied research under contract to a customer who determines the objectives. Results are wanted; hence, the project has a high expected usefulness. The choice of topics is determined by the market.

A third type of research is government-funded, not strictly related to education, and not covered by a contract with specific purposes. It is supported in universities and other institutes by normal or special government funds distributed by a national research council or a similar organization. It accounts for much of the R&D in some countries. The topics are frequently decided upon by the researcher or the institution; the results often do not find application, or money is spent on irrelevant topics or frittered away on a "scientific hobby." But resources are scarce and should be spent properly; value should be had for money. An active sales program might turn part of this research into contract research, but there are areas in which this is not easy. Then the idea is to convert this research into requirement-oriented research. Research funds should be allocated through careful project selection, in which priorities are assigned in accordance with socioeconomic requirements. Ideally, selection methods for centrally funded projects should be compatible with those used by
each institution for deciding its own projects. In some instances a cost—benefit approach can be used, but generally this is not easy to do because of the difficulty of predicting the costs and, particularly, the benefits of R&D. A variant of the utility—efficiency approach might be used to guide such decisions. The considerations are that the research project must promise results of high social usefulness, and that the project must be designed, organized, and carried out efficiently with a high probability of producing the results on time and within budget.

Implications for S&T Planning in Different National Situations

S&T planners should contemplate the creation of new capacity and the use of present capacity. Which one they emphasize should depend on the stage of S&T development of the country. Developed countries already have an S&T infrastructure; the principal role of S&T planning there is to put the infrastructure to work according to national needs and objectives. In contrast, the main business of S&T planning in many developing countries is to create an S&T infrastructure. The appropriate mix of these two types of planning depends on each country's degree of S&T development.

The time frame of planning is longer for building up the infrastructure than for using existing capacity. In countries with a weak S&T infrastructure an important part of the total resources assigned to S&T should be devoted to investment, according to long-range needs. A medium-range development plan, however, may give useful indications for orienting the activities of an established S&T infrastructure, as has happened in Brazil and India.
16. The Outlook for Science and Technology Planning in Developing Countries

Alberto Aráoz and Francisco R. Sagasti

In this chapter we will pull together the various aspects covered in this volume to provide a general view of S&T planning in developing countries, the issues on which research and debate should centre, and the outlook for S&T planning.

General View

S&T planning in developing countries is a young field in rapid evolution. Experience is scarce. Conceptual and theoretical approaches are still piecemeal and tentative; the complex subject matter does not easily allow for wide generalizations or the use of formal analytic models. Although many significant observations can be made about the relations between S&T and society in Third World countries, these are yet to be woven into a solid conceptual structure. We have much to learn about S&T as a factor in a country's development and about planning the expansion and use of S&T capabilities.

Two main concerns emerge out of the experience reviewed in this volume. The first is that of integrating technology considerations into development planning. The analyses of the Argentine and Brazilian experience show that the role attributed to S&T by economic planners is largely implicit and marginal. We should strive to get explicit attention paid in development planning to technology as well as to science. The chapter by Sachs and Vinaver contains valuable suggestions in this respect.

The second concern is that of planning S&T activities on their own. In some instances this will be a discrete sector in economic development planning; more frequently it will be a separate, specific planning exercise with a longer time frame. Several developing countries have followed this approach. Some of them — India, Venezuela, Mexico, and Brazil — have produced comprehensive S&T plans that direct S&T activities according to national economic development or other plans. Other countries have limited such activities to certain sectors or problem areas. This is the case in Egypt, Colombia, and, to a large extent, Argentina, where S&T planning has not yet become important. Partial attempts have also been made in the industrial sector in Peru, although the Peruvians are really putting a policy into practice rather than planning in the sense understood here.

The introduction of technology considerations into development planning and the planning of S&T activities may be integrated, as shown by
the Korean attempt to do so. Detailed analysis of how the exercise was done and what its results were would be of great interest. To arrive at such an integration, however, a country may have to go through some preliminary stages. In this sense, planning S&T on a sectorial, discipline, or program-oriented basis may be a first step, to be followed by overall S&T planning, and later by integrated planning of S&T and socioeconomic development.

Why should developing countries go into S&T planning? The reasons seem to be clear:

- Rational intervention by the state is possible.
- Resources are scarce and should be used optimally.
- Left to its own, S&T will not develop sufficiently and will not be assimilated properly by the production sector.
- The "brain drain" must be stemmed.
- The benefits from planning far outweigh the costs.
- The planning exercise is, in itself, useful.

