Towards a new approach
for scientific and technological planning

1. Introduction

This essay proposes a theoretical basis and suggests guidelines for scientific and technological planning in underdeveloped countries, particularly those of Latin America. The paper is based on a report prepared by the author at the University of Pennsylvania and presented to the Department of Scientific Affairs of the Organization of American States (Segasti, 1972). The ideas and concepts put forward are derived from a critical appraisal of current planning methods, from a conceptual model of the nation as a system, from an analysis of the Latin American situation in science and technology, and from recent developments in planning theory. The second section is devoted to an examination of the concept of planning, the third defines the principles on which to base a planning methodology for science and technology, the fourth proposes a framework consisting of five categories to group planning decisions, and the fifth contains a summary.

2. The concept of planning used in the essay

In the broadest sense, planning is anticipatory decision making. It consists in exerting choices in situations which have not yet occurred but which are perceived to occur, which are interrelated and interdependent, and which are not known with certainty. Planning is essentially rationalist and interventionist in its approach. It implies that by making commitments in advance and by taking action as present it will be possible to influence future events. Planning seeks to control these future events to a greater degree, to orient them in the appropriate direction in order to obtain desired results, and to foresee their possible consequences.

Planning, and the anticipatory decisions that constitute it, are primarily concerned with the generation, identification and evaluation of alternatives.
Policy-making can be distinguished from planning because it involves establishing criteria for generating, identifying and choosing among alternatives. Therefore, planning can be defined as the collection of activities which, taking the principles and criteria established by policy-making, generate, identify, and select among alternatives through a process of anticipatory decision making. Thus policy-making can be considered as the part of the planning process whose task is to set principles and criteria for anticipatory decision making.

A planning methodology refers to the procedures followed in arriving at the commitments made in advance by the planner, and to the way in which actual decisions are made. The anticipatory decisions included within the scope of planning are concerned with the structure and functioning of the system to which planning is addressed and also with changes in its environment. A plan consists of statements spelling out the anticipatory decisions taken, their interrelations, and the criteria employed in making them.

Traditional or orthodox planning has usually been concerned with the allocation of resources and the definition of activities to be performed by the system, particularly in the short and medium terms. Conventional approaches to planning generally take the institutional infrastructure and the environment of the system as fixed continuities which are not acted upon. They also leave aside the long-range problems of designing desired futures for the system, or treat them by extrapolating short and medium-term planning methods.

The conventional approach to planning puts great emphasis on the preparation of plans, which become the "final product" of planning. Plans are considered as collections of statements describing and justifying a series of activities to be carried out during a fixed period, and to which resources are allocated. This view of planning suffers from several deficiencies.

First, by focusing efforts on the preparation of a plan, producing documents becomes the central concern of planners. The documents are usually obsolete by the time they are published, discussed, and approved; however, after that, they are often used to impose a life of their own, in spite of their inadequacies. The rapid tempo of change prevailing in underdeveloped countries makes this approach to planning self-defeating.

Second, the importance attached to the preparation of a set of documents separates the functions of plan preparation and plan implementation almost completely. The planners' task becomes that of generating documents which are then to be implemented according to their implementation.

Third, planning tasks are defined on the basis of a fixed period, the time horizon of the plan, which becomes a fundamental category of analysis. Different types of planning decisions, which generally involve different time horizons, are forced into the same time frame ("five year" plans for example), and planning decisions become fixed parameters to be reviewed only at the time of preparing the next "plan." The failure of economic development planning in Latin America (Inter-American Economic and Social Council, 1965) during the 1960s can be attributed in part to this conventional view of planning which emphasizes the plan as a collection of documents.

The approach adopted here considers that the value of planning does not lie in the generation of plans as such, but in the process of producing them. The main benefit that decision-makers obtain from planning derive from their participation in the planning process, and not from the use they may give to the documents describing the plan. The learning process that takes place during the preparation of the plan becomes far more important than the plan itself.

In the view of planning adopted here, the "time horizon" becomes a flexible concept. Anticipatory decisions are not referred to a rigid and pre-defined time frame; different types of decision have different time horizons. These anticipatory decisions are continuously in the making; they are reviewed and revised whenever it becomes necessary to do so. Therefore, rather than using rigid time intervals (expressed in years, months or weeks) for differentiating between long, medium and short-range planning, I shall define the long-range as that time horizon beyond which the present existing situation does not condition to any significant extent the behavior of the system. The short-range would be defined as the time horizon for which the present situation and the dynamics that led to it determine the behavior of the system to a large extent. The medium-range would be defined as the time horizon for which present conditions have a significant influence on the behavior of the system, but do not determine it.

Orbeck's conceptualization of planning (Orbeck, 1969) is also closely related to the one used in this research:

"Planning is... a form-oriented decision continuum that can be visualized as a three-level structure set as a multiphase process. The structure is made up of different hypotheses of decisions. The process consists of various functional relations that go into a complex network of action flows and control mechanisms." (p. 116)

Although I shall propose a different typology of decisions than the one Orbeck develops, the similarities between the two approaches to planning outweigh the differences. Furthermore, Orbeck's (1969) concept of "willed future" and Ackoff's (1971) concept of the "ideal system," shaped only by stylistic constraints, provide the main theoretical basis for the category of stylistic planning.

