METHODOLOGICAL GUIDELINES FOR THE STPI PROJECT*

Lima, April 1974

*These guidelines have been drafted by Francisco Sagasti and Alberto Araoz. They draw heavily on previous contributions to the STPI project, on the diverse country team proposals, and on the comments received at the technical meeting held in Lima, in January 1974, where a preliminary draft was submitted.

I. THE STPI PROJECT

1. Introduction.

The Science and Technology Policy Instruments (STPI) Project is a cooperative research effort undertaken by national research teams of Africa, Asia, Latin America, and Southern Europe, the general purpose of which is to gather, analyze, evaluate, and generate information that may help policy-makers, planners and decision-makers in underdeveloped countries to specify the ways and means for orienting science and technology towards the achievement of development objectives.

STPI was formally born as a result of a meeting that took place in Barbados, in January 1973, but its gestation spanned a period of about two years during which active discussion as well as a number of written contributions helped to define its objectives, its scope, and its manner of organization. Appendix 1 of the report refers to the background and characteristics of STPI, while Appendix 2 lists the various methodological papers and feasibility studies that have been carried out.

2. Subject matter and Specific Purpose of the Project.

Science and technology, or rather, the set of functions and activities -- which we may term "science and technology variables"* -- that have to do with the production, diffusion, and transfer, and utilization of scientific and technological knowledge, are rarely an end in themselves. Science and technology (S&T) are to be regarded as intervening variables that have an influence upon socioeconomic development (rate of growth, employment, income distribution, health, welfare, etc.) and other national objectives such as prestige, defense capabilities, and self-reliance.

How S&T variables act on national objectives is a subject which has been and continues to be, abundantly explored

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*In this report we use the concept of "variable" in the sense it is employed in social science research, making a distinction between "dependent variables", the functions and activities that suffer an influence, and "independent variables", the sources of such influence.

in the vast literature about science and technology and their relations to development. However, much less is known about the procedures, ways and means of formulating and putting S&T policies into practice, particularly in less developed countries. This is the subject matter of the STPI project, whose specific purpose is to explore how policy-making and the policy instruments that are used (taken to be the independent variables) exert an influence and through what means, on S&T functions and activities (the dependent variables), in diverse contexts of underdevelopment.

3. Structure of the Project.

National studies will be undertaken by the participating countries according to a common outline. The results will be integrated in a final synthesis report, together with other relevant information. In addition, a number of special studies will be undertaken by consultants, some of which will be of a methodological nature. Other studies will look into specific issues, such as "technological dependence/self-reliance" and into science and technology policy in China and Japan. Furthermore, close contact will be kept by the Field Coordinator's office with research on scientific and technological policies and instruments taking place elsewhere in the world. This information will be fed to the country project teams and into the final synthesis report.

4. The Present Guidelines.

The objective of the present guidelines is to provide the participating country teams with a common set of concepts and research procedures, in order to facilitate cross-fertilization during research work and assure that a comparative analysis may be fruitfully carried out during the last phase of STPI.

The guidelines start with an examination of concepts, categories, and research approaches relevant to the project. The following section presents a summary of what has been agreed to cover in each of the five phases of the work. Detailed research guidelines for Phases 1 and 2 are presented next. Guidelines for research on Phases 3 and 4 are to be prepared in the coming months, and will be sent separately to the country teams.

II. THE RESEARCH APPROACH, CONCEPTS AND CATEGORIES.

1. The Effects of Policy and Contextual Factors on Science and Technology: An Overview.

One of the main concerns in the STPI project is to analyze the effects of three types of influences on functions and activities related to the production, diffusion, and transfer and utilization of scientific and technological knowledge. This may be done (a) for the whole of the industrial sector (and other areas such as mining, infrastructure services, etc., thay may be of particular interest), and (b) for certain branches of industry chosen for special study. The analysis may start from the source of influence, looking at the effects that are produced upon the S&T functions and activities (the top-down approach) or from a certain S&T function or activity, tracing back the sources of influence that produce effects on it (the bottom-up approach). As we shall see both approaches are complementary for the understanding of our subject matter.

The main idea is to explore cause-to- effect relationships in an ordered way, generating partial explanatory hypothesis that, once verified, may provide the basis for better control over the S&T functions and activities, in order that they should make a better contribution towards development objectives. Effects may be characterized by modifications in the sign and magnitude of the dependent variables, or by constraints placed to such modifications.

It is recognized that such cause-to-effect hypotheses will not usually be simple and unidirectional, and that many provisos will have to be incorporated in their formulation; moreover, it may not be easy to express them in quantitative terms. But such characteristics are to be expected in a complex world, and in a complex subject matter. The difficulties involved should not detract from the usefulness of the exercise, both as regards the final results of the research and the knowledge and training that will surely accrue to those performing it.

A general scheme of the interaction between sources of influence and S&T functions and activities is presented in Figure 1.1.

For analytical purposes we have distinguished three groups of independent variables, or types of influences:

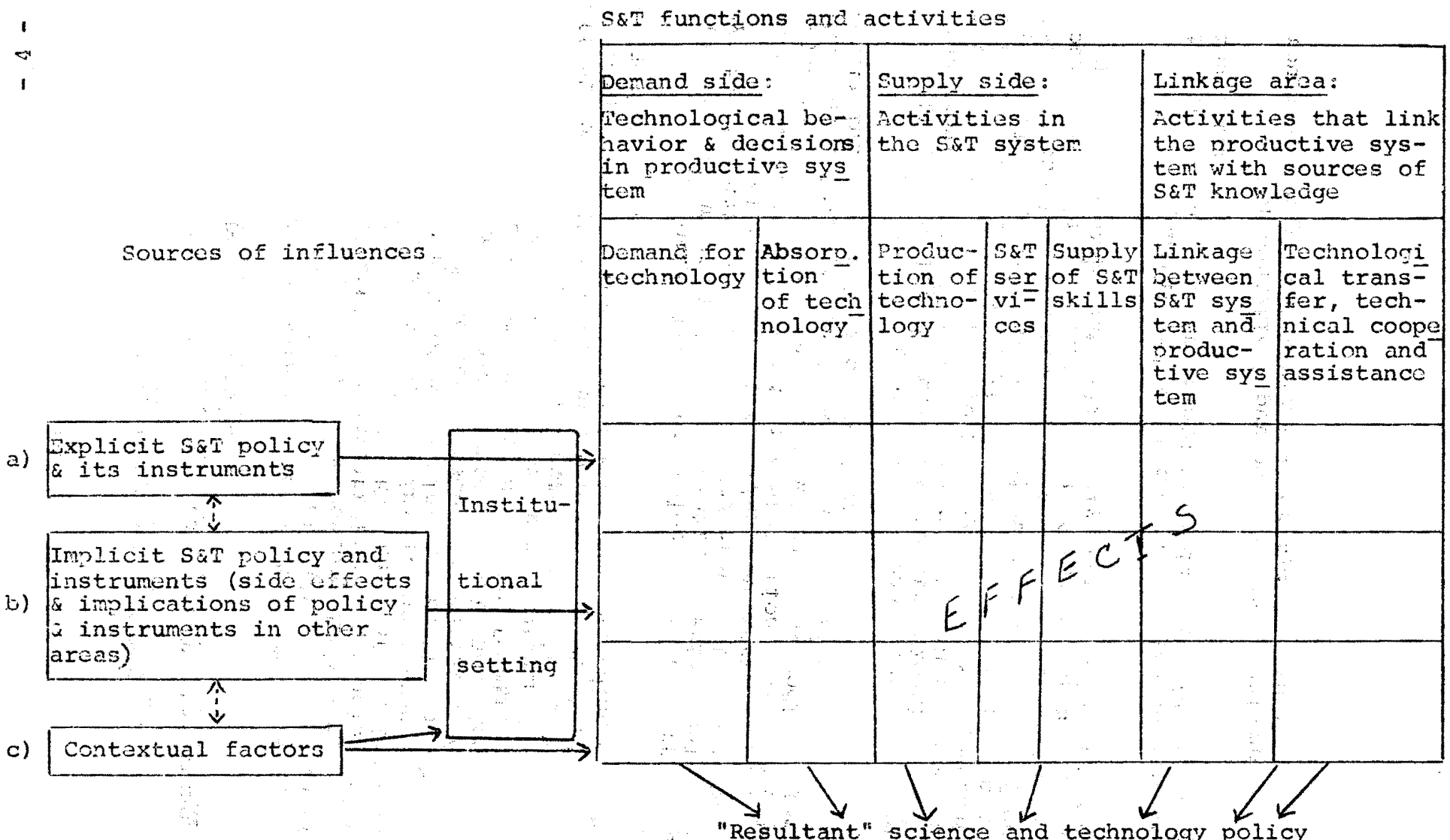
S&T functions and activities
Demand side: Technological behavior & decisions in productive system
Supply side: Activities in the S&T system
Linkage area: Activities that link the productive system with sources of S&T knowledge
Demand for technology
Absorption of technology
Production of technology
S&T services
Supply of S&T skills
Linkage between S&T system and productive system
Technological transfer, technical cooperation and assistance
Sources of influences
a) Explicit S&T policy & its instruments
b) Implicit S&T policy and instruments (side effects & implications of policy & instruments in other areas)
c) Contextual factors
Institutional setting
EFFECTS
"Resultant" science and technology policy

FIGURE 1.1

(a) Explicit science and technology policy and its instruments. Here there exists a definite, identifiable purpose of causing an effect on S&T functions and activities.

(b) Implicit science and technology policy and its instruments. Here the purpose is to produce effects on variables that do not belong to the group of S&T functions and activities, but, as a result, unintended effects take place upon the latter. Such unintended effects may be termed "side effects" or "implications". A better knowledge of them may enable policy-makers to minimize or eliminate their negative influence or to heighten their positive implications, and eventually to transform these implicit policies and their related instruments into purposeful "indirect" policies and instruments for science and technology.

(c) Contextual factors. These are factors that cannot be adscribed to government policies; they are a consequence of the country's past history, cultural and social features, resource endowment, geography, etc. They are modifiable in the long run, but for the purposes of this research they must be considered as fixed. Their effect on science and technology functions and activities is principally that of putting constraints on their modification; that is, to place limits to the effects of explicit or implicit policies and instruments. They may refer to broad macroeconomic, cultural, social, etc. aspects, as well as to the characteristics of enterprises, research institutes, etc., which are the result of the country's evolution.

Explicit and implicit S&T policies and instruments may act directly on the dependent variables, but usually they do so through various institutions that are in charge of wielding them. The institutional setting may modify or distort in various ways the "messages" they transmit, thus affecting the magnitude of the resulting effect upon the dependent variable, and the effectiveness of the instrument. Contextual factors also have a definite influence on the institutional setting and the way it works.

The "dependent variables" in the exercise are those functions and activities related to science and technology which have to do with the production, diffusion, and transfer

and utilization of science and technology. For analytical purposes they have been divided into three groups:

(a) those on the demand side, that have to do with the technological behaviour and the technological decisions of productive units;

(b) those on the supply side, that have to do with the activities in the science and technology system proper that have as end products new technological knowledge and various scientific and technological services;

(c) those in what may be termed the "linkage area", that have to do with linking of the productive system with domestic and foreign sources of S&T knowledge.

2. S&T Functions and Activities (Dependent Variables)

These are the functions and activities related to science and technology, which have to do with the production, diffusion, and transfer and utilization of scientific and technological knowledge. The three main groups to be considered are: the demand side, the supply side, and the linkage between the two.

Such a classification comes naturally from considering that scientific and technical knowledge is an important input for the production of goods and services and that productive units generate a demand for S&T knowledge which is satisfied from local or foreign sources (demand side); that there is domestic production of scientific and technological knowledge, some of which feeds into productive units (supply side); and that the flow of scientific and technical knowledge between the producers and the users of such knowledge takes place in many cases through intermediary structures and institutions (linkage area). Instruments for science and technology policy should act upon the functions and activities of these three areas in order to achieve stated objectives. The following diagram illustrates these remarks. (See Figure 2.1)

This diagram may be taken to represent the general situation in a country for all productive units and scientific activities, but a similar sketch may be made for industry or agriculture, or for specific industrial branches. In this case we would be especially interested in science and technology policy problems for the branch in question. the vertex "productive units" would comprise all those in the branch; the vertex "activities of the scientific and technical system" would take

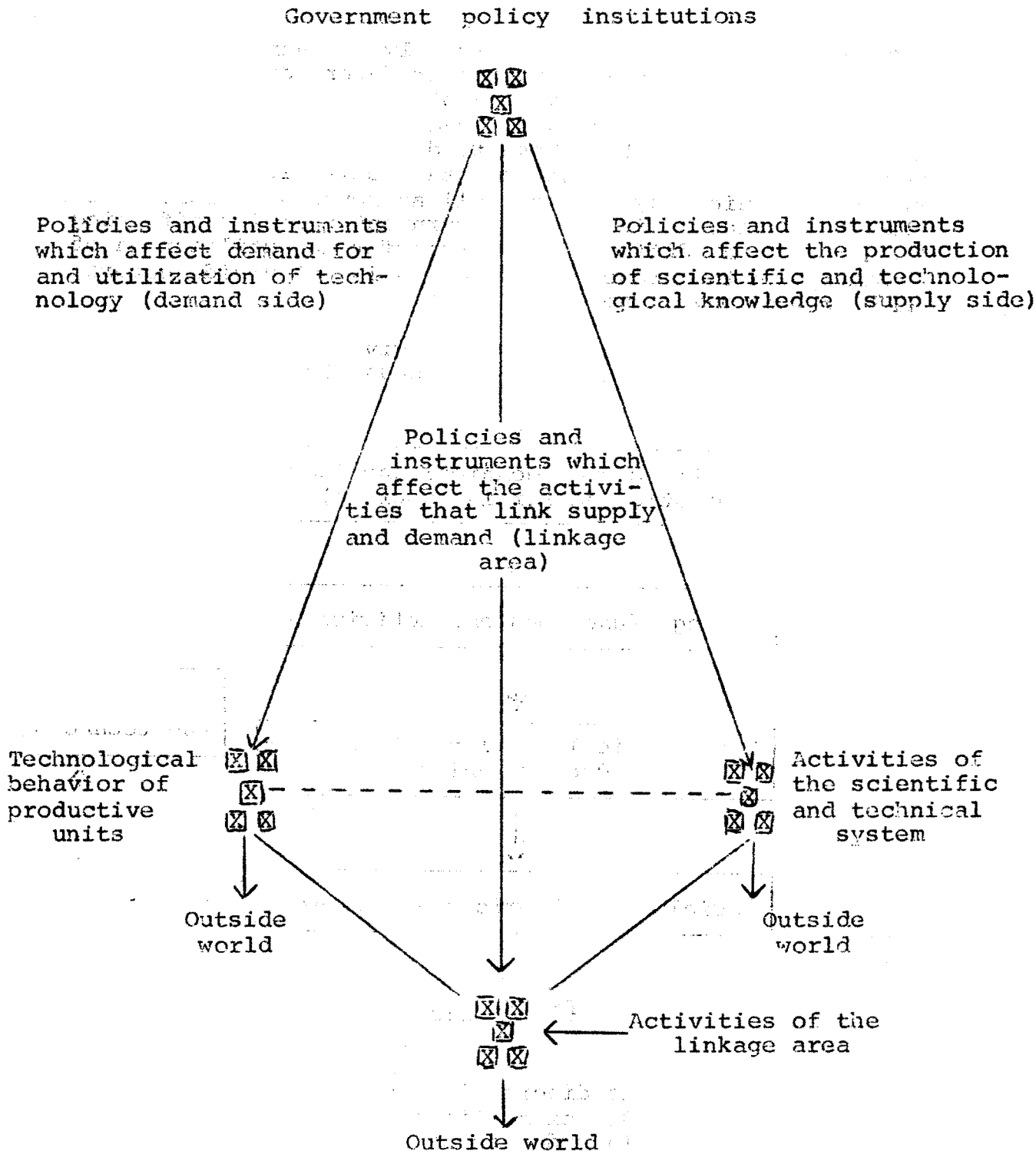
Government policy institutions
Policies and instruments which affect demand for and utilization of technology (demand side)
Policies and instruments which affect the production of scientific and technological knowledge (supply side)
Policies and instruments which affect the activities that link supply and demand (linkage area)
Technological behavior of productive units
Activities of the scientific and technical system
Outside world
Outside world
Activities of the linkage area
Outside world

