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TECHNOLOGICAL DEVELOPMENT, DEVELOPMENT STYLES  
AND ENVIRONMENTAL PROBLEMS

This study was prepared by Mr. Warren Crowther while he was an advisor of the International Development Research Centre, as a contribution of this organization to the CEPAL/UNEP Project on "Styles of Development and Environment in Latin America". The opinions expressed in this study are the exclusive responsibility of the author.



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The purpose of this paper is a critical review of technological change models which challenge the ascending development style in Latin America, by emphasizing local creativeness, constructive international interdependence and better environmental adaptation. Several models proposed in the region, including broader technology assessment associated with socio-economic planning, the science and technology infrastructure strategy and appropriate technology, are described. While they do address and propose to modify some of the more obvious negative aspects of the presently ascending model (the modernization cycle of the transnational development style), they include elements which have proven to be ineffective in reducing technological dependence and environmental stresses.

There is a need to return to basic definitions of technological development and environmental development, such as those given here, so that diversity and social meaning are combined, as are individual creativity and community protection of ecosystems.

#### A. ENVIRONMENT

All decisions, studies, issues and problems are circumscribed by temporal, spatial, methodological and other boundaries. Much of the professional and political debate that takes place is related more to divergent points of view regarding the appropriate boundaries of a subject under discussion, than to the solutions which should be adopted. The limits of what it is considered legitimate (reasonable, practical, pertinent, etc.) to talk about, or study, or take into account, in the face of a particular problem or challenge, encompass a system. While organizations (in terms of organizational goals), professions (in terms of professional qualifications), sciences (in terms of Kuhnian paradigms), coalitions (in terms of agreements), technocrats and other groups may agree on the nature or definition of the system, which is the subject matter for their attention, most systems actually are in a constant state of flux. Goals, qualifications, paradigms, agreements, etc. are temporary and subject to interpretation.

Table 1 cites a number of systems which are presently used in socio-economic and technological decision-making and systems analysis, including cost-benefit analyses and operations research, and which exclude environmental costs and benefits of increasing interest internationally. The environment consists of the residual variables not incorporated into the system, and values which have not been considered relevant for the system variables. The environment can be all such residual variables or values, or may consist only of those "additional" variables and value ranges which, according to the critics of a system, should be taken into account.

/Table 1

TABLE 1

SYSTEMS AND ENVIRONMENTS

<u>Systems</u>	<u>Environment</u>	<u>How to expand system boundaries</u>
1. That part of the universe that is of particular interest to us in a given context.	That which is irrelevant.	Incorporate new variables, representing what was previously uninteresting
2. That part of the universe which is potentially subject to effective control.	That which is constant or imperative	Extend the reach of potential control to new areas
3. Those factors which are circumscribed by individual decision-making (e.g. behavior of a single firm), and for which the individual directly suffers the costs involved	Those factors which imply costs to the community, or for which the "free-rider" problem arises	Internalization of externalities
4. Same as 3,	Same as 3; the factors also are characterized by the community as susceptible to degradation and as worth saving (i.e. degradation is unacceptable)	Same as 3
5. The structure of production and consumption of material goods and services.	Factors of "quality of life" beyond the structure of production and consumption	Same as 3; also environmental impact studies; incorporate the entire raw materials-final consumption chain
6. Same as 5	Natural resources, especially those which are non-renewable or scarce	Planning for the use of natural resources, or substitutes
7. Economic growth factors	Qualitative or social factors	Adoption of a "unified approach" for interdisciplinary studies

<u>Systems</u>	<u>Environment</u>	<u>How to expand system boundaries</u>
8. Ecosystems	Residuals (outputs) which are not reabsorbed as inputs into the system, where inputs are finite (i.e. limits on the "carrying capacity" of the earth)	Ecoregional development; or more careful technological selection and displacement; or holistic approaches
9. Same as 8	Same as 8; plus concern for more equitable distribution of costs and benefits	Same as 8; and lower consumption of rich countries; or more transfers to poorer countries
10. Environmental system	Social, political and psychological factors which impede implementation of techno-economic solutions	Elaboration of new political structures or strategies

/An environmental problem

An environmental problem is a problem or matter on which serious disagreement exists regarding the appropriate limits of the systems being studied, discussed or implemented. The progressively deeper consideration and the resolution of environmental problems are facets of development in favour of the environment, or environmental development. Environmental development, may be analyzed as a permanent broad challenge or in terms of immediate specific environmental problems.