The present approach to scientific and technological planning is also conditioned by, and coincides with, that of Emery (1967) and Emery and Trist (1965). Their typology of organizational environments and their description of the fourth type, that of turbulent fields, provide a way of conceptualizing interactions among systems which helped in clarifying the concept of contextual planning. The work of French and Jones (1960), being closely related to that of Emery and Trist, also proved useful in this respect.

1. Of course the lack of a real political will to make planning work was perhaps the most important factor in this failure.
The approach to planning taken in this work is also derived from earlier work done by the author in the field of scientific and technological planning (Sagasti, 1970a; 1980), where the characteristics of an idealized planning methodology were suggested and their implications examined. These led to some of the principles to be discussed in the following sections. Some of the abstract and theoretical issues related to this planning approach are also discussed in other papers (Sagasti, 1971a; 1971b).

In short, the work of Ackoff (1966; 1968; 1970; 1971), Emery (1967), Orbe- khan (1969; 1971), Box (1966), Emery and Trist (1965), Fried and Jensen (1969), and also that of Friedmann (1967), Harris (1970), and Vickers (1965), provided the elements for organizing the theoretical basis of my approach to planning. The background on planning theory, combined with the critique of current methods for scientific and technological planning (Sagasti, 1970b), with the conceptual model of the raise as a system (Sagasti, 1970b) and the analysis of the Latin American situation (Sagasti, 1972) led to the framework and the methods for scientific and technological planning which will be discussed in the following sections.

3. Principles for scientific and technological planning in underdeveloped countries

Five principles for scientific and technological planning in underdeveloped countries have been identified. Each will be listed and discussed in turn. These principles are derived primarily from the work of Ackoff (1971) and Waldo (1969), and they have been examined in the light of the empirical context of the Latin American situation in science and technology.

1) Planning for the development of science and technology should be continuous

Planning is a process consisting of decisions made in a set of interrelated and anticipated choice situations. The anticipatory decisions should be modified in the light of new information and unexpected changes in the system and its environment. In consequence, planning has no natural beginning or end point. The planning process is a on-going process. While the planning procedure, other than the main justification for it. This implies that all types of anticipatory decisions will be continuously in the making, conditioning each other and interacting in a continuous fashion. It is not possible to stipulate a rigid sequence of the type of planning activity proceeds the others in a rigid sequential way, they should all take place simultaneously with anticipatory decisions made in one area feeding information into the others.

2) Planning for scientific and technological development should be participative

Effective planning cannot be done for a system or organization, it has to be carried out with it. This principle suggests that the involvement of the scientific community, the users of research, the government, and those engaged in systems related to the scientific and technological area is critical for success in planning. The scientific community in particular is primarily interested in maintaining freedom of research and usually resists interventionist measures. Therefore, efforts should be made to incorporate in the planning process the largest possible number of scientists, professionals, and technicians. This principle also postulates that extensively centralized planning procedures which would attempt to define in detail desired futures, institutional structures, patterns of interaction with other systems, activities to be carried out and the allocation of resources, would not be effective. The planning methodology should establish a proper balance between central guidance and individual initiative. Underdeveloped countries lack the governmental machinery to perform these planning tasks in a centralized fashion; even if they had it, such an approach would succeed, but probably at the cost of threatening the freedom and independence which are required for creativity in science and technology.

However, this does not imply an abandonment of planning. The principle of participative planning seeks to establish a balance between the approach which is limited to gathering and coordinating individual initiatives, and that which attempts to control in detail the behaviour of the scientific and technological system. Given the relatively low level of developers - the institutions performing scientific and technological activities in underdeveloped countries this principle would encourage institutional development. It would provide guidance and general direction, while at the same time promoting individual initiative within an established frame of reference.

3) Planning for scientific and technological development should be integrated with other planning activities

This principle refers to the need for integrating scientific and technological planning with other planning activities within the nation. This requires broadening the perspective of the planning process by including the system's environment, formed by the other systems that are interrelated with it, within the scope of the planning efforts. In particular, an analysis of the Latin American situation pointed out the need for integrating economic planning, educational planning, and scientific and technological planning in order to resolve the divergences between individual and collective rationality and the contradictions that are highlighted in Sagasti (1972, chap. 4 and 6).

4) Planning for scientific and technological development should be coordinated and internally coherent

The scientific and technological system is formed by organizational units at different levels performing different functions. These units generate
plans which need to be coordinated and made compatible with each other. This principle puts emphasis on designing the appropriate institutional infrastructur e and defining the channels of communications among the organizations involved in planning, in such a way that the planning process would become capable of responding to the needs of the different units in the system. Coor dinated planning is therefore concerned with attaining coherence within the system by making compatible the plans of individual units at the same and different levels.

3) Planning for the development of science and technology should be experimental and adaptive.