FIGURE 2.1

into account those which are directly relevant to the productive units of the branch, and their future development (one may also include in this vertex other scientific activities that support the former ones); the activities in the linkage area would be those that have to do with connecting the productive units of the branch and the activities of the scientific and technical system, as well as sources of foreign technology relevant to it. Some Government policies affecting the production, diffusion, and transfer and utilization of knowledge in the branch may be of an industry-wide nature, while others may be specific to it.

This static picture may give way to another representation that introduces a broad cause-to-effect chain, as shown in Figure 2.2.

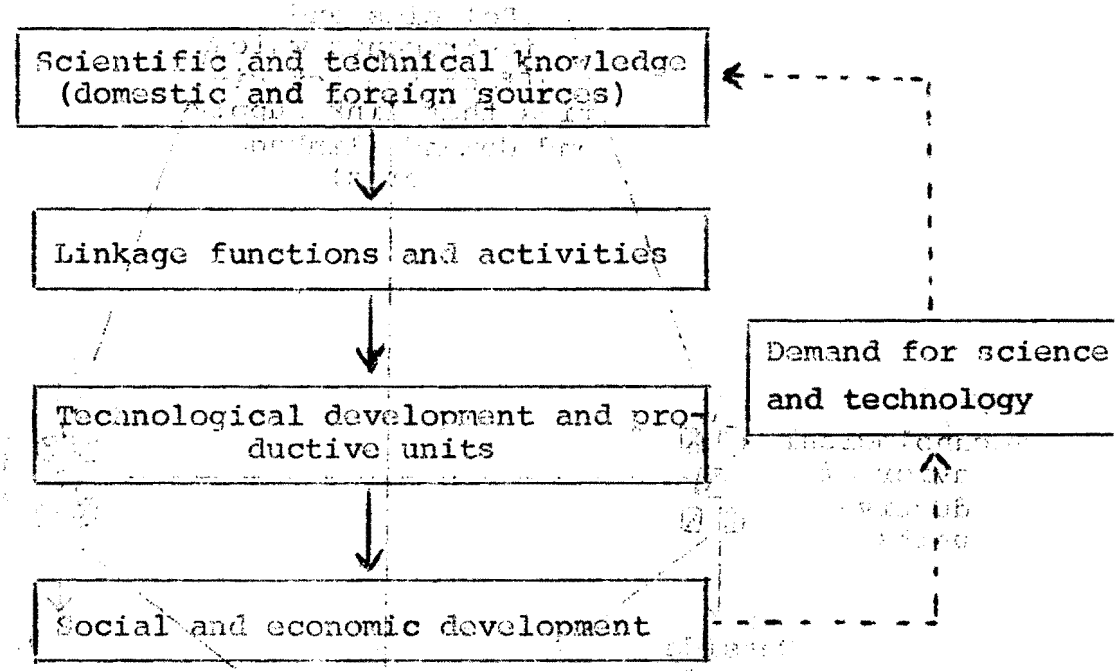

Figure 2.2

Behind the diagram lies the belief that technological development needs scientific and technological knowledge of the right kinds in order to contribute to national development objectives.

As far as science and technology go, all activities and decisions connected with it may be taken to have the

following main outcomes:

- in productive units, "technological development";
- in the activities of the science and technology system, "the production of scientific and technological knowledge which is relevant to the productive system";
- in the linkage area, "regulation of the transmission of scientific and technical knowledge from local and foreign sources to productive units for purposes of technological development".

These three outcomes we may call "resulting variables" and note that, at least in principle, they may be subjected to some sort of quantification.

Working backwards from the resulting variable in each area it should be possible to identify other variables of more specific character, that may be acted upon to obtain the desired outcome. This process of disaggregation and of finding out what variables (and the activities, functions, and decisions that have to do with their handling) contribute to the desired outcome, requires some sort of theory to explain how actions upon a certain variable may influence the succeeding ones in the sequence leading to the desired outcome. These interrelations may be easy or hard to uncover depending on the nature of the outcome and resulting variable, and on the complexity of the network of variables and influences leading to it. Furthermore, it is not possible to conceptualize the whole chain of influences as a tree branching backwards from the resulting variable or outcome. Acting on a certain variable may imply side effects on other variables and there may be feedbacks along time, making the whole network of reactions a complex set of influences and counter-influences.

One of the key features of the research approach in the STPI project, is the attempt to deal with this complex network of interactions, whose elements are policies, S&T variables, effects on end variables, policy instruments, etc., without introducing overly simplifying assumptions. The idea is to attempt a systematization of these interactions, maintaining a reasonable degree of complexity that will render the results of the research useful in practice.

For the purposes of the research, an attempt should be made at making a list of "dependent variables", in each of the three main areas, in order to study causal chains from policy to effect and put forth partial explanatory hypotheses that may be useful to policy-makers. However, to make a list

of dependent variables within each of the three groupings is not a simple thing, and any a priori attempt at a coherent taxonomy is open to critique. It is possible that a satisfactory taxonomical classification may be one of the important by-products of the project, of particular interest for policy-making purposes. At this stage it is possible only to provide some broad suggestions to the national teams, and to look forward to an exchange of ideas and experiences.

2.1. Demand Side: Productive Units

The resulting effect is identified as "technological development" of productive units, a complex "variable" closely linked to concepts such as "innovation", "technical progress", "technical advance", etc. Attempts have been made to quantify it (through measurements of productivity, production function characteristics, etc.), although at present there is no satisfactory way of doing it.

What does "technological development" at the productive unit level depend upon? We may point out to two groupings of major variables underlying it: the introduction of new knowledge, expressed as the "demand for technology", and the assimilation and improvement of existing technology within the productive unit, which we may call the "absorption of technology".

(a) Demand for Technology. This refers to knowledge which is needed for new (for the enterprise) products and processes, which may originate from domestic or foreign sources, and which may appear in disembodied form (proprietory and non-proprietory, including knowledge supplied by S&T human resources), or as embodied technology (principally equipment and capital goods). It may be fruitful to break down this heading according to the source of the technology demanded.

(i) Demand for Domestic Technology. This may come from the firm itself (research and development activities), or from the purchase of research and development activities and their results from outside the firm. Another source is technology which exists elsewhere in the country and is made available through "diffusion", not involving compensation.

(ii) Demand for Foreign Technology. The sources of which may be foreign firms and ins-

titutions that sell proprietary and non-proprietary technology, technical cooperation and assistance from foreign governments or international agencies, or the stock of freely available knowledge which can be tapped through the literature, personal contacts, and visits or training abroad.

To handle new knowledge and its incorporation into production, the productive unit will have to make a number of decisions which we may call technological decisions. Some of them are clearly concerned with the choice of alternatives about the source of new knowledge, the source of equipment, and the use of such inputs. Others have to do with the building up of the firm's capacity (technical and design groups, administrative organization, information), to exert such choices, to adapt foreign technology (a very important activity because of the contribution it makes towards the optimal use of foreign technology and of the way it can link foreign technology to domestic scientific and technological activities), and to incorporate effectively new knowledge into production. The attitudes of decision-makers towards technological innovation constitute an important ingredient in the way decisions are made.

(b) Absorption of Technology. This set of activities is directed towards the assimilation and improvement of technology which the productive unit has already incorporated, and comprises items such as the following:

i. Production research, plant optimization, product development, the search for minor innovations, the adoption of quality control standards, trouble-shooting and other such technical activities within the firm;

ii. Purchase of scientific and technological services directly linked to productive activities which may come from the scientific and technological system or from foreign sources;

iii. Information about practices in other firms obtained through the diffusion process.

It may be possible to go backwards from these main variables to various types of activities, functions, and decision points that have to do with them, but as mentioned above,

at the general level the exercise may not be warranted in the initial stages of the project. However, national teams may find it useful to analyze the structure that is currently being employed by the OECD in research about innovation.*

2.2 Supply Side

In this case the resulting variable or outcome is the supply of scientific and technological knowledge relevant to the productive system. We may distinguish three groups of functions and activities behind it: generation of technology, supply of scientific and technological services, and supply of scientific and technological skills.

(a) The generation of technology would refer to the science and technology functions and activities of organizations which produce scientific and technological knowledge. We know that these institutions should be made more efficient, that they should be given as much stability as possible, that they should be oriented to the needs of socioeconomic development, etc. There are a number of parameters and decisions affecting these issues, and it is upon these that a study of the influence of policy instruments should be focused. There are also the issues related to the organization and building up of scientific institutions. The two groups of issues may require different treatments.

(b) Similar remarks can be made with regards to the supply of science and technology services, which allow the productive system to use more efficiently the knowledge generated by the S&T system or purchased from foreign sources. These services also refer to the activities that allow the production of knowledge to proceed more efficiently.

(c) As regards the supply of scientific and technological skills, the focus of attention is the set of activities

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*We have refrained from using the category of "innovation" as a dependent variable since we feel that it does not discriminate enough for our purposes; it is too broad and differing interpretations of it may be advanced.

S&T FUNCTIONS AND ACTIVITIES USED IN THE OECD STUDY ON TECHNOLOGICAL INNOVATION

OVERALL AIM: To improve the Capacity of the Firm to innovate

OBJECTIVES: to improve	SUB-OBJECTIVE	VARIABLES CHOSEN	MEASURES
Economic-Financial Capability	Protection against Risk	Technical risk	Risk sharing of Development Expenses
		Commercial risk	Risk sharing of Expenses for Export Promotion
	Availability of Capital	Degree of Auto-financing	Fiscal Policies
		Availability of Risk-Capital	Creation of Specialized Establishments
		Access to Financial Markets	Policies Covering Market for Bond and Securities
	Marketing	Public Sector Markets	Specifications of Performance for Tenders
		Foreign Markets	Services supplying information on Foreign Markets
		Domestic Markets	Services supplying information on Domestic Market
Organizational Capability	Mobility of Personnel	Internal to the Firm	Financing of Retraining of Personnel
		To and From the Firm	Redundancy Payments associated with Modernisation of Firm
	Flexibility	Structures of Production	Special Loans for Modernisation of Plant
		Legal Structure	Tax incentives for Mergers

S&T FUNCTIONS AND ACTIVITIES USED IN THE OECD STUDY ON TECHNOLOGICAL INNOVATION (Contin.)

OVERALL AIM: To improve the Capacity of the Firm to innovate

OBJECTIVES: to improve	SUB-OBJECTIVE	VARIABLE CHOSEN	MEASURES
Scientific-Technological Capability	Use of Existing Knowledge	Use of Government owned Patents	Exclusive right for a Limited Period
		Functioning of the Market for Patents and Licenses	Prohibition of Restrictive Clauses in Licensing Agreements
		Foreign Investment	Preferential Tax Treatment of Imported Capital associated with know-how
	Scientific Discovery	Appropriation of R&D Results	Patent Legislation
		Use of External Facilities	Tax Relief on Payments made to cooperative Research Centres
		Volume of Intra-mural R&D	Financing of Certain Projects
			Tax Exemptions

S&T FUNCTIONS AND ACTIVITIES USED IN THE OECD STUDY ON TECHNOLOGICAL INNOVATION

OVERALL AIM : to improve the capacity of the firm to innovate.

OBJECTIVES: to improve	SUB-OBJECTIVE	VARIABLES CHOSEN	MEASURES
Economic Environment	Favourable Market	Ease of Entry	Tax incentives for newly created firms
		Degree of Competition	Tariff protection of new firms
			Legislation on Restrictive Agreements
		Minimum size	Exports credit
			Favoured access to Government Markets
	General Economic Situation		
	Mobility of Employment	Functioning of the Labour Market	Specialised Employment Agencies
Institutional-Social Environment	Consumer Protection	Standards	Creation of Consumers' Associations
		Control of new products	Authorisation Required before Sale to General Public
	Environmental Conservation	Noise Abatement	Regulation of Noise level at Airports
		Pollution Abatement	Regulations concerning Detergents
	Protection of Employees	Prevention of Industrial Accidents	Factory Safety Regulations

S&T FUNCTIONS AND ACTIVITIES USED IN THE OECD STUDY ON TECHNOLOGICAL INNOVATION (Contin.)