S&T planners attempt comprehensively to build an S&T infrastructure of people and institutions, to use existing S&T capabilities, and to increase the efficiency of S&T activities. In most developing countries each of these three aspects calls for some sort of structural transformation. These countries cannot afford to do everything at once, and therefore have to define priorities according to their development styles and national needs. The pertinent question is: Can developing countries afford not to plan S&T?

S&T planning is not free of risks. No one will pay any attention to it unless it is backed by political will, funds, and an implementation scheme; even then the technocratic plan may be rejected by those who are supposed to make it work but had no say in its design. A plan that has been designed with wide participation has a better chance of success, but it still needs political backing and funds, of which a developing country may not have enough. Whatever the cause of the plan's failure, efforts will be wasted, expectations will not be fulfilled, there will be frustration and lack of credibility, and in the end things may be worse than if no planning had taken place. Perhaps developing countries should approach S&T planning cautiously, not trying to produce a final, comprehensive plan at first, but building up political support, consensus, and goodwill through a series of partial planning efforts starting where success is most likely and gradually extending to other sectors until the whole spectrum of S&T activities is covered.

The S&T planning experience of developed countries is only partially relevant for developing countries. In the former, planning principally orients installed S&T capacity in an environment in which new results can readily be applied. There production units are technologically developed, S&T services exist, there is a self-sustaining scientific community, and imported foreign technology does not have an overwhelming influence on the technical progress of the modern sectors of the economy. S&T planning in these countries thus becomes the planning of R&D.

Developing countries have few or none of these advantages. Therefore, S&T planning goes far beyond planning R&D; it seeks to create
conditions favourable for S&T progress, train the necessary personnel, make and carry out policies, and develop scientific institutions. S&T planning must provide all the elements needed for R&D to be significant. The job in less-developed countries is much more complex, and it 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. Less-developed countries have to find their own solutions; they cannot rely on the experience and advice of developed countries.

The Issues

Decision Tools

S&T planners need ways of drawing up plans and methods to guide the decisions they make while doing so. Such decisions have to do mainly with the allocation of resources at different levels (national, sectorial, branch, program and project) and for different purposes (investment or current expenditure; R&D or other S&T activities).

What sort of decision tools may be used in S&T planning? There are two views. The first favours the use of analytic methods involving quantitative models, such as those employed in economic planning. However, this type of decision analysis is not yet well advanced and may not be appropriate for S&T planning, as is mentioned in chapter 2.

The second view favours the use of formal approaches that involve logic. Formal nonquantitative methods are usual, although quantitative methods may be adequate. Formal approaches should provide a framework for sequential decision-making without oversimplifying S&T phenomena. Techniques include analysis of development styles and long-term trends, technological forecasting, relevance trees, boundary methods, Delphic techniques, matrix analysis, and, in general, formal “rules of thumb.”

Emphasis should be on the latter category of decision tools. Some examples exist in this volume, and there are undoubtedly many more in S&T planning already carried out. Decisions taken on mainly qualitative or empirical grounds, such as those of expert committees and bargaining interactions, should also be studied. Such research promises more than the development of sophisticated mathematical models.

The Context of S&T Planning

S&T planning encounters many obstacles in a less-developed society, particularly in the interactions between S&T and the underdeveloped economy. These obstacles include external pressure through technological dependence, patents, international science, foreign investment, multinational corporations, and conditional loans for large investments. Other obstacles are political indifference, the liberal attitude of scientists, the entrenched interests of the existing scientific agencies, and unfavourable implicit policies. Planning thus becomes a political process rather than a technical one, and the imperatives of maintaining political support and attaining a consensus among interested groups becomes overwhelming.
For this reason, wide participation becomes absolutely necessary. Gradualism will gain allies, as well as enable planners to learn and to demonstrate results that will open the way to wider and more complex planning attempts.

The Approach to S&T Planning

In chapter 12 Chaparro contrasts two approaches, one that starts at the top and plans programs to be undertaken by S&T institutions, and another that studies what the institutions are doing and integrates this into a plan. He suggests that these two extremes be combined. As a result, without unduly changing what the institutions are doing, some reorientation may take place and new programs be started.

This course of action seems to be appropriate. It calls for participation in planning, so that there will be a good chance of acceptance. It raises the question whether central authority may veto programs that S&T institutions wish to carry out with their own resources. It calls for analyzing the best way of using a central fund to cover new programs and to reinforce existing ones.

The Information Base for S&T Planning

On account of its inherent complexity, S&T planning requires a vast amount of information, as is shown by Parthasarathi in chapter 13. This may come from several sources — the statistical systems of other sectors such as education, statistics and inventories of the S&T system, technology transfer statistics, special surveys, special studies (as, for instance, on the technological characteristics and problems of production sectors and branches), the economic development plan, long-term projections, and so on.