Relatively little is known about the factors and conditions affecting the behavior and performance of the scientific and technological system, particularly in underdeveloped countries. Therefore, planning for the development of science and technology will be unavoidably experimental and steps should be taken to allow interpretation of the anticipatory and actual decisions to be made within an experimental design framework.

In addition to the uncertainties arising from the lack of knowledge about the behavior of the scientific and technological system and its constitutive units, there are the uncertainties associated with changes in the system and its environment. These uncertainties regarding the future choice situations to which anticipatory decisions refer, require that the planning process be flexible and adaptable in order to respond to new developments in the system and/or its environment. In short, the planning process should be experimental, flexible, and adaptive. The planning methods associated with it should be capable of making planning a cumulative learning process.

A final remark on principles for scientific and technological planning in underdeveloped countries (refers to the need for avoiding rigidity in planning methods. A methodology for planning science and technology should be applicable under a variety of circumstances that may change continuously. Hence the importance of providing a frame of reference within which planning procedures, methods, and models could be placed as they are modified and augmented in order to conform to evolving situations.

4. The categories of anticipatory decisions involved in scientific and technological planning.

As long as anticipatory decisions are the building blocks of planning, the development of planning methods should consider explicitly the different types of anticipatory decisions that have to be made, for three may require different types of planning procedures. Five general categories of decisions can be identified in the process of planning for scientific and technological development: first, the definition of long-term ideals and the desired future image of the system; second, decisions regarding the pattern of interactions with related systems and their decision areas; third, decisions about the institutional infrastructure of the system; fourth, determining the scope and nature of the activities to be performed by the system; and fifth, decisions on the allocation of all types of resources. These five anticipatory decision categories are the domain of stylistic, contextual, institutional, activity, and resource planning respectively.

The interactions among these categories of decisions can be summarized by saying that resources are allocated to activities through mechanisms, taking into account the context in order to approach the desired future.

However, even if a conceptual and operational separation of these five types of planning activities is possible, it must be emphasized that they are not independent and that they cannot be dealt with separately and individually. A planning methodology which would simultaneously identify the combination of activities, the institutional structure, and the allocation of resources that optimize the performance of the system making it approach an ideal is what planners would like to have at their disposal. Unfortunately, it is rather unlikely that such a methodology could be developed in the near future, and the most viable alternative appears to be the development of iterative planning procedures which would take each category of decisions in turn, defining a provisional plan to be revised once anticipatory decisions have been made in the other areas.

The five categories for scientific and technological planning can be regarded as a framework within which to order the tasks involved in planning for scientific and technological development. Current planning methods refer only to the categories of activity and resource planning; there are no methods specifically designed for anticipatory decision making in any of the three other categories. An analysis of the Latin American situation (Sagami, 1972) shows that the context and institutional categories are of particular importance for science and technology, and recent developments in planning theory (cf. Ackoff, 1971; Cederbaum, 1969) suggest that the category of stylistic planning is of fundamental importance orienting planning activities as a whole.

The different characteristics of anticipatory decisions in each of the five categories impose the need for developing different planning paradigms, conceived as the collection of points of view, basis of thought, methods, and models, for the five different categories of planning activities. Planning concepts, procedures, and methods which are appropriate for one planning category cannot be expected to be equally appropriate and applicable for any of the other categories which differ in almost every respect. For example, resource planning procedures and the resource perspective of planning cannot be applied effectively for institutional, contextual, and stylistic planning. The particular problems of resource distribution and allocation have little in
common with those of institutional building, those of coordinating plans and policies, and those of designing the ideal desired future. Hence, it becomes necessary to discard old thinking habits when moving from one category of planning to another. These remarks can be put forward in the form of an additional principle: Planning for scientific and technological development should consider the different categories of planning activities that have to be made and develop methods appropriate for each.

The different characteristics of the five types of anticipatory decisions described above, suggest that they may fall within the domain of different planning organizations. Assuming the existence of a central agency to charge of scientific and technological planning, stylic planning would then be performed by the planning agency and the interest groups which are in some way or another affected by the anticipatory decisions to be taken. Centrally planning would be a task to be performed by the planning agency in conjunction with planning agencies in other related systems. Institutional, activity, and resource planning could be carried out by the planning agency and the other institutions and organizations, using within the boundaries of the scientific and technological system.

The relationship between the different categories of planning and the three time dimensions of long, medium, and short-range planning can be outlined as follows: stylic planning is essentially a long-range planning activity, and the dimensions of medium and short-range are not relevant to it. Contextual, institutional, and activity planning are seen to be primarily medium-range planning activities, although the identification of ideal processes of interaction, institutional structures, and patterns of activities would be included within stylistic planning and hence become part of a long-range planning exercise. The discussion of short-term planning appears to be less important for these three planning categories. Finally, resource planning involves the three time dimensions considered, although it is primarily oriented to short-range planning. Occasionally long-term and short-term resource commitments have to be made, but by large resource planning is concerned with short-range considerations through the budgetary process. Summarizing, we may say that the short-range is the dominant time dimension for resource planning, that the medium-range is the dominant time dimension for activity, institutional, and contextual planning, and that the long-range is the dominant time dimension for stylistic planning.