OVERALL AIM: to improve the Capacity of the Firm to innovate

OBJECTIVES: to improve	SUB-OBJECTIVE	VARIABLES CHOSEN	MEASURES
Scientific-Technological Environment	General R&D Effort	Government R&D	Financing Specific Projects
		University R&D	Financing of Research
	Innovative Climate	Use of R&D Results	Creation of Specialised Agencies
		Individual Inventor	Assistance with Commercial Application
	Growth of Industrial Research Facilities	Access to Government owned Facilities	Possibilities of sub-contracting of projects
		Co-operative Research Centres	Government Aid with Subscription of Firms
	Diffusion of Information	Publications	Financing of University
		Access to Information Services	Establishment of Specialised Integrated Systems

that supply human resources with the skills needed to carry out the spectrum of S&T functions and activities. This requires going beyond the general training given by the traditional educational system. We may mention as examples the activities of graduate schools in science and engineering, various training programs for researchers, and continuing education schemes for engineers. Such activities are of great importance if science and technology are to be effectively promoted and put at the service of national objectives.

A detailed description of parameters and decisions is beyond the scope of the present guidelines. Each project team may attempt to work with an exploratory list which could be shared and discussed with other teams.

2.3 Linkage Area

The resulting variable or outcome is the facilitation and regulation of the transmission of scientific and technological knowledge to productive units. These are the functions and activities which relate the "supply" side with those of the "demand" side, and as such provide the channels through which technical knowledge can flow towards productive activities. On the other hand, they also channel the demands of the productive system to the local or foreign sources of knowledge.

The activities related to such variables are those of extension services, engineering firms, organizations for control of technology imports, industrial information systems, etc. Once again, there are functions and decisions about choice of alternatives and the building up of activities and institutions.

3. Sources of Influence (Independent Variables)

We shall now examine one by one the three types of sources of influence to be considered in the course of research, giving more attention to explicit policies and their correspondent instruments since many of the concepts that refer to them will be used througout the guidelines, and in particular when examining the other sources of influence.

3.1 Explicit Science and Technology Policy and Its Instruments

This category refers to policies and instruments that have a definite and explicit purpose to provoke an effect

on science and technology functions and activities. The purpose originates in a policy- expressed in documents or statements of varying degrees of normative power. A policy may sometimes have a direct effect on the dependent variable it has been designed to influence, but more often it needs an instrument which acts through an organizational structure and a set of operational mechanisms.

The Concept of "Policy Instruments"

Because the research in STPI focuses on the issues related to the design and operation of policy instruments, it is necessary to define more clearly these concepts.*

An explicit science and technology policy is a written statement by a high level government official or institution (such as a Ministry or the Planning Secretariat), that deals with an "issue" in S&T: it expresses a purpose (effects to be produced upon S&T variables), and may set objectives, define desired outcomes, and establish quantitative goals. Policies also contain criteria for choosing among alternatives with regards to the performance of S&T functions and activities, providing guidance for decision making. Although policies refer primarily to orientations set by government officials, in countries where the private sector has a significant influence, policies may also be formulated by representatives of the private sector. The issue dealt with may be very specific, referring to some particular purpose or decision to be taken and the criteria associated to it, or it may be of general nature.

A policy may remain a main rethorical statement if no means are provided to implement and realize its potential effect. To do this a number of things may be needed, and we shall incorporate them under the term instrument, or policy instrument. A policy instrument constitutes the set of ways and means used when putting a given policy into practice. It may also be considered as the actualization of the capability to influence decisions that those in charge of formulating and implementing policies have, and use with the

*Although the definition of an instrument is made here in connection with explicit policies, it is equally applicable for implicit policies and "indirect instruments" (see Section 3.2).

purpose of achieving their objectives and operationalizing the decision criteria set in the policies. A science and technology policy instrument would be one where the ways and means, or the actualized capabilities, include as a significant component the manipulation of S&T variables. It may also be said that a policy instrument is that which attempts to make individuals and institutions to make decisions following the rationality dictated by collective objectives. It is the connecting link between the purpose expressed in a policy and the effect that is sought in the dependent variables.

A policy instrument may be direct when it refers explicitly to S&T functions and activities; it may be indirect when, although referring primarily to policies, functions, or activities other than science and technology, it has an important indirect effect on S&T functions and activities, through what we have called "side-effects" or "implications".

An "instrument" is a complex entity, and we shall take to comprise one or more of the following items:

(1) A legal device*, which may also be called the "legal instrument". This embodies the policy, or parts of it in the form of a law, decree, or regulation. Formal agreements and contracts may also be considered in this category. The important thing is that a legal device goes one step beyond a "policy" by stipulating obligations, rights, rewards, and penalties connected with its being obeyed. The potential effect of the policy is then on its way to being actualized.

(2) An organizational structure, that is put in charge of implementing the policy. Under the term "organizational structure" we may include:

i. One or more institutions; a policy may be implemented through one or more existing institutions, or a new one may come into being. This may be thought of as the "hardware" aspect of the organizational structure.

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*We are using the words "legal device" as a translation of the Spanish "dispositivo legal" or "disposición legal", which refer to any legal or formalized agreement that carries prescriptive weight, is imposed by some authority, and is sanctioned in some way by the society within which it is issued.

ii. The procedures, methodologies, decision criteria and programs that may span one or more institutions. These are of an administrative and technical nature, and specify the steps that must be carried out in processing or combining pertinent information for the purpose of applying the policy. They may be considered as the "software" aspect of the organizational structure.

Often, S&T policies are implemented through organizational structures which already exist for other policy areas. For instance, a law allowing the free import of scientific equipment would naturally be implemented through existing import control mechanisms and institutions.

(3) A set of operational mechanisms, which are the levers, or means, through which the organizational structure finally implements the decisions, and acts in attempting to obtain the desired effect on the variables the policy has set out to influence. They would correspond to the capability of enforcing the decision arrived at in accordance to policy, producing the desired outcome or applying the results of work prepared.*

Throughout the analysis of an instrument it is important to keep in mind the "actors" or key decision makers who are directly involved in the design and use of a policy instrument. An instrument does not act on its own, and responds to the will of the policy makers and decision makers using it. This conceptualization of "policy" and "instrument" may be seen more clearly in Fig. 3.1. Three simpler cases are shown in Figure 3.2:

(a) no legal device. The instrument is made up of the couple organizational structure-operational mechanisms;

(b) no organizational structure specifically involved: the instrument is made up solely of the legal device and its action takes place through existing social and institutional structures. This situation in general will be the case of certain across the board or non-discretionary instruments;

(c) no instrument is provided to implement a policy; the effect is obtained solely by means of exhortation and persuasion, acting through cultural and emotive mechanisms. Naturally, a danger exists that the policy will remain dead letter.

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*A higher degree of consistency is needed among different operational mechanisms if the same effect is desired through the use of different instruments. To assure such consistency (although this is not often used) two or more instruments may share the same operational mechanism, which would convey (and at the same time combine) decisions made by different organizational structures.