These sources may provide much useful information, particularly for preparing a policy and rough guidelines, but a large part of the information needed in the detailed design stage can only come from those with the relevant knowledge and experience in government, science, technology, and production. Planning in any area largely means the collection, screening, and use of information; in S&T the information required is so complex that all involved in the planning must contribute. Hence the importance of organizing their participation and the implausibility of technocratic planning by a few persons in a science ministry or council.

The definitions and classifications in science statistics are not yet satisfactory from the conceptual and operational points of view. This limitation, together with difficulties in data collection and delays in publication, means that published statistics are of limited reliability (particularly when a country gathers them for the first time), and therefore they are to be used with care. Also, currently published science statistics and inventory survey results contain only a small part of the total information needed for S&T planning. Their value is somewhat greater if planning is restricted to R&D, as in the developed countries where science statistics systems originated. Science statistics and inventory survey results are useful primarily for international comparisons and background information for each country; great efforts should not be devoted to them.
Institutional Aspects of S&T Planning

There are two main institutional aspects to S&T planning: the planning of S&T institutions and the institutions concerned with S&T planning. The first aspect is treated by Sagasti in chapter 14, and we need to add only a few remarks. First, long-term S&T planning requires particular attention to the creation, reinforcement, and good functioning of institutions that perform S&T activities, including those at the applied end of the spectrum, such as consulting and engineering services organizations. Second, S&T institutions each have a development stage, which may last many years, during which they build up and train their staff, create knowledge, gain experience, and find their place in the environment; only when this stage is well advanced and an institution reaches maturity can we reasonably expect full results. Hence, it is not enough to create an institution; it is necessary to continue supporting it while it develops. Impatience of planners and policymakers may be an obstacle to the institution’s maturation. Third, S&T institutions need good management to be efficient.

On the second subject, many institutions are concerned with S&T policymaking and planning. They should be integrated into some sort of system, possibly under the leadership of the S&T planning agency or some other top-level organization if planning is to be coherent and to draw a wide consensus. The situation varies from country to country; no general recommendation can be made except that efforts and political skills should be applied to transform the institutions into a concerted system.

Implementation of the S&T Plan

Given the paucity of experience in putting into effect S&T plans, further research and exchanges of experience may be useful in the following areas:

- Mechanisms for plan implementation, particularly central funding and national S&T budgeting.
- Review, control, and evaluation of programs financed by the central fund, or by ministerial or agency budgets, and feedback mechanisms to correct deficiencies.
- Monitoring of S&T activities within the production sector and action when called for. This is specially important for S&T activities connected with imported technology.
- Periodic review and redesign of the S&T plan.

Human Resource Planning

The main issue here is how fast the stock of qualified scientists and engineers can grow, as people are a limiting factor in the expansion of S&T activities. There is little information on this matter, but few countries have been able to double their stock of such individuals in less than 10 years. A developing country bent on expanding its system from very low levels may repatriate scientists and engineers, pull such persons out of productive activities, and even import personnel. This would quickly raise the level of human resources involved in S&T activities. But once this was done,
further expansion would depend on the education system, and this would have to be looked into if realistic targets were to be established and met.

Any analysis of growth in human resources must include studies of the education system, particularly at the undergraduate and graduate levels. Information may come from surveys of the S&T system, from education statistics, or from special studies of human resources. Such studies would show the characteristics of the group of qualified scientists and engineers, including their occupational status, their training at home and abroad, their specific training for research, and the disciplines in which this takes place. The extent of the brain drain would also be indicated. It is also advisable to examine the quality of these individuals and their attitudes toward national development.

Such studies encounter many conceptual and practical obstacles. Experience has shown that ambitious studies on human resources take too long, need too many resources, and produce only tentative results. Conducting the analysis on two levels may avoid this pitfall. First is an aggregate level, in which a few categories that are in harmony with education and production structures are used to produce an overview of the stock of qualified scientists and engineers and their production and use. Second is with certain critical areas (to be identified at the same time as long-term S&T requirements), in which detailed analyses would lead to recommendations on the training, specialization, and employment of these individuals. The aggregate level study should probably take place before the S&T plan is drawn up, for it will provide valuable input for policymaking. In contrast, the detailed studies may take place during plan designing to make full use of the information.

Some scientists and researchers may find it difficult to switch from activities oriented to the international scientific community to those oriented toward national problems. This difficulty, which calls for special attention, especially involves free researchers, who select their own research topics, proceed at their own pace, and publish their results. Their new role involves doing assigned tasks, meeting deadlines, and being discreet. An identity crisis may result in extreme cases, and this will lead to personal dissatisfaction, low productivity, and eventual migration.