The main characteristics of the five types of planning activities are summarized in Table 1. The codifying factors, the areas where emphasis is placed, the type of process and the participants involved, the organizations responsible for carrying them and the dominant time horizon, are specified for each of the five type of categories of planning activities.

It is also possible to relate the five principles for scientific and technological planning identified in the preceding section with the five planning categories of stylistic, contextual, institutional, activity, and resource planning. The

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- **Stylistic:** Long-term, involves the identification of ideal processes of interaction, institutional structures, and patterns of activities.
- **Contextual:** Medium-term, involves the determination of the ideal processes of interaction, institutional structures, and patterns of activities.
- **Activity:** Short-term, involves the determination of the ideal processes of interaction, institutional structures, and patterns of activities.
- **Resource:** Long-term, involves the allocation and distribution of resources over the medium and short-term.
five principles apply to the planning process as a whole, and hence to each of the five categories. Table 2 summarizes these relationships.

I shall now describe in further detail the nature and characteristics of the five categories of planning which have been identified and are offered as a framework for scientific and technological planning in underdeveloped countries.

1) Syllactic planning

The general objectives of syllactic planning are to project a desired future image of the scientific and technological system as an ideal to be approached, and to engage the participation of the interest groups affected by planning, exposing their values and preferences in the process. The syllactic plan is turned into an instrument to promote dialogue and participation, rather than being the justification for the planning activity. The main outcome of the process becomes a common view of the future and a perspective shared by those participating in the process, rather than the statements contained in the documents describing the plan.

Trist (1968), commenting on Cropper's analysis of French economic planning, has emphasized that the learning process that takes place during the preparation of a plan is far more important than the plan itself. Recent statements by Carroll (1977) point out that this learning process and the involvement generated by participatory forms of planning, particularly in technological matters, need not to be confused with the immediately intended parties, such as the government and scientist, but also spread to ordinary citizens. Therefore, participation and dialogue with all interested parties to identify the "style" in which the system would evolve, while at the same time initiating a learning process, becomes the main concern of this planning category.

Syllactic planning is an exploratory multiple-loop process conditioned primarily by value structures and preferences, this is what Arkoff (1970) calls "syllactic constraints," it puts emphasis on the specification of alternative futures and the definition of a desired image or a "willed future" (Osbetan, 1969).

The ideal future image of the system to be designed in syllactic planning must include statements on the patterns of interdependence with other related systems. For example, it should specify the possible contributions of science and technology to economic and educational development, and to the use of natural resources. It should also contain a description of the ideal institutional infrastructure for the system, the structure of activities to be performed, and the ideal pattern of resource acquisition and allocation.

The image of the desired future would be put forward in terms of "scenarios" consisting of qualitative statements about the characteristics of the system and its interrelations with the environment at a certain future time. The scenarios would be complemented by proposals respecting the general strategy.
to follow in order to approach the ideal state they describe. The statements presented need not be quantitative or supported by detailed projections, initially they should be impressionistic descriptions of the assembled and technological system as it is. In the interactions of the continuous process of stylistic planning in the future, scenarios would be refined and brought on form quite clearly to take into account possible developments in the system and external circumstances. A good description of the construction and use of scenario formats for suitable stylistic planning is found in Management and Behavioral Science motto. The planning horizon to which stylistic planning refers is the long range, a span of time long enough so that the present situation and its dynamics do not contaminate any significant developments in the future. This situation does not, however, that questions of feasibility and feasibility are completely discarded. The concern for the design of ideal future systems is not a recent one. In addition to traditional utopian thinking (Piatto, St. Augustine, St. Thomas More, etc.), the design of the ideal world has been advocated on the basis of Marxism, socialism, and the democratic and possibly the most coherent early descriptions of the possible use of the ideal scheme for taking action has been given by Kropotkin in 1873 (Kropotkin, 1979). In an essay titled "Must we occupy ourselves with an examination of the ideal of a future system?", he said:

"Believe that we must, in the first place, in the kind of life we can express our hopes, aspirations, and goals, irrespective of practical necessities, in order to achieve the degree of materialization determined by rational means. In the second place, the ideal can serve to guide our thinking. To the extent that we are not blind to the fact that we are not
distinctly to be considered as we are to be described by the political system. In other words, although some thought is without a doubt the inevitable, essential and critical in the context of trying to practice, and the efficiency of the system in the context of the realization of all of the goals of everyday life" (pp. 45-46).

Kropotkin stresses the importance of the imagination as a starting point in order to uncover latent social structures and preferences. In addition, Ackoff and Zerubavel (1980) have emphasized the differences in both Ackoff (1970) and Zerubavel (1980) have emphasized the importance of the mind in the current situation, benefiting from the ability to exercise in utopian thinking. Some benefit from the ability to consider such an exercise in utopian thinking.