Environmental development from a longer-range perspective is the constant expansion of system boundaries, beyond what has been considered theoretically consistent, practical, methodologically manageable or politically acceptable. The goal is to convert the "unthinkable" into something thought about, and address the "impractical" by means of new policy issues and measures. Challenges are encouraged against existing goals, qualifications, paradigms, agreements, discipline or organizational boundaries, etc. The answer, at this level, is the instrumentation of a constant process of creating new environmental problems and of system boundary expansion.

Several comments are in order about this. Even in carrying out a single decision or study, the boundary limits between system and environment are usually approximate and in constant evolution. When the variables are chosen, the joining of them in hypotheses, and the integration of the hypotheses in models, gives a content to the whole (hypothesis or model) greater than that or less than that of the variables taken individually and summed. Also, only in highly restricted (and thus mathematical) sciences, as opposed to more configurational sciences, are the measures and data for the variables likely to be sensitive to (i.e. controlled for) all the systems' spatial, temporal and other boundaries exactly as these have been defined in principle.

Are excursions into the "environment" to choose and pick new variables and values for our "systems" always to be encouraged? Is more chaos in systems analysis necessarily better, since it means a faster turnover of variables? Are we to make a general statement that all scientific revolutions and cultural upheavals are "good"? Or should we withdraw from such an anarchistic conclusion, and set out some higher value for rating or ranking environmental problems; a classification of the variables and indicators related to these problems; and criteria for identifying the variables and values of present systems which are worthwhile conserving?

For the purposes of this paper, systems boundary expansion involves the incorporation of new environmental factors, variables, indicators, values and feedback information in the systems, and the increase of popular participation in decision-making. Our interest is in approaches to technology that generally favour these aspects of longer-term environmental development.

/Environmental development



Environmental development from a narrower more immediate perspective addresses the nurturing and degradation of human habitat, the alteration of material-energy-information balances and other human and natural stresses on ecological zones (e.g. the ocean) receiving attention at the present.

Environmental development thus is primarily concerned with controls on and substitutes for highly entropic or wasteful processes.

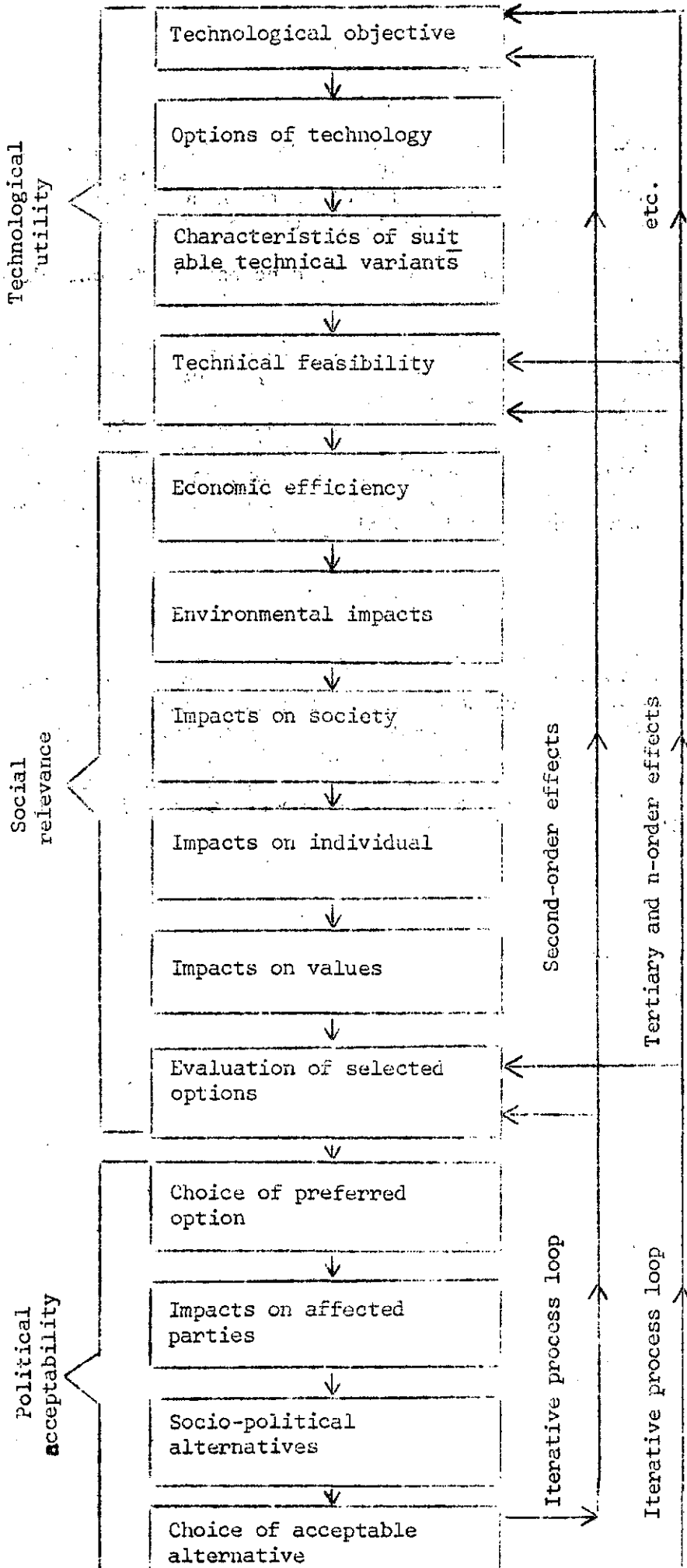
More specifically, environmental development involves: (a) monitoring for stress and degradation and for changes in energy-materials-information balances; (b) technology assessment in terms of social relevance and political negotiation or revolution as well as technological utility (see Graph 1); (c) orienting or creating new programmes in favour of the quality of life; and (d) expanding public involvement or representation, in order to assure a more accurate assessment of "needs" and to make decisions which give priority to the basic needs of the whole population.