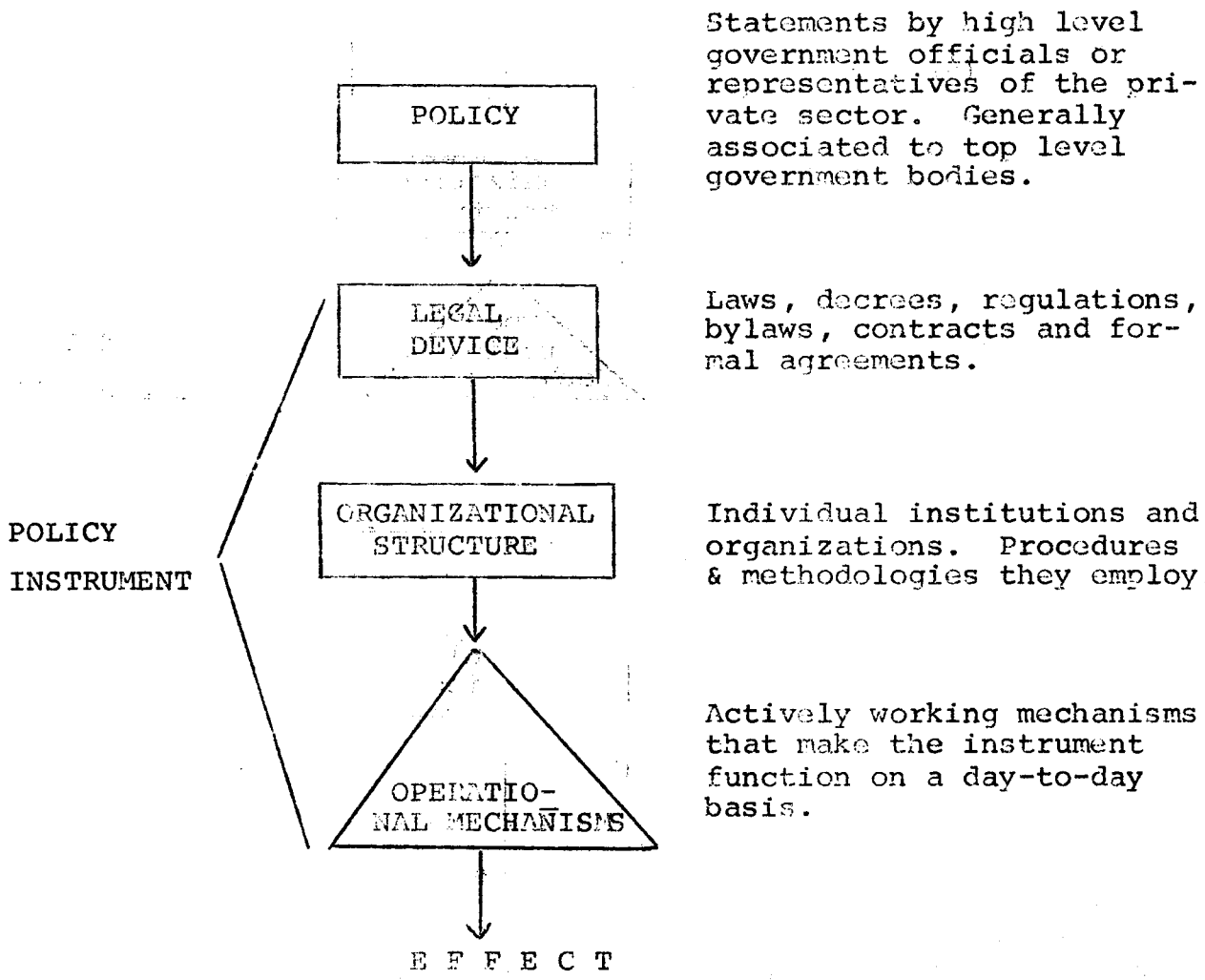


FIGURE 3.1 - STRUCTURE OF A POLICY INSTRUMENT

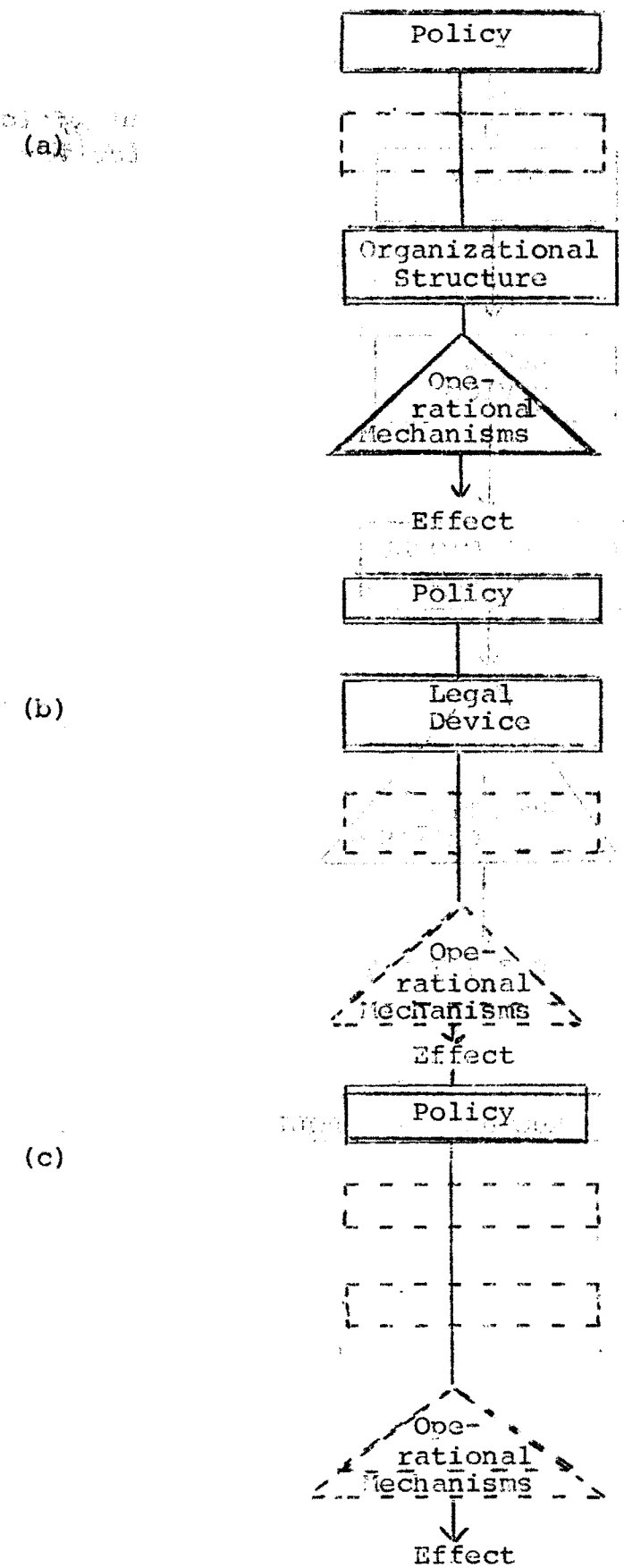


FIGURE 3.2 - Three types of policy instruments

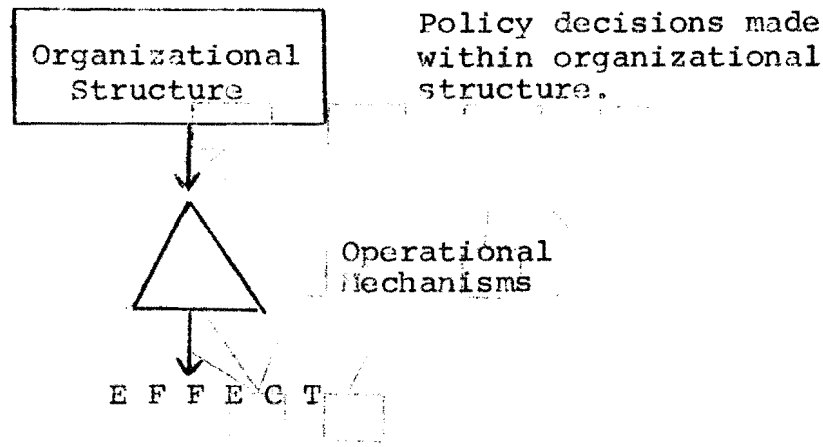
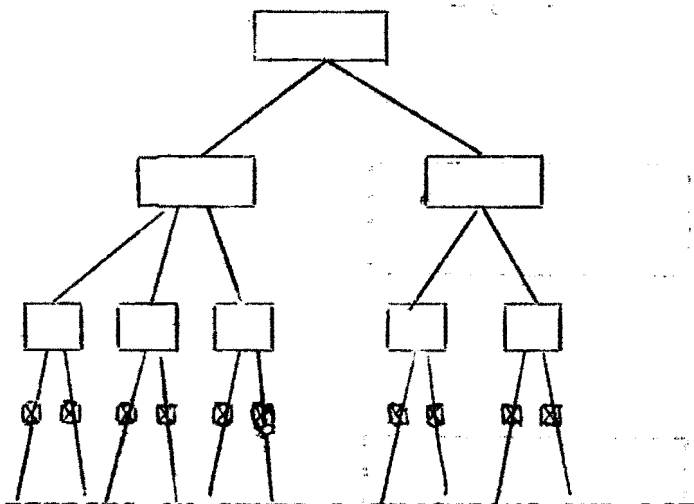
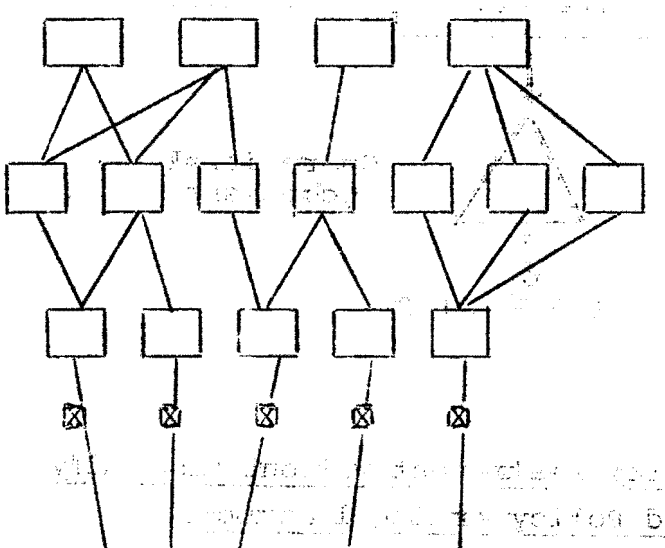


FIGURE 3.3 - A Policy Instrument without Centrally Guided Policy or Legal Device.



(a): Policy-oriented cluster of instruments (top-down)



(b): Function-oriented cluster of instruments (bottom-up)

FIGURE 3.4 - CLUSTER OF INSTRUMENTS

Finally, we may find the case (Figure 3.3) in which a policy decision is made within an individual institution or organization that does not have a broad policy making mandate. This is an important case since it exemplifies the situation of policies made in a pice-meal fashion by decisions of state enterprises, individual government agencies, and other organizations, without (or in spite of) an overall centrally guided policy.

Other situations may be represented using the concepts we have outlined, such as the two cases pictured in Figure 3.4. In (a) we find a number of instruments that intend to provoke different effects on account of one (complex) policy statement on one or more issues, such as a development plan. We may call this a policy-oriented cluster of instruments. In (b) various instruments, which obey several policies, all have effects on one variable. We may call this a function-oriented cluster of instruments. These two extreme situations are relevant to the present research since the first cluster corresponds to the "top-down" studies, while the second cluster corresponds to the "bottom-up" studies to be undertaken in Phases 3 and 4.

The Description of an Instrument

Using the concepts and diagrams put forward above it is possible to describe and analuze S&T policies and instruments of diverse nature. Such description should also pay attention to the policy level at which the instrument originates and the type of S&T function or activity it attempts to influence.

We feel it is not rewarding to prepare a complicated classification or taxonomy to help in this task, beyond the three categories suggested earlier for examining S&T functions and activities. Instruments may be classified according to whether the couple policy/instrument affects the demand side, the supply side, or the linkage area. This may be crossed with two categories according to the policy level, i.e., whether the policy originates in a government body that has a broad policy mandate, or in a particular organization at a lower level, (which may not belong to the Government, such as a producers' association, a large private enterprise, or a research institute). Figure 3.5 shows this two-way classification.

S&T FUNCTIONS AND ACTIVITIES AFFECTED

Policy Level	Demand side: technological behavior and decisions in productive system	Supply side: activities in the S & T system	Linkage area: activities that link productive system with sources of S&T
High (emanating from an institution with a broad policy mandate)	1	2	3
Low (emanating from an individual institution without broad mandate)	4 4	5 5	6 6

FIGURE 3.5 - CLASSIFICATION FOR EXPLICIT S&T POLICY

Some examples may be given for each cell in this simple matrix, keeping in mind that certain policies will affect, through their instrument cluster, more than one of the S&T categories of functions and activities.

High level policies*

(1) Articles or sections in "fundamental" laws, industrial promotion laws, development plans.

(2) Science policy statements, for instance, about the budget for R&D.

(3) Policies and legislation on technology transfer, technical cooperation agreements with other nations.

Low level policies**

(4) Policies and decisions of development banks, state enterprises and agencies; decisions about administrative mechanisms and about operational controls.

(5) Decisions about state R&D contracts; decisions about grants.

(6) Decisions made by offices in charge of international technical cooperation.

The distinction between the two levels may be useful when identifying the main policies and instruments that act on a branch of industry or on the whole industrial sector.

Other criteria for classifying instruments is whether they have a discretionary or non-discretionary character. The former involve an individual decision by some administrative authority in their application, while in the latter application follows automatically from a definite rule, without the possibility of discrimination. Discretionary instruments

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* These may also be called "first level" or "macro" policies.

** These may also be called "second level" or "micro" policies.

require the existence of an administrative capability and allow focusing on individual productive units, research institutes, etc., in the implementation of policies. On the other hand, they give the opportunity for interferences arising in their application (bribes, arbitrarinesses, etc.) Non-discretionary instruments affect S&T functions across the board, without allowing distinctions according to the particular situations of the different entities affected by the policy and the instrument. They require less of an organizational and administrative infrastructure for their application, and reduce the possibility of interference by interested parties.

It is possible to enlarge the set of criteria by which to classify policy instruments, including categories such as "positive" or "negative" instruments, depending on whether they are aimed at simulating, encouraging, facilitating and inducing, or whether they impose restrictions, prevent taking actions, prohibit certain activities, etc. However, the set of categories proposed above should provide a sufficient basis for the work of the country project teams, which could elaborate on them.

Evaluation of the Performance of Policy Instruments

The assessment of the performance of an instrument of S&T policy is a rather difficult task, but an attempt should be made to characterize policy instruments, or clusters of instruments, according to their usefulness in implementing certain policies. As soon as we raise the issue, a series of complex problems arises. Should an instrument be evaluated independently of the policy it is associated to? Is there a group of instruments better suited to a set of policies, purposes, or strategies than others? Is there an absolute measure of the effectiveness of an instrument, or should we attempt to carry out comparative analysis? Once again, this issue cannot be resolved a priori and in a general way for the project, and each team must examine this issue in the context of its own situation. Attempts to provide a coherent solution to this problem can be made only during the comparative analysis in phase 5 of the project.

However, there are a few concepts and tentative definitions that may provide guidance to the national teams in their own analysis. Ultimately the decision to use one instrument or another in the implementation of S&T policies should depend on some evaluation of its characteristics along the lines suggested below.

The scope and specificity of an instrument refer to the range of S&T functions and activities it affects, or the types of technological decisions it can influence. This attribute of an instrument could also refer to the size and volume of the functions and activities it affects. An instrument would have a wider scope the larger the number of S&T functions and activities it affects. On the other hand, it would be a very specific instrument if it is designed to affect one particular S&T function focusing on some determined group of enterprises, agencies, or research institutions.

The coverage of an instrument would be defined as the absolute number, or the proportion, of productive units, government agencies, research organizations, etc., that it is capable of affecting. This concept may be extended to consider side effects and implications. The equity of an instrument would refer to whether it has the same impact on all units that have similar characteristics and which it affects. Diverse situations, exceptions, loopholes, etc., may give rise to a situation in which the instrument cannot be applied with fairness in all cases that have similar characteristics.

The efficiency of an instrument would be the relation between the effort (administrative, financial, technical, etc.) and the effects that result from its use. The effort may include considerations of quantitative character, such as cost involved in its application, or qualitative character, such as expertise needed to operate it.

Other parameters to evaluate the performance of policy instruments may include the time lags involved in its application, the flexibility with which it can be used (meaning the possibility of applying it or not according to the circumstances), the amount of information required for its application, the degree of stability of the instrument (meaning the degree to which it preserves its properties in the light of contextual changes), and other parameters of similar nature.

Of particular importance is the concept of effectiveness of an instrument, which refers to the likelihood of obtaining the desired result; that is, implementing the policy, obtaining the desired outcome, and affecting the behaviour of productive units, units in the science and technology system, and units in the linkage area. However, this may be a rather difficult proposition, because instruments do not function in a simple, linear way, and there exist side effects which complicate the assessment of an instrument's effectiveness. This points out that it is necessary to take into account the effect

of the instrument, not only on the functions and activities it was specifically designed to influence, but also on other variables and on the effectiveness of other instruments as well.

Another problem that arises in the evaluation of the effectiveness of an instrument is that often they are designed to influence more than one S&T function and they may achieve this with varying degrees of success. Therefore, it may be necessary to examine the effectiveness of an instrument as a whole, considering the several S&T functions it should affect, and even the side effects it has on functions and activities in fields other than science and technology.

Throughout the discussion on performance we have talked of an "instrument" in singular, but these concepts may also be applied to a "cluster of instruments".

Examples of Instrument Description

Here we present brief analyses of three very different policy instruments. Note that in the third case "policy" is defined at the level of an individual organization that does not have a broad mandate for policy making, and the legal device is a contractual arrangement.

Case 1. Disaggregation of imported technology

Policy issue: excessive imported technology in new investment projects, much of it in turnkey plants.

Policy purpose

(a) to increase bargaining power
(b) to identify components for local production
(c) to facilitate technology absorption in the productive unit.

Legal device: one or more regulations, such as:
(a) prohibition to import turnkey plants
(b) model contracts with suppliers

Organizational structure: a special Government engineering organization to handle all large investment projects, with the support of a network of other institutions.

Operational mechanisms:

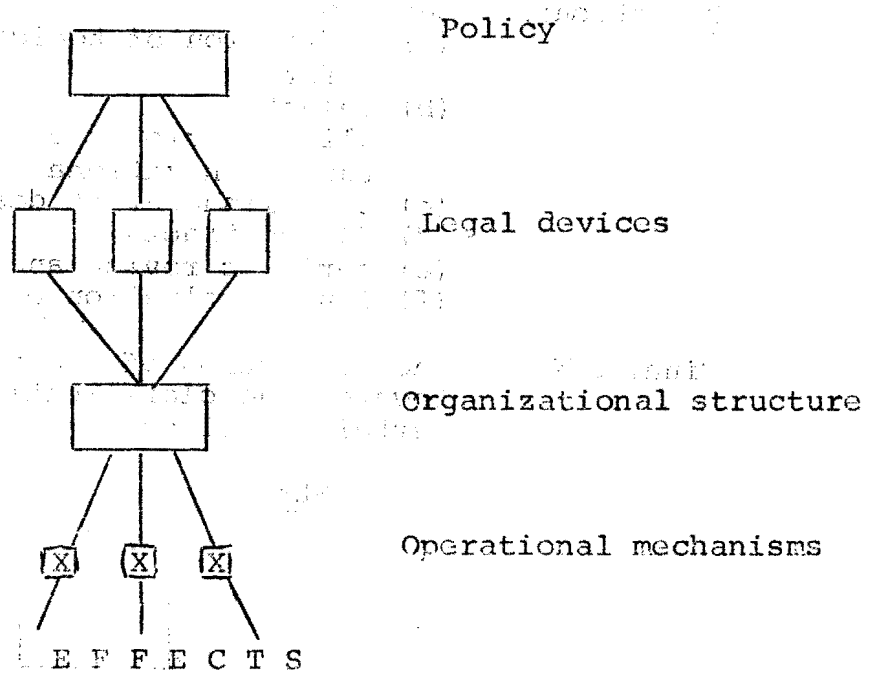
(a) approval, or not, of a certain contract. Effect: improvement of bargaining power.

(b) direct action through engineering activities. Effect: local purchase of inputs of goods and services, not previously bought locally.

(c) technical support and advice to productive units; stimulation to enterprise for disaggregation. Effect: facilitate technology absorption.

Final effect: improvements in the inportation of technology.

Structure of the Instrument



Case 2. State research contracts

Policy issue: lack of research and development oriented towards development problems.

Policy purpose:

(a) promote socially useful R&D in existing science system.
(b) promote the expansion of R&D capacity
(c) solve specific problems

Legal device:

(a) general law with norms instituting a system of state research contracts

Organizational structure:

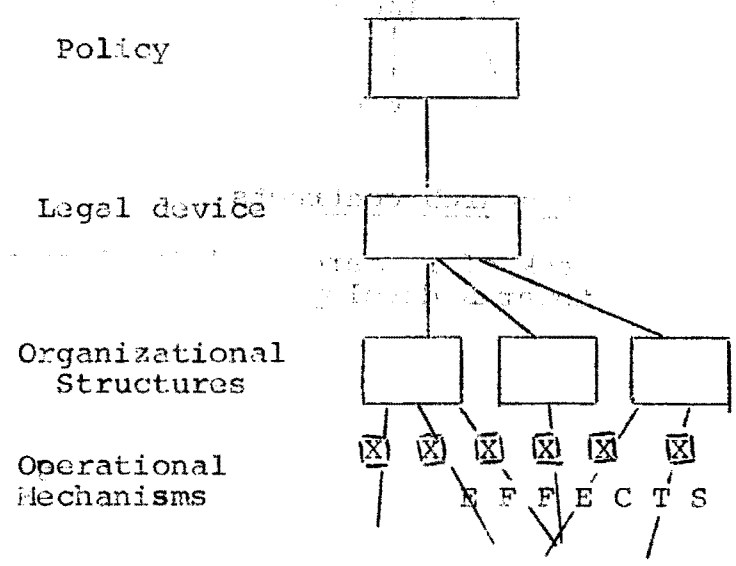
(a) Department of a Ministry
(b) R&D office in a state organization
(c) Special organization (like FINEP in Brazil)
(d) the structured procedures for:
- getting contracts going
- controlling project's advance
- evaluating final results of projects

Operational mechanisms:

(a) definition of topics for R&D and terms of reference
(b) selection of R&D contractors based on established priorities and using procedures of the organizational structure.
(c) establishment of deadlines and budgets
(d) R&D contracts
(e) periodic review and control of projects
(f) final evaluation of results of projects

Final effect: The production of specific knowledge oriented towards the clarification or the solution of certain problems.