Ackoff proposes the construction of scenarios which are bound only by stylistic constraints, and Zerubavel suggests the design of a wilder future. Scenarios address the importance of the mind in current situations, benefiting from the ability to consider such an exercise in utopian thinking. Ackoff proposes the construction of scenarios which are bound only by stylistic constraints, and Zerubavel suggests the design of a wilder future.
within the scope of stylistic planning for science and technology, it may be possible to avoid the pitfalls which are associated with overly simplistic and wishful thinking in the design of a desired future image. For the appendix to stylistic planning for science and technology, it is necessary to distinguish between the immediate, exceptional or task environment and the more general or contextual environment. The task environment consists of all organizations, groups and persons with whom the organization has specific relations, on both the input and output sides, even though it may not be aware of their complete range. The contextual environment, on the other hand, has a more comprehensive understanding of the role of both sectors of environment in society, and is not directly oriented to the world of the organization's core transactions. Events in the contextual environment may in any case be seen as having a direct impact on the organization in the task environment. For this reason, it is necessary to include the contextual environment in the planning process, and to consider the potential influence of the contextual environment on the task environment.

For a system to deal effectively with its environment it is not sufficient to pay attention only to the task environment, which is formed by the organizations, institutions, interest groups, and clients, having direct linkages with the system. It is also necessary to assess the potential influence of the contextual environment, seeking to anticipate changes which may affect the future behavior of the system. For the scientific and technological system, the relations between different components of the system must be considered. The behavior of the system as a whole and its relationship with the environment is determined by the interaction of different components and subsystems. The system must therefore be analyzed in terms of the interactions between these components.

In planning patterns of interaction it may be the case that some aspects of the system and its components need to be considered in a more indirect way. For example, in the process of formulating and implementing plans, the system may be perceived to be a complex economic system, with many components interacting in a non-linear manner. In this case, the system may be perceived to be a complex economic system, with many components interacting in a non-linear manner. In this case, the system may be perceived to be a complex economic system, with many components interacting in a non-linear manner. In this case, the system may be perceived to be a complex economic system, with many components interacting in a non-linear manner. In this case, the system may be perceived to be a complex economic system, with many components interacting in a non-linear manner. In this case, the system may be perceived to be a complex economic system, with many components interacting in a non-linear manner. In this case, the system may be perceived to be a complex economic system, with many components interacting in a non-linear manner.

The characteristics of the environment and of the policies made by the systems it contains, constitute in fact a set of implicit policies for science and technology. Government economic and educational policies, in particular, contain an array of consequences or implicit policies which regulate the behavior of the scientific and technological system in an indirect way. These implicit science and technology policies must be made explicit if planning for scientific and technological development is to be effective. The process of formulating them is likely to involve uncovering contradictions and inconsistencies between overt objectives and policies and their functional capacity to perform the tasks at hand. The process of uncovering implicit policies and exposing contradictions is likely to lead to value conflicts. Contradictory policies are made consistent simply by showing shortcomings and divergencies. These value conflicts must be resolved through coordination or negotiation; extreme cases may even require an open rift in order to determine the values and objectives which will prevail in the conflict. Once these conflicts are exposed in contrast-

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3) Institutional planning

The anticipatory decisions on institutional structure, which are the subject of institutional planning, refer to the organizational network through which activities are to be carried on and resources channeled, and to the rules and regulations which govern the behavior of the different units comprising the institutional infrastructure. Institutional planning is conditioned primarily by organizational constitutions and the possibilities for institutional development; this, in turn, is the organizational ecology of the scientific and technological system. It emphasizes the establishment of organizational and institutional channels and clusters, through a process of structuring and texturing which defines the organizational fabric of the system. The procedures followed in this type of planning activity include institution building and renewal, which refer to the creation and modification of institutions, setting the codes of behavior or "rules of the game," and defining the performance measures for organizations in the scientific and technological system.

The development of an institutional infrastructure for the scientific and technological system is a necessary condition for the development of science and technology in underdeveloped countries. René Mahieu, UNESCO’s Director General, emphasized the importance of the network of institutions in an address to a meeting of Southeast Asian Countries (Mahieu, 1967): "The scientific knowledge exists everywhere: it is this is precisely the secret of their technological pre-existence — that the social and economic benefits derived from oriented and applied research depend on the extent and efficiency of what is known as the country's "organizational network" of scientific and technological research institutions." (p. 10).

This network of institutions is generally well-developed in advanced countries, and therefore they have seldom dealt with it explicitly. Planners in underdeveloped countries take the institutional structures for granted and address themselves to the problems of priorities or resource allocation. The fact that institutional structures are more developed in advanced countries has often led to the belief that underdeveloped countries should follow a strategy of imitation in planning their institutional development. Whyte (1968, p. 371) points out that this has been the case in Peru:

"There is a widespread tendency in Peru to imitate the institutional structure and practices of industrialized nations and to accept the institutions in other countries as standards against which Peruvian institutions are measured. Peruvians are self-conscious of their insufficiency, and we often base meretricious comparisons of output influences and rigorous defense of what is Peruvian. But even those who express themselves in public more optimistically, in private and casual conversation, talk about the inadequacies of Peru and Peru and the need for change in Peruvian institutions in the image of those of another country."