#### B. DEVELOPMENT STYLE

The process by which environmental problems become discussed, and resolved or set aside is a part of the development style of a country or other political division. The style consists of a large number of inter-related components, each of which is characterized by different stages or patterns of change. These components are indicated in Graph 2 and Table 2, which also indicate the different levels of rule-making in and for the government, and the impact of the development style and governmental policy outputs on the system/environment.

/Graph 1

STEPS IN TECHNOLOGY ASSESSMENT

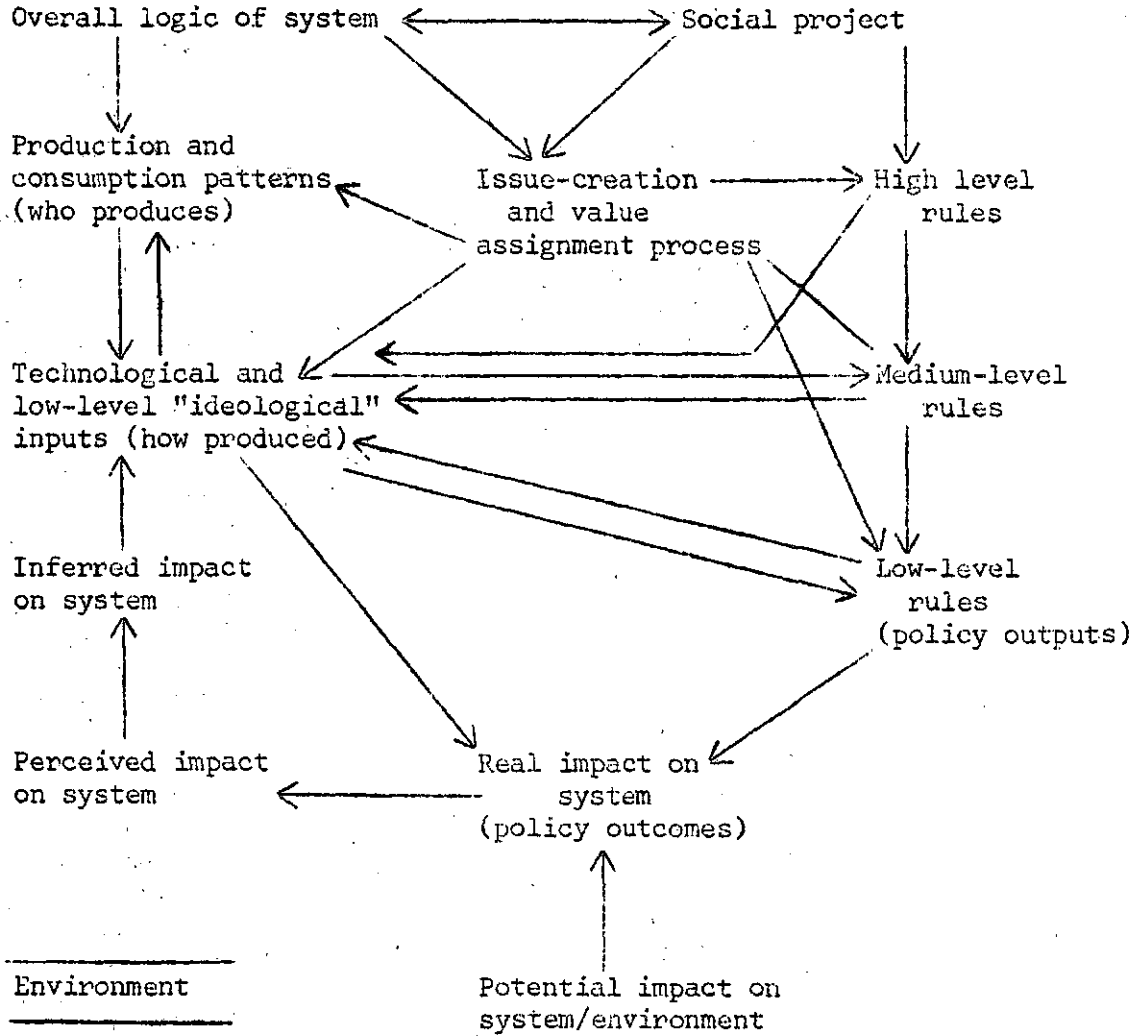


From Francois Hetman, "Steps in technology assessment"  
 International Social Science Journal, XXV (3), 1973, 267

GRAPH 2

Development style

Levels of policy-making (State)



/Table 2

TABLE 2

COMPONENTS OF THE DEVELOPMENT STYLE, AND PARTICULARLY THE  
TRANSNATIONAL DEVELOPMENT STYLE, AND OF GOVERNMENTAL  
RULE-MAKING

<u>Component of development style</u>	<u>Definition</u>	<u>Example:transnational development style</u>
1. Overall logic of the system	Ownership of means of production. Role of the state in relation to economic activities. General rules for the allocation of production responsibilities, determining production levels and allocation of scarce resources.	Monopoly capitalism, state capitalism or highly bureaucratized socialism. Transnational culture. Organizational planning instead of market for relating production consumption. Preference to regimes which favour professional control of specific policy areas, and with the capacity to divert or absorb the political claims of newly mobilized groups. Sequential and incremental payoff for the most articulate sectors, increasingly using inflation as an allocation mechanism. State policies decided largely in consultations of selected groups. Dependent development in the semi-periphery areas.