Structure of the Instrument



Case 3. Linkage science-industry: analysis of the "Service of technical assistance to industry" (SATI) of the Metallurgical Laboratory, Atomic Energy Commission of Argentina

Policy issue: little use by industry of Laboratory's capabilities.

Policy purpose: to supply industry with R&D and technical services in areas in which the Laboratory is active.

Legal device: agreement with the Metallurgical Industry Association setting up SATI, and establishing its purposes and bylaws.

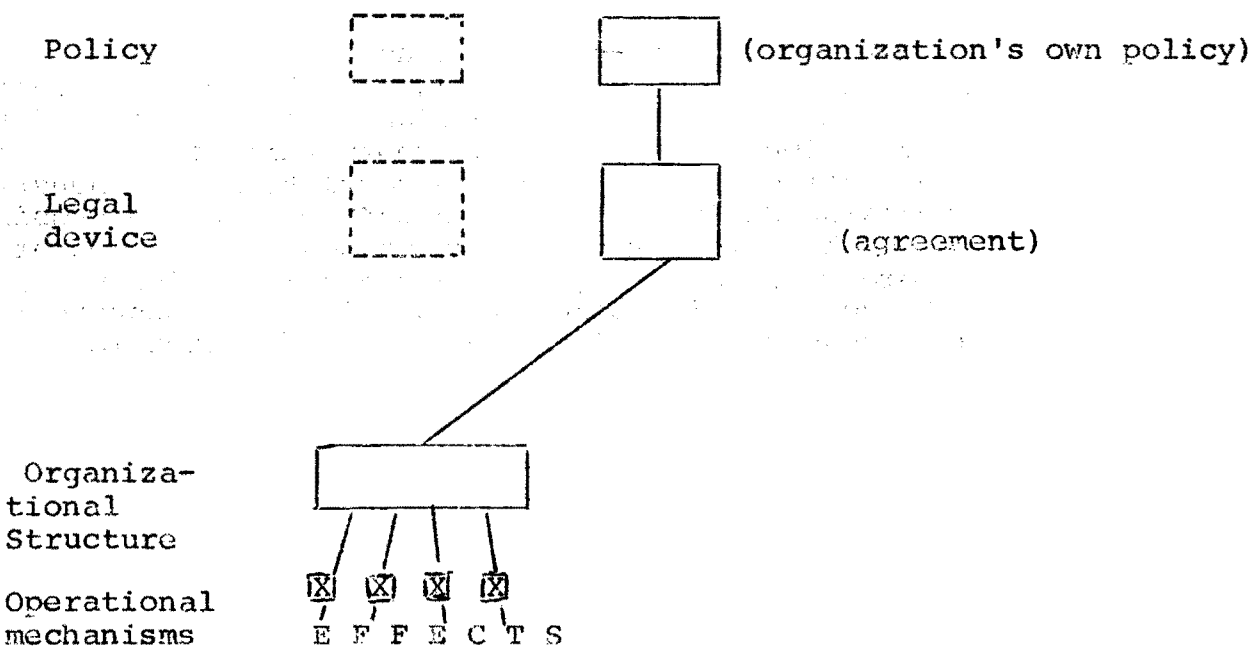
Organizational structure: SATI and its technical staff.

Operational mechanisms:

(a) information to industry
(b) training for industrial personnel
(c) publications
(d) visits to industry
(e) organization and execution of technical assistance, technical services, and R&D through contracts.

Final effect: (a) a reorientation of the Laboratory's S&T activities towards industry needs
(b) the supply of significant S&T inputs to industry.

Structure of the Instrument



3.2. Implicit science and technology policy and its instruments

Many policies and decisions at different ~~levels~~ LEVELS which are designed to produce effects on variables that do not belong to the group of S&T functions and activities, may have unintended effects upon the latter. None of these are aimed at in the policy or decision; awareness of them is dim at best, and the causal mechanisms through which they operate are usually ignored.

It is perhaps useful to consider two types of unintened effects, according to whether the effect is potential or whether it actually takes place. We may call the first implications and the second as side effects. Implications refer to what may happen to set functions and activities as a result of policies and decisions in other areas, and the testing of any hypotheses about them (for instance, a new law or policy) would require relying on opinions and other non-factual evidence. Hence any verification of hypotheses about implications would be of the weak kind. Side effects refer to what has actually happened, so that actual behaviour may be studied, giving a strong verification based on factual data. Of course it is not easy to draw a line between both types of unintended effects, and in some cases the study of side effects may rely on abundant empirical evidence, while in others only bits and pieces may be found. However, the distinction is a useful one for the purposes of the research in STPI.

A wide away of policies may have side effects and implications on S&T variables. As example, it is possible to mention:

- High level policies:
  Articles or sections of "fundamental" laws, industrial promotion laws, general and sectorial development plans, international agreements (particularly in commercial matters), budgetary decisions at the national level, decisions about wages and social security, etc.

- Low level policies and decisions:
  Credit system, foreign exchange regulations, characteristics of investment decisions, foreign trade decisions (particularly about import permits and import tariffs), manipulation of operative controls for the regulations of industry, etc; purchasing decisions by State enterprises, purchasing decisions by large private enterprises (in particular those of foreign ownership), and in general, decisions by Government agencies with some autonomy in their behaviour that may strongly affect S&T functions and activities.

This identification may be helped by using a check-list based on Annex 2 of the Jones report, which is reproduced here, noting that some of the items included correspond to "contextual factors" rather than to implicit S&T policies.

A study of the effects on S&T of implicit policies through diverse organizational structures and operative controls may follow a similar pattern than in the case of explicit S&T policies and instruments. The sequence policy-legal device-organizational structure-operational mechanism may be described in each case. A similar classification employing the six categories of the preceding section may also be used for implicit S&T policies and side effects.

The analysis of implicit policies in general laws (on industrialization, on mining, on foreign investment, etc.) should lead to uncovering the main implications or side effects for science and technology functions and activities. The first step would be identifying those policies oriented to areas other than S&T which could have an important impact on them. For this a certain understanding of the way the science and technology system functions in the nation is required, examining its place in relation to the economic, social, and educational systems.*

Once the set of policies with potential effects on science and technology functions and activities has been identified and ordered according to their likely degree of influence on S&T, it is possible to proceed with a detailed analysis of each. Although the form and content of laws will vary a great deal from country to country, it is possible to suggest a general outline for extracting the implicit science and technology policies.

The first task would be to focus on the articles and clauses that can affect science and technology functions in enterprises, government agencies, research organizations, universities, etc., describing their possible effect. The second stage would be to put together the implications of different clauses and articles referring to a single issue or S&T function, assessing their effect by taking them as a whole. These

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*This would be the result of phase 1 of the research.

IMPLICIT SCIENCE POLICY - policies indirectly affecting scientific and technological activities.

a. Economic (primarily directed to the functioning of the economic system)

- finance (credit, interest rates)
- fiscal (taxation, exchange rates, exchange control)
- external trade (tariff and non-tariff barriers)
- internal trade (prices, marketing, government procurement)
- wages and labour compensation policies
- foreign investment, compensation and nationalisation
- economic development policies
- specific industrial policies
- specific agricultural policies
- legal and general instruments
- policies towards regional development

b. Manpower

- educational system (literacy, primary, secondary, vocational, etc. education)
- higher education policies (universities, training institutes, management training, post-doctoral training)
- fellowship policies
- industrial training and retraining, technician training
- policies for the use of foreign manpower
- policies towards emigration of professionals
- policies twards repatriation of skilled manpower
- policies related to mobility of qualified personnel
- policies for the promotion of human resources
- salary structure and awards, mobility

c. Cultural

- mechanisms to modify the general value structures, attitudes, norms, etc., including the position of women
- policies towards modernisation and technological change
- popularisation of science and technology
- policies towards modifying the structure of status and prestige awarding procedures, mechanisms, etc.

d. Physico-ecologic

- policies for the exploitation and preservation of natural resources
- policies towards environment control, pollution

e. Demographic and social

- health care
- mortality rates
- population control
- income policies, distribution o of income
- policies towards increasing social mobility

potential effects or implications can then be put together across a single law or several of them, and also across various S&T functions and activities to identify the overall implicit policy.

When examining the implicit policies contained in general laws, one of three situations may arise with regards to the content of the implicit policy uncovered.

(a) The implications of the policy are so obvious and clearly defined that a conclusion may be arrived at as a result of the analysis.

(b) The implications of the policy for S&T functions and activities are not so clear and obvious, and their definite impact will depend on reactions of the enterprise, government agencies, research institutes, etc. The specific and actual content of implicit policy will have to be determined through empirical analyses, and the maximum that can be done is to formulate hypotheses on the effect of the law being analyzed.

(c) The law leads to the identification of one or more instances of intervention by government agencies, and the content of implicit policy will depend on the way decisions are made by government officials. To uncover the implicit content of S&T policy, an analysis of such decisions is in order.

Note that we are talking about "implications", although it is clear that if empirical data were available to corroborate the statements spelled out in the implicit policy, we would refer to them as side effects.

A similar procedure could be followed with regards to development plans. In this case it would be possible to make a direct comparison between implicit and explicit policies arising out of a single document. A plan generally contains objectives, policies and strategies spelled out clearly, such as in the case of general development plans, industrial development plans, manpower plans, etc. The procedure in this case could be as follows:

(a) Summarize the main objectives, policies, and strategy elements of the plan, examining each of them with regards to their impact on S&T functions and activities.

(b) Deduce what would be required in terms of science and technology functions and activities in order to be able to fulfil the objectives stated, to comply with the policies, or to follow the strategy. This would lead to an identification of the pre-requisites, from the point of view of science and technology, that are necessary to carry out the plan. The whole set of pre-requisites would constitute the implicit S&T policy contained in the plan.

(c) Summarize the components of the plan referring explicitly to science and technology, putting them in terms of the S&T functions and activities defined in the research.

(d) Compare the implicit and explicit components of S&T policy in the plan, examining whether they are coherent and there is a correspondence between the two.

A plan by definition consists of statements about what is to be done, and therefore, unless we are in a process of assessing past performance in comparison with planned objectives, it is only possible to derive implications, and not side effects, from such an analysis.

If the study of implicit policies were focusing on speeches, white papers, specific legal regulations, or other sources of implicit policies, a different treatment would be required. These two cases may provide an orientation of the research procedures that may be followed.

The uncovering of implicit policies which significantly affect S&T functions and activities would also lead to identifying the policy instruments associated to them which could be used as indirect instruments to implement S&T policies.

3.3. Contextual Factors

These are aspects of the societal system that cannot be changed in the short run, as opposed to policies which in principle may be rapidly modified. We suggest, as an operational line of demarcation, that if a certain characteristic may not be changed significantly during the period of a plan, say four or five years, it should be considered as a contextual factor.

The contextual factors that interest us are those that

a priori appear to have some effects on scientific and technological functions and activities, either directly, or indirectly through their influence on the organizational structure to implement policies. The effects can take the shape of constraints and limitations to what an explicit scientific and technological policy may attempt to do or achieve, or they may imply drawbacks and obstacles to the way the organizational structures function, thus having an influence on the effectiveness of instruments.

Many contextual factors carry a negative connotation which is typical of underdevelopment, and one of the aims of a development process is to change them in the long run. For example, it is possible to point out the lack of pressures to perform S&T functions and activities in underdeveloped countries as one of the characteristics of the S&T system arising out of contextual conditions.

In most underdeveloped countries the existing economic structure creates little or no pressures for the application of scientific knowledge and improved technology. Under these circumstances the scope, in practice, for exploiting modern science and technology is severely restricted. The limited growth of science observable in these countries must be considered as stemming from a lack or inadequacy of any social pressures or demands for science and technology, which must in turn be directly related to the social structures and the organization of the economy. The full potential for increased production and improved productivity which technological change allows can be properly exploited only in the context of structural changes in the economy. In other words, the possibilities of applying science and new technologies are contingent upon the scope and efficiency of general development policies, significantly changing unfavourable social and economic structures. The demand for scientific knowledge and improved technology should emerge as a consequence of the overall development programme.

In terms of the two main production sectors, agriculture and industry, this entails changes in their intersectorial relations, and changes in the organization of production within each sector. Agricultural production needs to move from semi-subsistence to a flexible, increasingly specialized organization, with increased land yields and labour productivity, able to meet the widening nutritional needs of a growing urban as well as the rural population, to provide raw materials for industry, to provide employment opportunities, and

to offer an increased export contribution. In industry, expansion must be accompanied by productive employment and growing incomes, with the ability to compete in international markets so as to allow increasing external trade while also supplying domestic demand.

Industries in underdeveloped countries have developed largely behind protective barriers in markets of limited size. This has resulted inevitably in small scale plants with varying degrees of cost inefficiencies. Within this development frame, technical adjustments in the product mix or production techniques are of limited advantage. In the absence of competition, there are no commercial incentives to reduce production costs or improve consumers products. Import substitution is often justified as a means to reduce foreign dependence, increase employment, balance industry and agriculture, and to strengthen balance of payments. But indiscriminate and excessive import substitution and protectionist policies can result in wasted resources and can have other highly detrimental technological side effects. Technological imporvements cannot be expected without a rational industrial policy frame.

A number of characteristics of the existing economic system in Latin American countries, and their industrial sector in particular, which are largely a result of the historical process of economic development and industralization, and have implications for science and technology, can also be identified as contextual factors. These are:

- Technological dualism
- Excess capacity in many sectors of industrial activity
- Deformed price formation mechanisms
- Predominance of foreign investment in certain sectors of economic activity
- Conservatism and lack of innovation in local entrepreneurial groups
- High unemployment
- Large inequalities in income distribution

These characteristics may be taken to be significant contextual factors that limit and condition the effect of explicit S&T policy and instruments. Many more contextual factors of an economic nature may be added to such a list, for instance, size of the national economy, dependence on a few export items, unavailability of a wide range of efficient technological alternatives, chronic inflation, large reliance

on foreign technology, land tenure patterns, small size of many enterprises, oligopolistic and monopolistic structures, unfavourable salary structures and characteristics of labour legislation, deficient communications and ~~irrigation~~ INFORMATION, etc.