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

A strategy of institutional imitation is likely to fail and should be avoided for the following reasons: first, the context and the environment in which institutions operate in a developed country are widely different from those prevailing in the underdeveloped ones, and there is no guarantee that the institutions will operate efficiently and contribute to national development. Second, if they had the choice, developed countries would probably prefer in many cases to develop a different institutional structure than the ones they presently have, and may have been copied. Third, the particular social and historical conditions of the underdeveloped country may provide with opportunities to develop new institutional patterns which are better suited to local conditions, and which could eventually become a model for other countries, underdeveloped and developed.

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

A well-organized institutional structure, particularly at the national level, cannot be developed from scratch in a short period of time. However inadequate, usually there is a core of institutions (even if they exist only on paper) from which to begin institution building and designing the organizational mesh for the scientific and technological fabric in underdeveloped countries. Institutional planning takes the existing structure as a basis, examines it critically and proposes changes and additions to it. Once proposals are implemented, they should be left to evolve without changing them again too soon. A certain lead time is required for the institutions to stabilize after introducing major modifications, and frequent radical changes may retard the development of the institutional structure.

It is impossible to "optimim" an institutional design in the traditional sense. As far as I am aware, there are no proposed criteria for identifying and generating optimal institutional designs, particularly for the scientific
and technological system in underdeveloped countries. One possible strategy for generating and choosing among alternative institutional designs must be based on a "satisfying" approach (Ackoff, 1970), in which minimal conditions which satisfy the minimal conditions would be left outside the scope of institutional planning. The "satisfying" strategy can be improved by adding a second set of criteria based on the institutional design's capacity for adapting to changes in the system. This would be a "satisfying" system and its environment. The results would be an acceptable performance, and the criteria would be the system's capacity for adaptation. How- ever, conditions which would ensure the system's capacity for adaptation, even if not always possible to define the adaptivity criteria in addition to the minimal set of standards, the institutional design should satisfy. 4) Activity planning Activity planning is concerned with the category of decisions that refer to the scope and nature of the activities to be performed by the system. It is conditioned by the existence and potential adaptations of the system and the dynamics of the processes taking place within its boundaries. Activity planning puts emphasis on the definition of priorities for concentrating activities and also on the evaluation of past performance as a guide for defining these areas. The goal is to define the activities that constitute the operations for the system. This is achieved through a process involving a diagnosis of the existing situation, setting targets and balancing the diagnosis with target-setting. The process is to follow in this type of planning include defining the activity planning, setting the system's and the external environment for the system. The objectives of activity planning are to provide priority and general orientations for the activities performed by the scientific and technological system. The methodology should specify the type of activities to be considered, taking into account the possible contributions to economic and social development. Thus the tasks in activity planning can be divided into two major parts: determination of the activities that should be carried out in the country and specification of the areas in which scientific and technological knowledge will be required from foreign sources.

The philosophy underlying the category of activity planning is that scientific and technological knowledge is practically impossible and even undesirable in the modern world, particularly for the underdeveloped countries of Latin America. The strategy proposed for scientific and technological development is one of selective interdependence with other countries and their scientific and technological systems. This implies that the underdeveloped country will seek to concentrate its scientific and technological efforts in areas for which it already has relatively high competence, or can acquire it in the short-term, and in areas for which knowledge cannot (or should not) be imported. The local scientific community would attempt to transform itself into a world center for those particular areas of scientific and technological knowledge, in which it has decided to concentrate its efforts, trying to compensate the flow of imported knowledge. The selective interdependence strategy thus implies the possibility of the country importing know-how, processing it further and then re-exporting it. Therefore, the selection of domains for scientific and technological activities becomes of crucial importance.

It is also necessary to control effectively the import of technology originating abroad, in order to ensure that in those areas in which the country will be dependent on foreign knowledge, it would obtain the best possible conditions from its suppliers. The bitter experience of Latin American countries with regard to the acquisition of foreign technology, show the need for exercising more adequate control over the process of international transfers of technology to underdeveloped countries.

The concept of a strategy of selective interdependence is based on the work of Emery (1967), New (1969), and Emery and Toto (1965), on the interactions between a system and its environment. Both Blackett (1967) and Gipin (1969), have argued in favor of strategies for determining priorities which are obviously related to the strategy of selective interdependence. It should be emphasized that underdeveloped countries should not re-invent whenever it can be avoided, and that before engaging in expense research and development efforts, the country should buy its way as near as possible to the front line of technological advance. Gipin identifies three general strategies for selecting priorities for scientific and technological development.

**The first strategy** is to develop scientific and technological development across the broadest front possible [1].

The second strategy is to develop scientific and technological specialization. The extent of this strategy is to support specific areas of science and technology, usually of commercial utility and economic value, to the maximum extent possible [2].