2. Process of defining issues and assigning values	Most influential groups (power elites, development agents) in defining environmental problems. How environmental problems are handled in the different levels of subjectivity. Rules of technology assessment and selection.	Transnational community. Professionalization as a group political strategy. Selected environmental problems are packaged, as are determined solutions, and disseminated first as symbols of modernization. High degree of specialization, plus some interdisciplinary work, in problem-solving, with organizational goals and paradigms very important in selecting technologies, methodologies and projects.

Table 2., continued

<u>Component of development style</u>	<u>Definition</u>	<u>Example: transnational development style</u>
3. Production and consumption structure.	<p>The structure of income distribution and demand for goods and services.</p> <p>The leading production sectors, in terms of linkages.</p>	<p>Replication of structure of more industrialized countries, where these latter do not succeed in imposing the principle of economic division of labour.</p> <p>Emphasis in on middle-class consumption, infrastructure development and luxury goods, in this general order, although postponement of the first of these is often advocated.</p> <p>Transfer pricing.</p>
4. Technological and low-level ideological inputs.	<p>The variables of the systems, and the ranges of values considered generally acceptable for these variables.</p> <p>Production techniques and evaluation measures.</p>	<p>Organizational accounting (particularly formal accounting and budgeting, as opposed to cost accounting) determines the most important variables. Profits as overall goal.</p> <p>Laboratory and statistical results and the technological capabilities of high-level technologies, largely determine the ranges of acceptable values.</p> <p>Social factors are important, as long as they do not displace or conflict with the others already stated.</p> <p>The State may accumulate a deficit balance on its accounts, but decision parameters still are mainly those indicated here.</p>
5.		