Other relevant contextual factors may be briefly mentioned.

- Cultural: habits of cultural dependence; ties of scientists to the international network of science; unfavourable value structures, attitudes, norms, etc., such as disdain for manual labour, humanistic and anti-scientific traditions, attitudes towards women's labour; structure of status and prestige, etc.

- Social and demographic: low educational levels, internal and external brain drain, deficiencies in the educational system, poor labour mobility, unavailability of skilled manpower, poor health, overpopulation, strong rural-urban migration, structural unemployment and underemployment, etc.

- Political and institutional: national development objectives not well defined; unawareness of the potential role of science and technology in development; habitual lack of coordination between policies emanating from various first - and second - level sources; heavy and slow decision making procedures; excessive red-tape; slow and complex control of expenditures; corruption; poor control of the implementation of Government policies and decisions; fossilized institutions and mechanisms that subsist well after they stop being useful; inefficiency of public administration, etc.

- Geographical, physical, and ecological: lack of certain natural resources; poor transport and communications within and without the country; ecological problems; climatic factors, etc.

Contextual factors make up what may be called the "environment" for science and technology in the country. Some of them may be taken to be "invariants", in the sense that they cannot ever be changed, or cannot be changed significantly in a very long period -- for instance, size of the country, lack of natural resources, climate, high demographic growth, certain cultural patterns -- and thus signify permanent, or quasi-permanent, restrictions to what an explicit S&T policy may do. Others may be changed gradually in the

course of many years (Japan) or quickly on account of a revolutionary upheaval (China).

The point to be made in the research is that each country team must identify and point out clearly which contextual factors are of relevance to the formulation and implementation of S&T policies.

The negative influence of many contextual factors on what an explicit S&T policy may achieve has induced some authors to believe that a proper regulation, control and utilization of science and technology to further development objectives is not feasible unless vast structural changes are effected in the first place. It is to be hoped that the STPI project will throw light on this issue, and show whether science and technology policy and its instruments have a significant place in changing underdeveloped societies, through gradual and cumulative action.

4. Approaches to the Research in STPI

There are in principle two approaches for the study of our subject matter. One would be to start from policies tracing down its effects - the "top-down" approach -, and the other to start from the effects tracing back the sources of influence behind it - the "bottom-up" approach. Both approaches are complementary. The first is useful for examining the effects of existing or intended policies (legislation, development plans, and practices of government agencies), and if a screening of key policies (explicit and implicit) is done for a particular branch, or even for the whole industrial sector, a "resultant" policy may be derived. This resultant policy would express the combined effects of the key policies on S&T variables, acting through the existing institutional setting and within the constraints imposed by the relevant contextual factors.

The second approach seeks to answer more specific questions about the sources of influence acting on a single "issue", "variable", or "problem area" of S&T functions and activities. For instance, we may be interested in why state enterprises in the metallurgical industries buy their capital equipment predominantly from foreign sources; or why the whole of the modern industrial sector tends to use capital intensive technologies. The bottom-up approach would lead to identifying the influences, both external (policies, instruments, and context) and internal (technical capacity, infor-

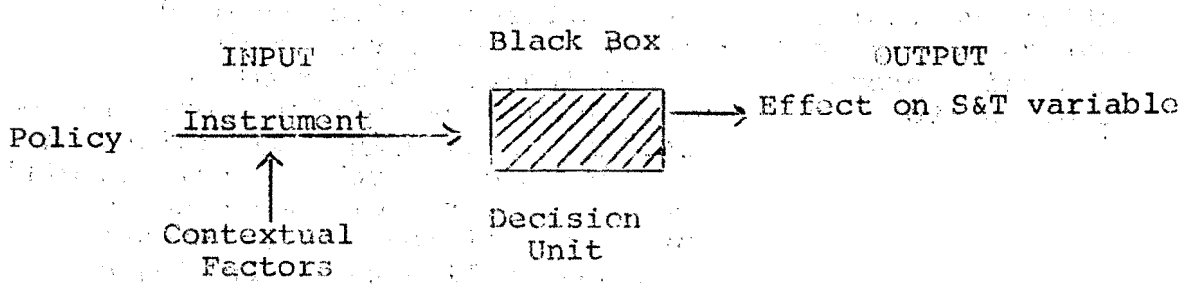
mation available, decision patterns, influence of decisions that do not strictly refer to S&T matters) to the productive unit which prove to be significant. This knowledge would be of use to improve the situation by modifying existing policies, introducing new policies, removing constraints, generating new instruments, and so on. Such an analysis will also give a good idea about the degree of congruence of the various policy instruments and decisions which emanate from different sources, what we have called the "function-oriented" cluster of instruments, and hence about the "resulting effect" this cluster has on the variable under study.

We have referred above, in our examples, to the "demand side" of S&T, i.e., what takes place in productive units; but similar examples may be given in regard to units in the supply side and the linkage area.

In order to avoid spreading efforts too thinly, the research teams should focus on a few important policies and their instruments and on a few issued related to S&T functions and activities. To a certain extent this has begun through the choice of a few branches of industry in each country, but it may be necessary to restrict the domain of inquiry even further.

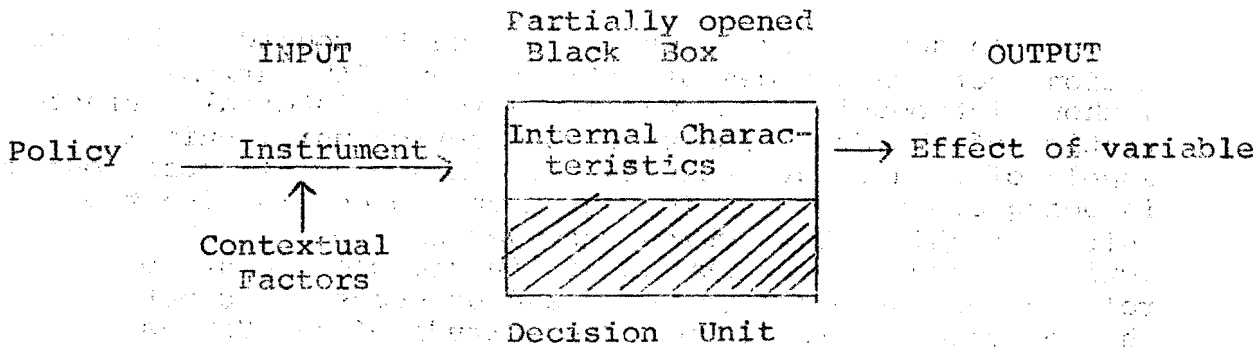
The sequence of research under either of the two approaches would be: (a) identification of presumed cause-to-effect links, (b) formulation of hypotheses about the effect (sign and magnitude) of policy variables (explicit or implicit) on dependent S&T variables, as well as hypotheses about the effectiveness of explicit S&T policy instruments, and (c) verification ("weak" or "strong", as the case may be) of such hypotheses.

In some cases it may be enough to consider the interactions between sources of influence and S&T variables, without introducing into the analysis the internal characteristics of the decission unit (productive unit, unit in supply of technology, unit in the linkage area) whose "output" is being studied. This is tantamount to considering the unit as a "black box" which receives an input -- the policy acting through an instrument within the constraints of the relevant contextual factors -- and produces an output, namely the variation in the sign and magnitude of the S&T variable under study:



This may be a useful simplification when the researcher is interested in the aggregate effect of the policy variable on many decision units taken together, and these units are not too large and have similar characteristics, so that a certain degree of homogeneity may be assumed.

However, when dealing with large units whose particular behaviour is of special interest, or which are in a monopolistic or predominant situation in their branch or sector (such as a large State enterprise in the oil and petrochemical field or an agricultural research institute that handles a large share of research in the agricultural sector) it may be useful to look also into what happens inside the unit when it makes decisions related to the "output" in which we are interested. This requires an understanding of the "internal" characteristics that, together with the "external" influence of the policy variable(s), may allow for a better explanation of the effect on the S&T functions and activities under study. Hence the "black box" should be opened as much as necessary for the formulation of better, more powerful hypotheses:



In the case of a productive unit, the internal characteristics in which we are interested are those aspects of its "hardware" (physical and human resources and their organization) and "software" (procedures, methodologies, decision rules, motivations behind those) that seem to be especially relevant to how the unit makes the set of technological decisions that constitute what we may call its "technological behavior". Viewed in this light, the effects of policy variables on the unit's S&T variables (the "outputs" in the above graph) may be taken to be as equivalent to the effects of policy variables on selected aspects of the unit's technological behavior, acting through the relevant "internal characteristics". The main advantage of this opening of the black box is that it may give the researchers a better idea about which internal characteristics to modify, through other policies, in order to permit existing or proposed S&T explicit policy to obtain the desired effects.

A parallel treatment to what we have suggested in the case of productive units may be applied to units in the supply side and in the linkage area; those large units that dominate a sector or branch would need an analysis of the internal characteristics that condition their "technological behavior".

Hence, there is a strong case for the study of technological behavior in the principal types of units of each grouping. Due to the emphasis of STPI on the industrial sector, and in view of the conditions that obtain in most of the participating countries, it would seem appropriate that such studies should concentrate:

- in the case of the productive sector, in large state enterprises, on account of their actual or potential role in some of the principal productive branches;

- in the case of the supply side, in large industrial research institutions;

- in the case of the linkage area, in large engineering consulting and design firms.

These studies of technological behavior could also be an important input for some of the case studies to be undertaken by the country project teams.

Another important area for specific research within STPI is that referred to certain complex organizational structures, or institutions, that are entrusted with the execution of many explicit S&T policies by means of diverse operational mechanisms. They also behave frequently as policy-makers at a lower level. They merit a careful description and analysis qua organizational structures. Among them we may mention:

(a) Offices in various Ministries in charge of formulating technological policies, and of controlling their implementation.

(b) Organizations in charge of formulating science policies (in the strict sense) and controlling their implementation, such as Science Councils, Research Councils, etc.

(c) The network of organizations in charge of promoting and executing scientific and technological activities, including University laboratories, research institutes, etc.

Finally, there are certain activities that are carried out with the participation of a wide array of persons and institutions for the purpose of defining policy objectives, policy instruments and programmes of action. Noteworthy among them is the activity of preparing scientific and technological plans at the national, sectoral, or regional levels. Such activity is worthy of study on account of its actual or potential importance for the whole subject matter of STPI. This suggests two types of studies: (a) normative studies on the methodology of, and the organization for, scientific and technological planning in less developed countries, and (b) empirical analyses of the science and technology planning process in the countries that participate in STPI.

III. The research phases of the STPI project.

It is hoped that the points contained in this methodological outline will be covered by each country team, in order to assure maximum comparability of results. Thus, the present outline represents the common research effort, though naturally different teams may want to explore other items not specified here.

It has been agreed that special emphasis will be put into the study of science and technology policy instruments in certain branches of industry, in order to concentrate research efforts. The list of branches chosen by the different countries is attached. It has also been agreed that case studies are to be made of certain institutions and instruments of particular interest (see attached list). To maximize the output of research efforts, it is recommended that, whenever possible, case studies should refer to the sectors chosen for study.

Phase 1. Background

(a) A description of the country's socio-economic system. Its evolution in the past; its trends. Description of the economic and structural aspects of the industrial sectors chosen, with emphasis on technological aspects.

(b) A description and diagnosis of the country's scientific and technological system, and its relations with socio-economic development objectives; evolution in the past; trends. Particular emphasis should be put in that part which is of relevance to the sectors chosen.

The output of this phase will generate the essential background information to orient the work in the later phases and to interpret and assess the results with a view to comparison between countries.

Phase 2 Analysis of instruments, identification of effects and formulation of hypotheses.

This phase will identify the main sources of influence that affect S&T functions and activities, focusing on the most important for detailed study, and examining the main types of effects they produce on science and technology functions and activities (the dependent variables). There will also be an analysis of the organizational structures that filter, transmit and mediate the sources of influence over the S&T functions and activities.

To study the effect of the three types of influences the following sequence is suggested.

1. Identify the principal items policies-instruments under each of the three headings that may be expected a priori to produce significant effects on science and technology functions and activities.

2. Describe each of the items identified.

3. Formulate hypotheses about the effects. This should be done at two levels:
   (i) at a general level, that is, for the whole industrial sector (and other areas if desired);
   (ii) at the level of the industrial branches chosen for special study.

Hypotheses should refer to the sign and magnitude of the effect, and in the case of explicit science and technology policy and its instruments, they should also deal with the effectiveness of the instrument.

4. Collect evidence from various sources, including opinions, that may give support or corroboration for the "general level" hypotheses. This may allow a screening in order to retain those hypotheses that seem more plausible. Hypotheses at the level of the industrial branches are to be tested through empirical studies in phases 3 and 4.

5. With the results of the preceding point, it is now possible to formulate a "resultant" policy that expresses the combined action of the different effects on S&T at the general level. Such a resultant policy may be checked later with the results of phases 3 and 4, as well as with other information that may come up during further research work.

Phase 3. Testing of Hypotheses at the Level of Productive Units

Within the industrial sectors chosen, and in a representative sample of productive units in each sector:

3.1 Verify hypotheses put forth in point 3 (ii) of Phase 2.

3.2. Identify and describe a number of main issues that have to do with the technological behaviour and decisions

of the productive units. Some of these issues may be of specific interest to the productive unit, others of relevance to the country's development objectives. Trace back the factors that influence such issues, due to the three types of causes mentioned in Phase 2.

3.3 On the basis of the evidence collected in 3.1 and 3.2 formulate the "resultant policy" that expresses the combined action of the different effects on the technological behaviour and decisions of productive units in the sectors under study.

3.4 It is possible to link some of the case studies listed in the project to the empirical work of phase 3. The case of state enterprises is a clear one, and it should also be possible to link the study of financial institutions and export promotion mechanisms.

Phase 4. Testing of Hypotheses and Case Studies - Generation of Technology and Linkage with Productive Units

Consider (a) the main scientific and technical institutions that supply technology and services to the productive units in the industrial sectors chosen, and (b) the main institutions that have to do with the diffusion and transfer of technology from domestic and foreign sources to those productive units.

4.1 Verify hypotheses put forth in point 3 (ii) of Phase 2

4.2 Identify and describe a number of main issues that have to do with the activities of the institutions under (a) and (b) above. Some of these issues may be of specific interest to the institution, others of relevance to the country's development objectives. Trace back the factors that influence such issues, due to the three types of causes mentioned in Phase 2.