In contrast to the first two strategies, the third is an importation strategy, which is based on importing foreign technology by the purchase of research and development effort, and then developing it and specifications of the areas in which scientific and technological knowledge will be required from foreign sources.
the second and third strategies identified by Gilpin. The existence of bound natural resources, for which technical knowledge is not available elsewhere, imposes the need for the "specialization" component of the strategy. The heavy reliance on foreign technology found in Latin America imposes the need for a component of the strategy based on imports of technical knowledge. The lack of human and financial resources preclude underdeveloped countries to follow the first strategy identified by Gilpin, which has only been followed by the Soviet Union and the United States.

The methodology to be followed in determining demands and priorities for scientific and technological activities is based on the Requirements and Possibilities method (Sugden, 1976a), which consists in comparing the capabilities or potential for doing science and technology with the demands or requirements of the economic, educational, physical-ecological, and other systems in the Nation. It requires the functioning of their demand generating systems, identifies their needs for knowledge, and brings these into the open. Once this is done, a comparison between requirements and possibilities is made to determine imbalance, seeking to couple demand with supply of knowledge. This balancing process would replace the market mechanisms for science in these countries with well-developed institutional structures.

However, it was found necessary to modify and extend the approach proposed by this method, particularly by redefining the conceptual term of "requirements". In both the OECD and DAAO versions of the method, requirements are derived from economic, educational, cultural and other activities on the basis of a one-way analysis: the needs of demand-generating activities are projected onto the scientific and technological system. The possibility that capabilities for science and technology may give rise to demand generating activities, which in turn would create requirements for science and technology is usually not considered. Scheme 1 shows graphically the concepts to be introduced.

For each of the two groups of activities under consideration, the scientific and technological and the demand-generating groups, the activities can be classified into several categories which could give rise to different types of requirements. Beginning with the demand-generating activities (economic, cultural resources, social, cultural, etc.), there are existing and planned activities, which give rise to requirements for science and technology that may be satisfied or unsatisfied depending on whether the relevant scientific and technological activities are being carried out or not. The unsatisfied requirements are those which generate a need for new scientific and technological activities while the satisfied requirements find scientific and technological activities which corresponded to the needs they create. Unsatisfied requirements may be identified at different levels. At an aggregate level, priorities for science and technology could be established for general problem areas of national importance or for economic sectors. At the level of productive units and specific technologies, research projects could be identified and priorities of concentration and determining priorities at each of these levels. Turning now to the other side, there are existing scientific and technological activities which do not find counterparts in demand-generating activities. Activities which would in turn generate requirements for science and technology must be defined for themselves by promoting their corresponding economic, social, cultural, etc., activities. Requirements derived from these "induced" demands generated requirements becoming apparent in the light of the characteristics of the scientific and technological development in Latin America.

Many countries possess capabilities in some segment of fundamental, or even if it is not uncommon to find relatively high levels of competence in areas such as electronics, physics, and chemistry, for which there is no effective demand but for doing scientific and technological work could not be better serviced activities, which would in turn require the research and development of new scientific and technological systems is capable of providing.

These induced requirements could play an important role, not only in the technological progress.
For the sake of completeness, it is possible to define another category of requirements for which neither the scientific and technological nor the demand for the services of highly qualified personnel. These non-technological personnel to be generated by activities arising from a different development strategy than the science and technology policy in an advanced economy under different economic development. The first category of requirements becomes particularly important when the possibilities of taking steps and of pursuing different styles of economic development are considered explicitly.

Therefore, at least two types of "requirements" can be identified: possible, induced, satisfied and unsatisfied. The original version of the requirements and possible methods, both in the GAS and OECD versions, only considers the last of these categories. Procedures for scientific and technological subsistence studies have been usually established from an analysis of existing and planned projects and activities which generate unsatisfied requirements. The explicit consideration of possible and induced requirements would alter these priorities by taking into account potential and possible activities, and the demands for knowledge associated with them.

5) Resource planning

The last category, resource planning, deals with the allocation of resources, is conditioned by the availability of resources and by the possibility of directing the way in which they are allocated, if there is any impact on influencing the pattern of resource allocations to and within the system. Resource planning mainly consists of an allocative and distributive process, which should also allow interpreting allocation decisions within an experimental context. The procedures followed to carry out this type of planning activity include acquiring and distributing resources, defining specific aims and goals to be achieved with given resources, establishing priorities for resource allocation, and generating a data base which would allow to interpret each resource allocation decision, at an experimental point of view, as a sample point allocation decision in a universe of possible decisions.

Planning a project seldom have a sizeable portion of the total resources allocated to science and technology under their control, it is necessary to include other institutions, such as private research organizations, universities, and other institutions, in the planning process, as effectively engaged in resource planning, even if they are not conscious of the role they play. Taking the planning agency's point of view, resource planning should therefore be aimed at allocating its own resources efficiently, as well as in influencing the way in which other institutions and organizations in the scientific and technological system allocate their resources.

With regard to human resources, scientific and technology planning agencies in Latin America have little direct control over the preparation and training of highly qualified personnel. These are functions of universities and other institutions of higher education, and the agency in charge of planning scientific and technological development can only propose policies, coordinate efforts and in general try to relate educational plans with scientific and technological development plans. Taking the areas of concentration defined in activity planning, the agency could point out to educational planners the needs for highly qualified researchers and technical personnel, suggest policies for recruiting scientists whose skills appear to be in demand. It could also promote meetings, and conferences to increase communication and interchange of experiences in the scientific community, as well as devise means for awarding prestige to scientific and technological activities which have direct relevance to development.