**Diffusion of Science Throughout Society**

A receptive audience should be created in various groups — government, entrepreneurs, labour unions, students, intellectuals, and the general public. S&T should be “sold” by lectures, seminars, round tables and written material directed to the main centres of decision as well as the mass media. In addition, science education should be improved in primary and secondary schools to give students a better understanding of S&T. At the university, science policy and technology management should be included in S&T undergraduate courses. Engineering, business management, and government administration students may later become important consumers of local S&T activities.

**Regional Development of S&T**

Much work remains to be done in the study of regional development of S&T:
• There are reasons for not overly centralizing S&T activities. These include, among others, the need to pay attention to regional S&T problems, the possible contribution of S&T to higher education and cultural life in the region, and the stemming of the brain drain from the region to the capital city.

• S&T activities should not be spread thinly around a country; points of concentration are more efficient. These S&T development poles would constitute subsystems within the national S&T system. Their locations may coincide with those of economic development poles.

• The S&T development poles should comprise various institutions, such as universities, research centres, and engineering organizations, that are near enough to each other for mutual reinforcement. Large national research institutions may set up branches to take care of local problems. Industry may also set up S&T facilities alongside. These institutions may be located in a campus or science park, as has been done in the Soviet Union, Canada, and South Korea. The institutions share basic facilities, thus promoting interaction among their personnel. An S&T development pole should have enough people and study diverse enough fields that it is not too dependent on the capital city S&T complex. Clearly this poses a problem for smaller countries.

• Conditions in the pole should favour creativity and efficiency. Scientists should be able to travel for discussions and meetings.

• Regional aspects are important when planning investment in new or reinforced S&T capacity and the use of installed S&T capacity. Regional problems in production, natural resources, education, business, and government are likely to be tackled better by people and institutions from the region. This would introduce a new dimension in S&T planning; the connection with regional planning in economic development, education, health, and other areas is easily seen.

*International Aspects*

There are external constraints to S&T development, such as the negative impact of technology transfer from developed countries, the distorting effect of foreign investment, and the rigidities of the industrial property system. S&T planners should consider how to resist these constraints as well as possibly joining other Third World countries to change the rules of the international game.

S&T planners in less-developed countries should take note of international scientific ties through exchanges, education, and training abroad, and other means. S&T development may need to use these mechanisms, particularly in new fields; but the rule should be to recognize and take advantage of opportunities not just because they are there, but also because they fit in with policy. Planners must watch that the inevitable international ties not become a vehicle for patronage, dependence, and alienation.

This linking up with the international S&T system also involves technical assistance from developed countries and international organizations. Many mechanisms exist — scholarships and fellowships abroad, foreign experts sent to the country for specific programs, supply of equipment and instruments, the “twinning” of a local S&T institution with a foreign one, and so on. Technical assistance may sometimes be an
important source of knowledge, skills, and physical assets, particularly when S&T capacity is being installed in a new field. Technical assistance should be planned so that resources are directed to where they can have the strongest impact, and local personnel and institutions should do their utmost to absorb the new knowledge and transmit it to their colleagues in the country. This requires good organization at the receiving end if opportunities are not to be wasted and if technical assistance is not to mean patronage and dependence.

There is also the possibility of exporting technology. Some developing countries may find a good market, particularly in other developing countries, for technological assets they possess and technological services (such as consulting and engineering) they may render. Such opportunities should be sought and measures taken to promote the exportation of technology.

The promise of technical cooperation among Third World countries is currently being recognized. The potential is large, either in traditional modes (experts, scholarships, personnel exchange, joint research programs, and creation of joint institutions through bilateral and multilateral agreements) or in commercial modes, whereby technology transactions between developing countries would adopt certain socially desirable characteristics that would give them a truly cooperative nature. S&T planners should explore the possibilities, identifying for instance, problems common to two or more countries where the complexity and magnitude of the task make joint efforts desirable.

Finally, there is the possibility of integration among a group of small countries that cannot each afford its own self-sustaining S&T community. Instead they would share institutions and some joint programs; this might even lead to a “common market” for S&T. Efforts at S&T integration are now being made in the countries of the Andean Pact, the Central American Common Market, and the Caribbean Community.

The Outlook

S&T planning in less developed countries is a new concern. Although many theoretical advances have been made, experience has been limited. Nevertheless, as this volume shows, S&T planning has proved desirable and feasible in less developed countries. What is the future for S&T planning?