4.3 On the basis of the evidence collected in 4.1 and 4.2, formulate the "resultant policy" that expresses the combined action on the activities of the institutions under study.

4.4 Link the case studies of selected institutions of types (a) and (b) above; of institutions that formulate and implement policies and programmes for the scientific and technological system; and of planning procedures and methodologies for science and technology. The case studies

listed by participant countries which would be considered are:

- Industrial research institutions; research units within enterprises;
- Standards institutes;
- Consulting and engineering organizations;
- Technical assistance and cooperation organizations;
- Organizations for the control of technology transfer and foreign investments;
- Science and technology planning procedures and methodology.

Phase 5. Country Reports and Comparative Analysis

(a) The results of the work performed under Phases 1 to 4 will allow each country to prepare a report with emphasis on those aspects that will permit a fruitful comparison between the various participating countries.

(b) A final report of the Project may then be prepared, by comparison and integration of the results of country studies, together with the results of studies performed by consultants and other relevant information. This synthesis should allow policy-makers to know about the impact and effect of alternative mechanisms and instruments for implementing scientific and technological policies in a variety of conditions of underdevelopment.

Branches of Industry Chosen by the Participating Countries

Name	N°	Countries
Oil and petrochemicals	7	Argentina Brazil Egypt Korea Mexico Venezuela India
Metalworking, capital goods, machine tools	7	Argentina Egypt Macedonia Mexico Peru Venezuela Nigeria
Iron, Steel and metallurgy	5	Argentina Brazil Macedonia Peru Korea
Food processing	3	Macedonia Nigeria
Electronic equipment	2	Korea India
Construction	2	Macedonia Nigeria
Ship building	1	Peru
Electric power	1	Brazil
Transport equipment	1	Argentina

Case Studies Chosen by Participating Countries

Case Study	N°	Countries
Industrial research institutes	8	Macedonia Argentina Brazil Egypt Korea Mexico Venezuela
State Enterprises	6	Argentina Brazil Mexico Peru Venezuela India
Science and Technology Planning	5	Venezuela Egypt Korea Peru India Colombia
Engineering - Design and consulting	4	Colombia Macedonia Argentina Mexico
Technical assistance and cooperation	4	Egypt Argentina Venezuela India
Financial institutions	3	Colombia Brazil Peru
Technology transfer	3	Macedonia Nigeria Korea
Standard institutions	1	Brazil
Export promotion	1	Mexico

IV Guidelines for Phase 1

The purpose of research under this phase is twofold. In the first place it should provide a background for the rest of the study. Secondly, it should supply elements for work in phase 2 by making a first identification of explicit S&T policy and its instruments, policies in other areas that may have (or have had) unintended effects on S&T, organizational structures of particular relevance because of concentrating decision power, and very especially the diverse societal characteristics that make up the context within the economic system and the S&T system work and interact with each other. Thus, the first phase should not only be seen as supplying a backdrop to the project, but also as an activity that will naturally lead into the second phase of the project. The dividing point between phases 1 and 2 is not sharp, work in the first one will lead naturally to involvement in the second one, and naturally the people who are to be mainly in charge of the second phase should also participate very actively in the first one.

Work is to be concentrated on the country's socio-economic system, its scientific and technological system, and their relations; other societal systems should be covered not for their own sake but, only insofar as they are relevant to the understanding of the two other systems and their interaction, and hence much less detail is expected in their analysis.

A historical perspective should be introduced into the analysis in order to understand better how things came to be as they are at present; but emphasis should be put on the analysis of the present situation, and of the trends that may show up.

In order to concentrate research efforts, and since the main focus of the STPI project is on industry, it is this sector that should be the main focus of the analysis, particularly when the present situation is looked at. And in order to open the way for research in phases 2 to 4, special effort should be devoted to analyzing the historical evolution and the present situation in those industrial branches chosen for special study, of the S&T activities and institutions of particular relevance to them, and the relations between both.

The following outline should not be taken to be an enumeration of steps to be undertaken sequentially, but rather as a broad

checklist of topics that would appear to be of relevance to most country studies, and which may allow fruitful comparisons among countries. Country teams naturally would include other items that they feel to be important for completing and rounding off the analysis.

It is to be hoped that the information needed to prepare phase 1 is already available within each country, and that fresh research of the data-generating type will not be required. This may not be true in the case of the analysis of the present situation of the science and technology system; in such a case the country may need a broad survey of the quantitative type which should preferably not lead on to a protracted and costly full-blown inventory.

Finally, it should be recognized that any analysis of the type Phase 1 intends to evoke is bound to show different interpretations of historical processes and present situations according to the ideology or the "school" of the person or group that takes up the task.

BASIC OUTLINE FOR THE REPORT ON PHASE 1 OF THE STPI PROJECT

1. Description of the main characteristics of the Human and Economic Geography of the Country (Size population, distribution of natural resources, geographical regions, etc.).

2. Brief description of the Political and Economic evolution of the country. Stages in the process of development, outline of the main economic policies followed during the last 30 years, rates of growth of the different sectors of the economy, evolution of employment, structure of foreign trade, etc.

3. Governmental structure.

   (a) Division of powers between the executive, legislative, and judiciary branches.

   (b) Description of the system for passing laws and general regulations.

   (c) Degree of descretionary power of government agencies with regards to by-laws, decrees, and interpretation of legal instruments.

   (d) Administrative structure of the government, description of key ministries, outline of main government agencies and their functions, governmental decision- making procedures, degree of participation of the different sectors of the population in government decision-making, etc.

   (e) Structure of the political system, role of political parties, electoral processes, etc.

4. Main social features. Population growth, urban migration, standards of living and their evolution, social class structures and their relative power, labor mobility, etc.

5. Structure of the educational system, literacy rates, proportion of students in the school system, description of the university system, distribution of students by discipline, the brain drain problem, etc.

6. Cultural pattern and their evolution. Impact of modern technology upon society, value structures, attitudes and norms, particularly with regards to manual labour, industrial activities, and science and technology.

7. Description of the industrial sector.

(a) Importance of the industrial activity for the national economy.

(b) Relative importance of the branches chosen for study in the industrial sector and the national economy.

(c) Outline of the historical evolution of the sectors chosen for study.

(d) Classification of enterprises according to the origin of capital, and to whether they are state, privately owned or mixed enterprises, cooperatives, self-managed organizations, etc.

(e) Main sources of financing for industrial development, particularly in the sectors chosen for study. Structure of the system for capital accumulation and its influence on industrial growth.

(f) Brief outline of the sources of technology used in the sectors chosen for study.

8. Description of the science and technology system.

(a) Human resources. The higher education system, number of students in technical professions, appraisal of the quality of students and teachers, evolution of the student population in defferent technical fields, importance of the education abroad, relation of the subjects to study to national needs, attitudes and motivations of foreign trained graduates, etc.

(b) Use of highly qualified personnel. Employment of graduates, distribution of professionals in industry, government and science, wage and salary structures, career possibilities, importance of part-time employment for scientists, etc.

(d) Financial resources for science and technology. Gross expenditure in science and technology for the whole country, percentage of the GNP in comparison with other countries, expenditures in science and technology services. Main sources of funds (government, university,

private, foreign, etc). Uses of the funds according to capital and current expenditures; breakdown of current expenditures into basic research, applied research, development, and other science and technology activities; breakdown of current expenditures by main fields of application, etc.

(d) Main issues on technology transfer. Expenditures in technology transfer and their relation to total research and development expenditures, distribution by main branches of industry, importance of multinational corporations, importance of licencing agreements and of the import of capital goods, technical assistance from other countries and from international organizations, etc.

(e) Installed capacity for science and technology. Basic data and brief description of institutions that perform research and development, human resources, funds physical assets, etc, related to research organizations. Use of the installed capacity in research and development.

(f) The environment for science. Support received by researchers, financial problems, administrative and burocratic problems, structure and cohesion of the national scientific community and the international science system, social recognition, prestige, and status of researchers. Recognition of the value of research by government, industries, and various social groups, outline of the image of science and of scientists.

(g) Linkages between the science system and society. Survey of extension activities, analysis of engineering design groups, contacts between the scientific institutions and the users of their work, popularization of science, etc.

(h) Importance of scientific and technological activities in the government and productive sectors. Level of conciousness attained by industry as regard the importance of research and development. Performance of science and technology activities by industrial enterprises and by governmental agencies.

(i) Organization of science policy. Decision making in science and technology matters, brief description of national research councils, universities, ministries,

and other public agencies. Participation of scientists and of users of research results in the policy making process.

9. Key issues in science and technology development. Problem areas of importance in the development of science and technology (e.g. transfer of technology, productivity of research institutions, relation of research and development to the planning process, interaction between technology and employment, participation of industry in research and development, etc.). Critical evaluation of the role of science and technology in the development of the country, and relevance of the key issues singled out.

10. Main obstacles for the efficient functioning of the science and technology system and its contribution to development. Policies and objectives for science and technology that can be derived from these.

ANNEXES.

A. Statistical summary regarding the structure of the economy, of industry, and of the branches chosen for study, quantitative description of the science and technology system, human resources, etc.

B. Principal legal dispositions regarding the functioning and operation of the science and technology system, as well as the organization of structure for science and technology policy making and planning.

V. GUIDELINES FOR PHASE 2

Phase 2 is concerned with the identification and description of the three main sources of influence -- explicit S&T policies and their instruments, implicit policies that have implications and side effects on S&T variables, and contextual factors -- which condition and limit the effects of the first two sources on the S&T variables.

The identification should take into account the spectrum of sources of influence that affect S&T in the industrial sector, and pinpoint the key sources of influence that may later on be studied in more detail, considering particularly the branches selected for study by the country teams.

The study should attempt to identify the principal policies and their instruments which act today upon S&T (historical studies, such as those being done in consultant studies for China and Japan, may also be made but in much less depth). It should not be difficult, in principle, to do this in a less developed country where science and technology policy is not too elaborate as yet.

Description should follow the pattern indicated in Section II of these Guidelines. National teams may also find examples in the feasibility studies prepared by the Peruvian and Argentinian teams and presented at the Barbados meeting.

Some countries may wish to carry the research a few steps further, by studying the effects of those key sources of influence on S&T at the general level of industry. The next sections describe the methodological steps that are recommended for carrying out the exercise. This description may also be valid for that part of research in Phases 3 and 4 that deals with top-down studies.

1. Study of the Effects of Sources of Influence on S&T Variables

We refer to the conceptual framework in part II of the present guidelines, and in particular to the matrix shown in Figure 1.1. The purpose of the exercise is to use the top-down approach in the research, from source of influence to S&T variable. This is to be done by formulating hypotheses about the effects that the sources of influence (independent variables) provoke on the S&T functions and activities (dependent variables). To do this we should enter the matrix from the left, by identifying and describing the main independent varia-

bles that may be expected a priori to produce effects (here the results of Phase 1 will be useful) and the dependent variables each of the former may affect. Hypotheses may then be formulated about such effects. Obviously, not all the subdivisions of the matrix need have an hypotheses tacked on to it.

Such hypotheses may be formulated at two levels:

(a) at a general level, that is, for the whole of industry, and the activities in the science system and the linkage area of direct relevance to industry; however, some of the participating countries may also wish to cover other areas of economic activity, such as agriculture or mining and other parts, or the totality, of activities in the science system proper and the linkage area;

(b) at the specific level of each of the industrial sectors chosen for special study, and of the activities of the science system proper and the linkage area of direct relevance to those sectors. Many of the hypotheses in these sets will be particular cases of the hypotheses set in (a) at the general level, but it is to be hoped that a greater degree of precision may be attained in their formulation than in the former case, since they are to be subjected to careful empirical testing in Phases 3 and 4.

Hypotheses should refer to the sign and magnitude of the effect, and in the case where the independent variable is an explicit S&T policy instrument, also to the effectiveness of the latter. They should attempt at quantification whenever possible.

Hypotheses under (a) may now be subjected to scrutiny, by collecting and appraising evidence from various sources, including opinions, that may give them support or corroboration. This may allow a screening in order to retain those hypotheses that seem more plausible.

The results of this screening will produce a body of hypotheses about the effects on science and technology of explicit and implicit S&T policy and instruments, and of contextual factors. An examination will undoubtedly show many conflicts and contradictions, which are an important outcome of the exercise. Since an idea exists about sign and magnitude of the effects, it is now possible to construct what may be termed a "resultant" S&T policy that will compound the

effects under each of the main subdivisions of the S&T set of functions and activities. This resultant policy may be expressed in the form of a new set of hypotheses, and these in their turn may be summarized into a limited number of statements that may be of great use for policy makers. Such general statements, and the set of hypotheses that make up the resultant policy, may be later checked with the results of phases 3 and 4, as well as with other information that may come up during further research work.

Finally, the resultant S&T policy may be examined as regards its effect on social and economic development, by spelling out its implications for the latter. Such an exercise should probably be left for the end of the project, once the results in phases 3 and 4 are on hand. The usefulness of this is obvious, since it would then be ideally possible to carry out a veritable planning exercise that would start from development objectives and trace back cause-effect relationships to arrive at the explicit S&T policies and instruments, and the modifications to implicit S&T policies and instruments, that would be required in terms of these objectives, taking into account contextual factors, institutional settings, etc.

Having described the general outline of research, we shall now examine in more detail each step.

2. Effects of Policy Variables and Contextual Factors on Dependent Variables.

This task looks deceptively simple on being outlined. Having identified and described the various sources that a priori may have effects on science and technology variables, the question is to trace such effects and put forth postulates and hypotheses relating to them. For instance, we may take an explicit policy that puts a heavy tax on the import of certain capital goods, with the purpose of developing local production in some high-technology items. We would trace through the way this policy is implemented, i.e., describe its instrument (or instrument cluster) according to the outline we have suggested; identify the dependent variables on which it will act (say, the selection of sources of capital equipment for the branches of industry using them), and make hypothetical statements about the sign and magnitude of the effect, and about the effectiveness of the instrument. Such hypotheses may be made at the general level of the whole industry, and for each of the branches which have been

selected for detailed study; in the latter case one would attempt a higher degree of precision.