There are two areas of human resources planning in which the planning agency may exert direct control. These are the administration of fellowships and scholarships and the preparation of qualified personnel for scientific and technological planning and other supporting activities for the scientific and technological system. Through the administration of fellowships, particularly those to study abroad, the planning agency would be in a position to influence the volume and composition of highly qualified personnel, and therefore, exert a certain degree of control in the coordination of its development. The preparation of personnel for scientific and technology planning and the training of all kinds of auxiliary personnel needed for supporting activities (documentation specialists and librarians, for example) are additional tasks which the planning agency should consider.

With regard to the allocation of financial resources, two different procedures may be followed, depending on whether funds are controlled directly by the planning agency or are under the control of other institutions. In the case the resources made available to the planning agency should be allocated to the general areas defined in activity planning. If research activities in these areas can be performed directly by the planning agency, or one of its dependencies, the problem becomes one of selecting and selecting projects they should be allocated to. If projects are to be performed by other organizations, the planning agency should request that proposals be submitted in the domain or area given priority. The problem then becomes one of selecting among research proposals submitted to the planning agency. Procedures such as cost/benefit analysis are available for this purpose.

For the financial resources that are not directly under its control, the planning agency should propose allocation methods and criteria to other institutions, suggest uniform budgeting procedures which would allow inter-institutional comparisons, and initiate the preparation of an annual consolidated budget for science and technology showing how financial resources are being allocated in the nation. Resource planning would also include the generation of information systems and a data base on resource allocation, which would help the construction of mathematical models for the allocation of financial
5. Summary

This essay has put forward several ideas for scientific and technological planning in underdeveloped countries. Section 2 introduced the concept of planning which was used throughout the work, and related it to recent advances in the field of planning theory. Section 3 proceeded several principles for scientific and technological planning, which will be viewed as guidelines for the development of planning methodologies. Section 4 placed emphasis on the analysis of the different types of decisions involved in scientific and technological planning, grouping them into five homogeneous categories. The categories of planning, decision making, and resource planning, constitute a framework for identifying and planning, particularly evaluating the different types of planning processes that must be taken, and the need for developing different planning paradigms for the different types of anticipatory planning. The work on which this essay is based (Sapienz, 1972) explores in more detail the theoretical implications of the conceptual framework and provides some examples of its application.

APPENDIX

Further notes and stylistic planning

The relation between the system's present situation and the desired future image results in a two-directional process with respect to the timeline. (Figure 3) It requires designing a desired future image and steering backwards towards the present (in order to leave the present that would lead to it), and it also requires diagnosing the existing situation and assessing its potential for future development. (Figure 1) From the struggle between these two types of analysis, the result is an image of the desired future world. (Figure 2)

Figure 1. Relation between existing and future situations in stylistic planning

Two pathological conditions in the relation between the existing situation and the future image are presented in Figure 3. The first occurs when the future image is designed in such a way that coming backwards from it does not appear to be possible for reaching it, but the existing situation and trends will not allow its system to attain the desired image. The range of possible future states given present conditions, does not include the desired future image. This defines an intransitive planning gap between the most likely and the desired future image. Borrowing a concept from statistical inference we may call this the Type I error in stylistic planning: designing a desired future image which is apparently inaccessible but which may be so.
Figure 2. Pathological relations between existing conditions and future images in stylic planning

Type 1 error in stylic planning

Type 2 error in stylic planning

the present states that may lead to it, shows that the range of possible starting conditions does not include the present situation, although a careful examination of the present state, its dynamics, and of the possibilities for action would show that the desired future image is indeed attainable. We may call this the Type 2 error in stylic planning: reaching a desired image on the grounds that it is apparently not reachable when really it is achievable.

Of course a priori it is not possible to know with certainty whether the process of designing a desired future image for the system will lead to any of these pathological conditions or not. Uncertainties regarding the behaviour of the system and its environment during the time encompassed in the planning horizon prevent planners from devising a strategy which would lead irrefutably to a certain future. In addition, the desired future image is likely to shift continuously, whereas changes in values, the inclusion of different interest groups in the planning process, and changes in scanning what is feasible. The point to be made is that stylic planning requires careful analysis in the two dimensions along the time dimension: from the desired ideal state to the range of possible starting conditions leading to it, and from the present situation to the possible futures open to it.

Furthermore, the methodology for stylic planning should lead to a framework for thinking about the other categories of planning activities, providing guidance to conceptual, institutional, activity and resource planning. However, the desired future image need not be specified with great detail and concretized all at once. It could be developed through a series of modular studies forming part of a framework, but which would also have value and operational significance on their own. Through a continuous iterative process the framework would be filled sequentially by carrying out modular studies. The final outcome would be a set of scenarios depicting the desired future image of the system and its interrelationships with other systems. It would be obtained by integrating the different modules into a composite view of the desired future.
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