Table 2., continued

<u>Levels of governmental rule-making</u>	<u>Definition</u>	<u>Example:transnational development style</u>
1. The national or historically social project.	The general model of development which is adopted, indicating the general set of objectives or values of the most powerful sectors as a guide to government action or inaction.	Greatest emphasis on economic growth in rather narrow terms. Considerable decentralization of decision-making among productive and social sectors, using "planning" as a symbol of supposed coherence. United States' governmental administrative patterns, and especially service and production techniques generally serve as a model.
2. High-level rules	The general issues publically debated regarding governmental action or inaction.	Among such issues are:public/private ownership, inflation, energy dependence, acceptable debt levels.
3. Middle-level rules	Governmental policies at the sectorial or organizational level, guiding general budgetary decisions	Policies which promote consolidation and linkages of economic activities. Social programs which are necessary for social/political stability Patchwork techniques in State economic interventions, including State subsidies, for decentralize or private economic activities.
4. Low-level rules	Specific policy outputs:regulatory and allocative decisions of governmental agencies.	Although there is considerable diversity here, the transnational community does interchange very influential points of view about generalized solutions for specific problems.

/The existing major development

The existing major development styles are challenged in different epochs by an ascending development style. 1/ Thus the ascending development style is not always the dominant style in a country at a given time, but rather a tension exists with the other major development styles. The ascending development style in Latin America is the transnational development style, as described in Table 1.

Different styles depend on the initiative and efficacy of different political actors. The transnational style is sponsored and maintained by the transnational community (characterized by the ownership of the means of production and the top managerial, financial, professional, and bureaucratic positions, and by the possession of a specialized knowledge which they have convinced other sectors to be indispensable for innovation and production). 2/

The hypothesis has been strongly stated that variations in development styles may have significant effects for the "environment". This statement could approximate a redundancy or circular argument depending on how "environment" is defined. It is our preference to divide this into two separate questions: (a) whether or not a variation in development styles has or is likely to have a significant effect on system boundary expansion; (b) whether or not such a variation would have predictable effects on the resolution of certain key contemporary problems, considered as environmental problems.

The transnational development style is a determinant of certain limitations and possibilities of system boundary expansion in general. And at least in that degree, the transnational development style implies restrictions and potentialities in dealing with contemporary environmental problems. We will argue that the configuration of this style leads to a highly restricted manner of positing and implementing technological solutions for environmental problems.

Governmental policies are likely to be coordinated, but not totally consistent, with the development style. 3/ Government policy-making to some extent competes with private decision-making and some of the values of the predominant development style, especially to the extent that the government is sensitive to conflicting interests. These potential conflicts can be resolved by the existence of an institutional process of defining issues and assigning values which are respected (to the extent of displacing or postponing fulfillment of individual goals) by the most powerful interests. That is to say, if the key decision-makers in all sectors guide their decisions according to certain cues or patterns (e.g. incrementalism, cyclical inflation rates, periodic elections or political movements), then a lot of the potential conflict might be softened. Reduction of uncertainty follows from compliance with certain general rules-of-the-game.

Although the specific patterns or rules-of-the-game for decision-making vary among developing nations, the general result is to promote a working consensus in the transnational community and to favour the institutional and

/individual members

individual members of this community: transnational corporations, international organizations, professionals working in the decentralized entities of the State, local private capital, etc.

### C. TECHNOLOGY AND TECHNOLOGICAL DEVELOPMENT 4/

Technology refers to closely inter-related sets of hardware, software (which include guidelines for product design, production processes and facilities, and management techniques), human resource (and skill) requirements, and performance guidelines. A technology is that combination of these resources and know-how which "work" or "function" together in a strictly technical sense (e.g. highly controlled laboratory situation), apart from contextual considerations, in order to produce or modify a good or service. The technology becomes a technological package when it is labelled by a policy symbol, and subjected to a series of technological utility and economic efficiency decisions (Graph 1). A technological package often is popularly known by a set of symbols loosely associated with some of its components, or the uses to which it commonly is put. These symbols are attached to the package, usually in the interest of promoting a professional, technical or commercial group's own goals. Later social relevance and political acceptability decisions are likely to take these symbols, and a respect for the inviolability of the package, all too seriously.

Development which takes advantage of technology, or technological development, is an attempt to obtain the following conditions in a country: 5/

- (1) The capacity to identify and translate the country's major socio-economic problems and possibilities into a coherent set of technological requirements, and to evaluate and prepare the technical and human resources of the country to meet these requirements, so that technological transfers are made mainly to help develop these resources, to cover unavoidable deficiencies of resources or in an exchange of technologies based on comparative economic costs.
- (2) The recognition and promotion of the capacity in all segments of the population to innovate, to implement innovations and to deal with their effects, with ample planning and consideration for the socio-economic realities of the country.
- (3) Simplified presentation and ample diffusion of information regarding local technological options and challenges, in order to create an environment of dialogue and experimentation on product design, operating procedures, performance guidelines, engineering and tooling, etc. at the level of production and services.