Even in this apparently simple example many problems may soon be observed, because a complex chain of effects is set in motion when the instrument acts. One way of looking at it is to say that on raising the value of certain inputs, management decisions in the productive units will be affected so that there will be a shift (how big? how quick?) from foreign imports to domestic production. This will, in time, have several repercussions:

(a) In the short run, the rise in price may cause the firm to lean towards less capital-intensity of their investments. Or the firm may look forward to a raise in the prices of its products, on account of both higher price and less efficiency of national equipment. Such types of behavior have impact upon end variables of economic development (employment and rate of inflation in this case).

(b) Suppose that local manufacturing is not well developed as yet for this particular type of equipment. The firm cannot any longer just order from a catalogue from an overseas supplier whose costs and quality are familiar and trusted. One may hypothesize that the firm's technical staff will have to take up responsibilities about setting up technical specifications for would-be local suppliers of equipment; moreover, it will have to locate such suppliers, help them with their technical production problems, follow up their work, make a control of the quality of deliveries. This would be a likely effect if certain other conditions obtain, such as a forward looking management, certain minimum technical capacity to start from, a firm which is not small, etc. If such favourable conditions (which belong to the firm itself) do not obtain, the replacement of foreign equipment by national equipment may mean a penalty for the firm in terms of cost and quality, save if action is taken by an outside institution.

(c) There are evident repercussions of the firms' behavior upon the local producers of equipment, which would have a higher demand for their products. This in turn may push the latter to make technological improvements, particularly if help is provided by the client firms and/or by other institutions.

(d) Local producers may make a demand to the scientific and technical system for knowledge to help them meet the users' technical requirements; or they may look for foreign technologies through licensing.

(e) The existence of a tariff barrier may make it profitable for foreign capital to install a local subsidiary for the local manufacture of the equipment. The implications of this course of action should in turn be considered.

Hence, the full effects of this policy are not easy to trace. There will be a first-order effect, or direct impact, upon one easily identified function or activity, as well as high-order effects within and without the firm that take place over time. On studying a recent measure many of these effects have not yet had time to manifest themselves and we would then more properly speak about "implications". But even in the case of long-standing measures, it is not simple to trace through the network of effects.

The analyst, having made an effort at identifying the network of effects, may then summarize his belief of what happens (or may happen) in the form of a hypothetical statement, which in our example may be thus: "This policy intended to provoke local manufacture of equipment X. We hypothesize the following effects: state firms will on the whole continue to import the equipment since state decision makers have a tendency to total safety in their investments*; private firms of local and foreign capital will tend to buy locally but only in a few cases will they act upon the suppliers to make them produce better equipment, suppliers cannot expect help from the science and technology system since there is little capacity related to the manufacture of this type of equipment*; suppliers will tend to buy licences abroad; one or two foreign manufacturers may set up shop in the country, through new investment, purchase of a local firm or a joint venture with

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* Note that the constraint put by a contextual factor is clearly identified.

it, the final effects upon macro economic and social variables will be such and such. As to the effectiveness of the instrument, it may be said that it has attained its purpose of local manufacturing at not too much direct cost (in handling the instrument) but that if all the effects are considered, it is not clear whether the measure by itself has been a good one". Once he has verified this proposition the analyst might recommend: "Measures of this sort should in the future be adopted only after a careful study of their implications, and concurrent measures should also be taken to assure its best social impact, such as a scheme to help technically and financially equipment manufacturers with their technological improvement, and a stiff control of investment decisions by state enterprises that will make them purchase the local product". The analyst is now speaking really about an ideal "function-oriented" cluster of instruments to act upon the S&T variable.

It should be noted that to spell out such a hypothesis the analyst must have a good knowledge of how the economic system in the country actually works, of how firms are bound to react (which depends on numerous factors and variables specific to the firm), of how the science and technology system and the linkage area function, of what constraints are put by the context. The research undertaken under Phase 1 will therefore be of great relevance to national temas when working in this part of Phase 2.

Some types of hypothetical statements, obtained through deduction, may be accepted as they stand without the need for empirical testing. These we may call "conclusions". Other types, which stem from deductive and inductive reasoning, are in need of verification and may be considered as "hypotheses".*

However, the testing of the latter type of statements may have varying degrees of conclusiveness. At one extreme we have what we may call "hypotheses about implications", which refer to policies that have not yet been in operation, or have been operating only for a short period; here there

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* Recall the analysis of implicit policies in section 3.2 of part II.

are no actual effects to be looked at, and it is only possible to corroborate the hypotheses by asking persons and institutions that may be affected by them about how they are bound to react. This corroboration based on opinions and anticipated reactions we may term "weak". At the other extreme we may have "hypotheses about actual effects" which may be verified by analyzing actual behavior, leading to a "strong" corroboration. Intermediate situations may give rise to weaker or stronger corroboration. Of course, it may be impossible to verify certain hypotheses about actual effects if it is not possible to gain access to data about actual behavior, here perhaps some weak corroboration may be looked for through opinions or the examination of secondary sources.

We have referred up to now to explicit policies and their instruments, but the implications and side effects of implicit policies may be treated in a similar manner and give rise to conclusions and hypotheses of similar nature.*

In the case of contextual factors, we may also put forth hypotheses about the constraints and limitations they place on the effects of policy variables, either directly, or through their influence on institutional structures. However, it seems unlikely that any strong corroboration may take place by analyzing actual influences, since by definition a contextual factor cannot be changed in the short or medium run. Contextual influences "are there", so to say; they do not suffer rapid changes that would easily uncover their effects. Two ways of "weak" corroboration seem open. The first one is taking a historical perspective, looking many years back to see how slow changes in a certain contextual factor has influenced the effects on certain S&T variables. History, historians are fond of saying, has its uses for the future. The problem is that most of the countries in STPI have a very short history in science and technology, and perhaps the time span will not be enough to throw sufficient

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*The report "Technology policy implicit in the industrial development plan, the General Law of Industries and the General Law of Mining in Peru", contains a number of examples of conclusions and hypotheses (about implications mainly) that have come out of the analysis of government policies in Peru, and may be helpful in guiding the work of the country teams.

light about the effects on it of slow changes in contextual factors. The second way is to rely on opinions about possible reactions to hypothetical questions like: "would university scientists be more interested in working in national problems if they were to take their advanced degrees at home and not abroad?" Such questions, not easy to phrase, would naturally follow from the hypotheses which have been formulated.

However, one of the advantages of a comparative project like STPI is that we may put forth hypotheses to be tested cross-section among countries, since differences in contextual factors will be found between the participating countries. Hence, from the various outcomes of the national reports, to be obtained after Phase IV, a number of central questions about the influence of contextual factors on science and technology may be put to the test in Phase 5. Hopefully, the corroboration may be "strong" for some of those questions. On the other hand, the experience of China (to be studied by a consultant) will be of great value at this stage, since it may show what can happen when a country willfully decides to change rapidly what other countries consider as contextual factors not amenable to rapid change.

Let us now refer to the various sets of hypotheses that should be generated. We have already stated that for each source of influence conclusions and hypotheses should be formulated about their effects upon S&T variables under the three headings of demand side, supply side and linkage area. Such hypotheses, as we have endeavoured to show, will only rarely be simple and unidirectional, nor easily amenable to quantification; they will tend to be complex statements of cause-to-effects. We are not interested in having an exhaustive set of hypotheses that cover all causes and all effects, nor is it possible tothink of such a comprehensive set. The aim should be to cover the principal sources of influence, and for each, the principal effects or implications. On the other hand, once research is under way, the interchange of information between national teams, primarily through the Field Coordinator's Office, may lead to formulate hypotheses about the actions of similar sources upon similar variables. This would indeed be a very desirable thing, since it would heighten the value of the comparison exercise to be undertaken in Phase 5.

3. Corroboration of General Level Hypotheses

At this stage we should have a description of how the principal explicit policies, implicit policies and contextual factors act on S&T variables, together with a set of hypotheses at general and specific levels, about sign and magnitude of the effects, and about the effectiveness of instruments in the case of explicit policy.

The general hypotheses should now be subjected to corroboration, as far as this is possible with the help of existing data, opinions, and other elements. We suggest that this be done at this time for two reasons. One is the intrinsec value of finding out how valid the hypotheses are, and the second because the exercise will allow a much better planning of activities in Phases III and IV, particularly in what regards the preparation of checklists, questionnaires, nad other methodological instruments. It may also be said that this general type of corroboration may allow to reformulate more carefully the specific hypotheses to be tested at the micro level.

Let us now see how this scrutiny and verification may take place. The research team, on preparing the analysis of effects and formulating hypotheses, will already have amassed a certain body of evidence in their favor. But it is now a question of casting the net wider, of collecting published information and approaching people and institutions with questions framed as precisely as possible. Though we can hardly suggest a set procedure for this stage, we may refer to a promising technique: to set up panels of knowledgeable persons to whom these questions are put, so that they may be able to give their opinion about the validity of most of the hypotheses. This panel would also be important in bringing to the attention of the team various types of recent information that may be of help.

Once this is done, the team may screen the hypotheses and retain those that seem more plausible, leaving the corroboration of more precise and detailed hypotheses for Phases 3 and 4.

4. Resultant S&T Policy

The results of the previous steps will have produced a body of hypotheses, to which high plausibility may be attached, about the effects on S&T of explicit and implicit S&T policy and instruments, and of contextual factors.

An examination will undoubtedly show various conflicts and contradictions, which are an important outcome of the exercise. Since an idea exists about sign and magnitude of the effects, it is now possible to construct what may be termed as a "resultant" S&T policy that will compound the effects of all the sources of influence.

To give an example, we reproduce a table about the impact of the economic system and government economic policies on the S&T system in Latin America. Most of the characteristics shown in this table would seem to have a negative impact on the development of domestic technological capabilities. The resultant policy might be expressed as follows:

> Domestic scientific and technical capabilities do not need to be developed beyond a certain minimum. The greater part of technological knowledge to be employed in productive activities should be imported, especially from the countries where technology is most advanced, even if this implies higher cost. Therefore, only the strictly necessary S&T activities to support such productive activities, particularly those of a routine nature which do not imply research, will be undertaken domestically.
>
> The larger enterprises, particularly those associated with foreign firms, are the only ones that should use S&T inputs intensively. All other enterprises would be better off using traditional production methods, even if they are obsolete, and should not try to introduce S&T research.
>
> Enterprises should be protected from foreign competition and guarantees should be given them that they will yield benefits. It is irrelevant whether they employ or not technologies which are adequate to local conditions; what matters is to stimulate entrepreneurial activity.
>
> The production of goods and services should be oriented towards the satisfaction of the demand from the higher income brackets, to which the production of the most dynamic industrial branches with high scientific content is directed.

TABLE V.1

SOME CHARACTERISTICS OF THE ECONOMIC SYSTEM AND OF GOVERNMENT-ECONOMIC POLICIES IN LATIN AMERICA AND THEIR IMPACT ON THE SCIENTIFIC AND TECHNOLOGICAL SYSTEM

Characteristics of the Economic System and of Government Economic Policies	Implicit Impact of the Scientific and Technological System
Characteristics of the Economic System	
- Technological dualism (a few advanced firms coexisting with a large number of backward ones)	- Only a small number of firms are capable of absorbing modern technology and hence potential users of the knowledge generated by scientific and technological activities. These generally connected with foreign corporations.
- Underutilization of existing capacity (excesive capital investment)	- No need for doing production research to increase level of output, production can be easily expanded.
- Deformed price formation mechanisms (protectionism, oligopolies, myopic price controls).	- Entrepreneurs have no real incentives to reduce costs and operate more efficiently, hence there is little demand for scientific and technological activities.
- Predominance of foreign investment (particularly in key dynamic sectors)	- Need for scientific and technological activities, particularly research and development, are satisfied from abroad. Only routine activities are performed locally.
- Gross inequalities in the distribution of income	- Industrial activities are oriented towards producing goods for a small segment of the population with high income. Technologies are geared to producing a large variety of goods for this population segment and imported for this purpose.

TABLE 5.1 - Continued

Characteristics of the Economic System	
- Conservatism of local entrepreneurs	- Distrust for local scientific and technological capabilities, preference for well known and proved technologies (generally foreign). Risk capital for new and advanced technologies are not available.
- High rates of inflation	- Long-term capital-intensive investments are preferred, particularly when funds are borrowed from state sources.
- Lack of viable technological alternatives	- Unsuitable technologies developed elsewhere are imported and used in a different context.
Characteristics of Government Policies	
- Credit policies biased towards capital equipment, particularly when foreign aid and credit are involved	- Capital-intensive technologies are preferred over capital-saving or labor-using technologies.
- Fiscal incentives geared towards promoting additional capital investments (tax credits, tax exemptions, etc.)	- Investment in equipment becomes more attractive than investment in working capital to enlarge the labor force.
- Social policies which make labor expensive (social security, unemployment funds, medical benefits, etc)	- Demand for capital equipment, machinery and even intermediate products is oriented outwards, particularly towards developed countries.
- Overvaluation of exchange rates (making imports cheaper)	- Importing foreign machinery and equipment becomes attractive.
- Tariff barriers and protectionist measures are taken as part of an import substitution industrialization strategy	- Indiscriminate protection makes inefficiency profitable and reduces effective demand for scientific and technological activities.

> Capital intensive production techniques should be preferred over labour intensive techniques. Incentives must be given to entrepreneurs for strong investment in machinery and equipment, even though they should not be fully utilized. Machinery and equipment should be imported whenever possible and therefore there is no need to promote the development of labour intensive techniques adapted to local conditions through S&T research.

Perhaps no government official would accept that this represents the policy of his government. And he may point out to certain policies that would seem to correct the set. In Peru, for instance, the Development Plan 1971-75 has a chapter on technological policy with various statements which would attempt to redress the situation. In this specific case the explicit policy of the Peruvian government shows contradictions with the implicit technological policy derived from its economic structure and from the characteristics of some government policies (for instance, explicit policy desires to develop labour intensive technologies but there is an implicit obstacle to this possibility). The exercise of contrasting explicit and implicit policies cannot be resolved exactly, nor is it possible to reach deterministic conclusions. The implications of many implicit policies are derived through deductive reasoning and are not easy to verify empirically. In a similar way, it is difficult to know what the real effect would be of explicit policies which some times are not implemented properly, or just remain on paper.

On account of these difficulties it is proposed that the resultant policy should be expressed in the form of a new set of hypotheses which themselves may be subjected to corroboration - as far as this is possible - through the same procedure of panel discussion we have referred to above. From such an examination it may now be possible to summarize the resultant policy into a limited number of statements which may prove of great utility to policy makers.

Such a summarized resultant policy, which has been obtained through work at a general level, may be checked later with the results of Phases 3 and 4, as well as with other information that may come out during further research work.