There is no coherent body of knowledge and practice labeled “S&T planning.” The wide diversity of approaches, points of view, experience, conceptual frameworks, and methods are far from constituting a “paradigm.” This volume demonstrates the diversity but does not refer to a number of theoretical developments that point out the many different directions the field may take in the future. Finally, there is still a great deal of knowledge to be generated, sifted, and applied before S&T planning develops its full identity.

An obvious but important observation is that the nature of S&T planning will vary according to the stage of development of each country. For countries with an established infrastructure of S&T institutions, resources, and activities, the problem is mainly one of reorienting and
using effectively their capacity. Where capacity does not exist, the planning should emphasize the training of personnel, the foundation and development of institutions, the acquisition of physical facilities, the expansion of higher education, and the creation of policy mechanisms to promote S&T. At a very early stage of development, a country's S&T needs are likely to be so obvious that there is no need for a complex planning exercise: common sense will dictate priorities. Countries with a small economy and few qualified people may be unable to develop a workable S&T system, in which case elaborate planning may not make sense, except in cooperation with similar countries. 

There are many differences among the countries of the Third World. For the smaller and least developed countries the S&T planning exercise mainly involves judgments by a few knowledgeable people rather than mechanisms or methods. Most of this volume does not apply to such countries. For middle-sized countries with the beginnings of a workable S&T infrastructure, S&T planning efforts could have an important impact; most of the material in the preceding chapters (particularly those about Colombia, Peru, and Egypt) applies to these countries. However, given the relative small size of the S&T community, it may be more appropriate to engage in sectorial, problem area, or partial planning exercises rather than to attempt to develop a comprehensive S&T plan. International cooperation may change the situation, greatly enlarging the scope for fruitful S&T planning.

There are also larger less-developed countries that have the necessary bases of resources and a well developed S&T infrastructure. Says Roche:25

... science and its related technology, stand their best chance of flourishing, at least quantitatively, in a young, underdeveloped country, rich, but not too rich, that has decided to devote considerable resources to scientific activities; it must have a very tolerant religion, or no religion at all; at the same time, it must respect science for its own sake and be desirous of gathering the good things of this world made available by science and technology; it must have an independent industry, including a war industry; it must be under the influence of an education that stresses a critical attitude, independence and creativity; it must be economically independent, and have a large market for its products.

These conditions exist in few less-developed countries, and only in them is S&T planning likely to become well established. S&T planning may evolve independently from economic development planning, but if there is a planning tradition in a country this may make S&T planning more acceptable. However, the existence of a well entrenched economic planning technobureaucracy may be an obstacle; economic planners may resist the introduction of technological considerations into development planning.

As the gap between developed and less-developed countries grows and discussions about a new international economic order focus on technological issues, S&T planning in less-developed countries is likely to

acquire greater prominence. There will be, however, many false starts and truncated efforts. A few less-developed countries are likely to show spectacular successes in S&T planning, and there will be a rush to imitate them. International organizations will press for S&T planning. In the next few years, there will be conceptual developments and some experience, mostly negative, of actual planning.

Thus, the outlook for S&T planning is not wildly promising, but neither should it be written off as a lost cause in the Third World. From the many mistakes that will be made and the conceptual reappraisals they will force, we will likely see S&T planning evolve into an established body of concepts and practice. But this will not happen for at least another decade, after the trials and errors inevitable with a new area in development thinking.
Appendix. Participants in the Villa de Leyva Workshop on Science and Technology Planning in STPI Countries

Brazil
Ecila Mutzenbecher Ford, Financiadora de Estudios e Projetos (FINEP)
Tjerk G. Franken, FINEP

Colombia
Santiago Aráoz, Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales “Francisco José de Caldas” (COLCIENCIAS)
Fernando Chaparro, COLCIENCIAS
Miguel Infante, COLCIENCIAS
Luis Javier Jaramillo, COLCIENCIAS
Félix Moreno, independent consultant
Jorge Rodríguez, independent consultant

Egypt
Adel A. Sabet, National Academy of Scientific Research and Technology

India
Ashok Parthasarathi, secretary, National Electronics Commission of India

South Korea
Kyu Bok Whang, Korean Institute of Science and Technology

Mexico
Alejandro Nadal, El Colegio de México

Venezuela
Winston Briceño, Consejo Nacional de Investigaciones Científicas y Tecnológicas

26 Jack Baranson, consultant to the World Bank, also participated in some sessions.
Yugoslavia
(Macedonia)

IDRC

Organization of American States

Krum Evtimovski,
Secretariat for Foreign Economic Relations

Francisco Sagasti,
field coordinator, STPI project

Alberto Araoz,
consultant to the field coordinator,
STPI project

Phactuel Rego,
Department of Scientific Affairs