/ (4) The analysis



- (4) The analysis of the separate hardware and software components and capital requirements of technological packages, and the capacity to negotiate for only those components, on reasonable terms, that are deemed necessary.
- (5) Awareness of the ideological content of technologies and technical decisions, recognizing that the importance of technology is not its supposedly imperative nature, which is a myth, but rather its pedagogical value as it draws us from the known and perceived towards the infinite and inferred, and thus that great care is needed not to fall in the mistake of indiscriminately accepting pre-defined technological packages or professional paradigms.

From our definitions of systems boundary expansion and of technological development, it is clear that both environmental and technological development imply certain standards and procedures in technology selection: (a) to take advantage of the alternative combinations of the components of technological packages; (b) to study the possibilities that the objectives might be reached just as effectively under existing social conditions by the application of one type of component without the other (e.g. implement software without investing in hardware); (c) to incorporate a wide selection of social and economic variables in the analysis of alternative technologies; and (d) to look for less expensive substitutes, particularly where hardware is used primarily for its symbolic value in inducing organizational changes.

#### D. THE MODERNIZATION CYCLE OF THE TRANSNATIONAL STYLE

The transnational development style encompasses a pattern of selection and implementation of technologies, which we prefer to call the modernization cycle.

The modernization cycle emphasizes the socio-political and cultural factors which influence innovation and invention, the makeup of technological packages, the selection of technologies, the agents and conditions of diffusion of technologies and the reliance on performance guidelines for the technology which will almost inevitably demonstrate shortcomings in the use of the technology and the "need" to revert to its source for complementary technological components. These factors are shown in a concise form in Graph 3. They are explained in more detail in Appendix I. 5/

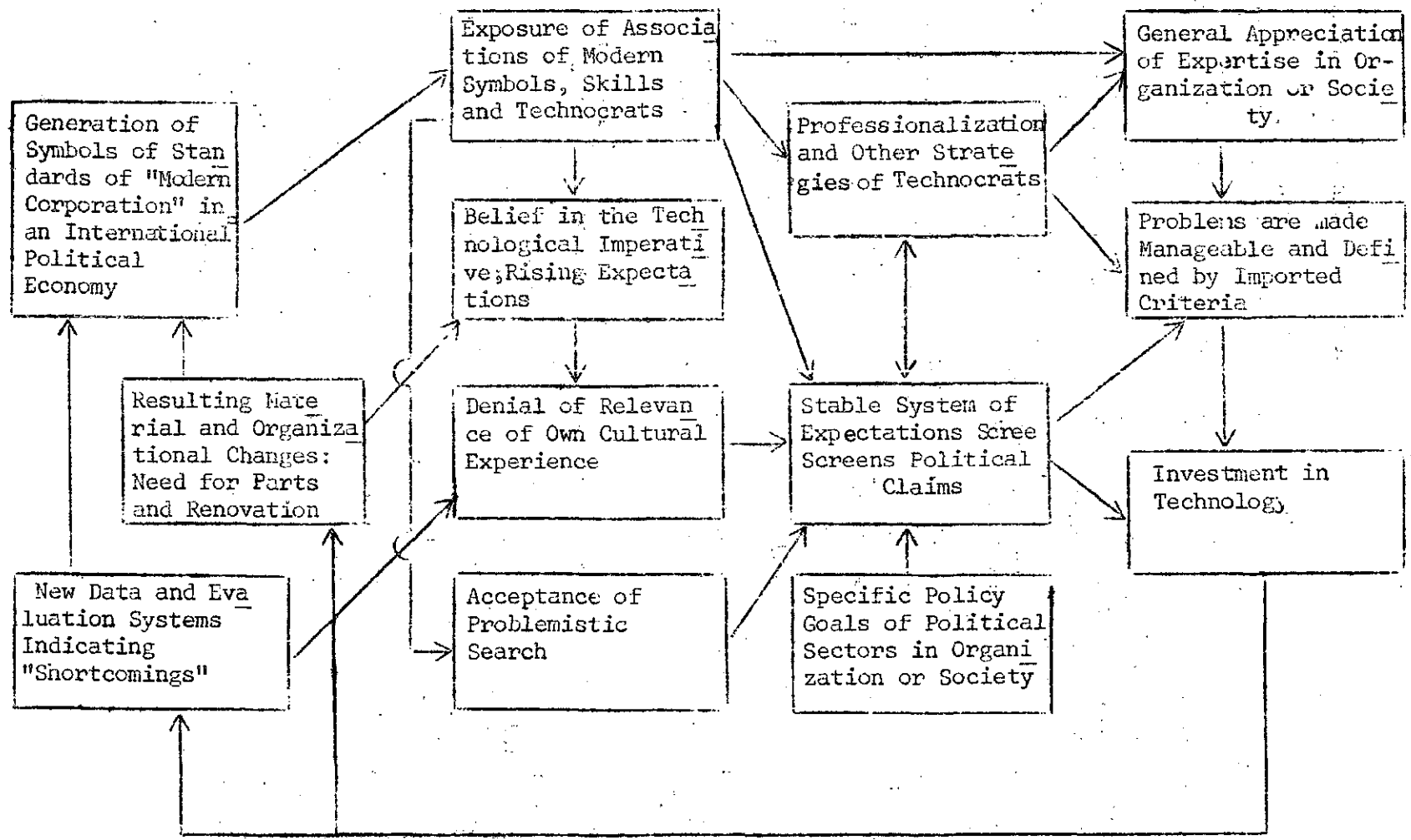
A complement to this model is the Kondratieff "long wave", initiated by a major new innovation which leads to a series of specialized and localized innovation activities, followed by a period of intense competition and emphasis on "process" rather than "product" innovation. 6/ Naturally, the initial thrust of the modernization cycle in response to a major new innovation is related to the availability of factors and market signals, and governmental restrictions, especially in the more industrialized economies. Once a "long wave" is set

/Graph 3

Confrontation with Cultural Beliefs and Attitudes

Goals of Political Actors

Reception of Modernization



THE MODERNIZATION CYCLE

GRAPH 3

in motion, and technological R&D becomes low-key and low-risk, the cycle pushes the market for what it will bear, above all in the developing countries. A marketing and political activity is organized to promote the application and diffusion of the "process" innovations.

The modernization cycle is inherently contradictory to environmental development and technological development. It is the well-functioning of the technology, rather than human or natural environmental stress, which is monitored and corrected; technology assessment explicitly emphasizes technological utility and economic efficiency rather than social relevance or political consequences; and commercial criteria override the consideration of basic needs. Technologies are transferred which are not adapted to local materials, nor to local living conditions.

Contrary to the arguments that the present competitive system favours scientific and technological progress, the modernization cycle actually means that flexibility in the design and application of technologies is constrained. <sup>7/</sup> Problems are defined in terms of the more easily controlled variables, management is over emphasized, and there is a strong tendency to discard options, including options which could be important for anticipating, recognizing and resolving environmental problems. Rigidities and unnatural constraints characterize the defense of technological packages, and thus of the organizational goals, scientific paradigms, professional qualifications, political agreements, and other "systems" which are promoted or serviced by such packages. Even new technologies specifically intended to address present environmental problems are designed and engineered in much the same pattern.

#### E. THREE MODELS OF TECHNOLOGICAL CHANGE AND CONCERN FOR THE ENVIRONMENT IN LATIN AMERICA

Several models of technological change have been posited for Latin America, with differing grades of confrontation against the ascending style and its modernization cycle of dependence. <sup>8/</sup> Confusion exists regarding the extent to which these models could co-exist or preclude each other, and the extent to which they are applicable throughout the region and in all sectors or are viable only on a partial basis.

One model involves the introduction of environmental impact statements and the integration of technological concerns in global socio-economic planning. <sup>9/</sup> Usually in relation to a particular industrial sector or agricultural product, State, local capital and foreign capital interests negotiate a package of tax breaks, credits, import privileges, labour conditions, industrial location incentives, transportation rates and other policies; ideally, environmental protection, promotion of local research, use of local materials, training of local personnel and other concerns would be included in the package. The packages fit into an overall scheme of State cooperation with international capital to assure stability as the country moves beyond the phase of industrialization based on import substitution.

By this means, more consistency should be obtained among policies with explicit impact on environmental, scientific and technological development,

/as well as

as well as in the application of direct and indirect instruments of such policies.

In this model, the interests of the transnational community, and the functioning of dependent development (i.e. the alliance of transnational, State and local capital, and the global application of scientific and technological paradigms), are not threatened, but rather an attempt is made to modify the terms of their interaction in order to obtain both the transfer of more relevant technologies and a larger share for developing countries of value added of scientific and technological work.

There are exceptional cases in Latin America of the State and local capital being able to induce the transnational corporations to accept greater local control and inputs, by taking advantage of national control of raw materials, by offering labour and general economic policies which are attractive to the corporations, and by appealing to competition among the corporations. As a result, the corporations are motivated to finance local product research, to refrain from transferring environmental-unsound processes and products to the developing countries, and to reduce other discriminations against these countries. Naturally, the larger developing countries are in the best position to obtain such "concessions", along with the supposed (but actually highly exaggerated) advantages of know-how and management technique, from the corporations. 10/

Unfortunately, the conditions which favour the local bargaining position are very difficult to replicate, and in general this model is not viable simply because it involves a commitment to foreign capital which is not interested in local development, a respect for foreign know-how which is antagonistic to local innovation and a concern to produce for a privileged segment of the population.

Throughout this Century, an increasingly large group of Latin Americans in the transnational community has supported a second model: the science and technology infrastructure strategy. 11/ This is an attempt to institutionalize a strong negotiation position regarding international technology transfers, a strong economic demand and political support for local R&D, and the development of a greater absorption capacity for new technologies. This model, like the previous one, accomodates to the modernization cycle.

The science and technology development strategy has been adopted, with certain variations among Latin American countries, to promote and develop, especially under State control or guidance, a set of technological support and regulatory elements deemed necessary for appropriate technological decisions. Table 3 indicates these support and regulatory elements and the decisions to be affected. The decisions to be influenced are those of enterprise (public, mixed or private), Ministries, national councils on science and technology, and national or sectorial planning. The support and regulatory elements are encharged to a great variety of institutions and services.

TABLE 3

TECHNOLOGICAL DECISIONS AND INFRASTRUCTURE

<u>Elements of technological support</u>	<u>Basic decisions</u>	<u>Elements of technological support</u>
A. Conceptualization of the factors that lead to technological development or dependence	1. National development plans, including sectorial plans	G. Technical assistance
B. Case studies of technological development	2. Normative directives and guidelines in the form of technological development plans, policies and controls	H. Criteria for development of technological infrastructure and information systems
C. Research and development (R&D)	3. Decisions on programming and administration of production and services:	I. Difusion of information
D. Education and training of professionals, scientists and technicians	(1) Investments	J. Technical standards and quality controls
	(2) Selection and adaptation of technologies	K. Patents and industrial property
	(3) Needs for technical assistance	L. Financing of technological development
	(4) Conditions accepted on purchases of new technologies or on technical assistance	
	(5) Organizational and information system development	
	(6) Levels of production and services	

/In some countries

In some countries, the attempts to organize support elements began in the late 19th Century, particularly in relation to mining, railroads and other engineering work. Throughout the first half of the 20th Century there were sporadic efforts to institutionalize support elements especially in relation to industry. These efforts were provoked by professionalization in the region, by depression- and war-related "involuntary" industrialization and later by industrialization due to deliberate protectionism and the deteriorating trade balances. Only on rare occasions were these efforts tied closely to a plan or program for development of the industrial or other sector. During the 1960s and 1970s, there was increasing awareness that the support elements were not having much impact on technological selection and implementation, and there was a surge of developments to centralize or coordinate governmental activities related to technological research, transfers and technical assistance. The restriction of transfers increased in importance, as a complement to the support elements. There is ample documentation, indicating the meager results from these efforts. 12/

The most popular explanations of the poor results of this strategy are the lack of sufficient political support for the strategy (because the politicians apparently do not comprehend its importance), the contradictions between the explicit policies to foster local science and technology and other ("implicit") policies which favour indiscriminate technology transfers, insufficient attention to bringing local science and technology directly to bear on private and public investment decisions and the inability of even those small countries which are well organized to regulate or control the operations of the huge transnational corporations. Many proposals have been set forth to deal with these problems. 13/

Other problems with this strategy have tended to be confronted only superficially. These include the fact that the scientific and technological infrastructures have not really broken with the international scientific and professional paradigms (and their accompanying status systems) which constrain scientific and technological path-finding; that the information used in technology assessment generally comes from sources which do not replicate the real conditions or needs of the developing country; that much is said but relatively little has been done concretely to discover technologies which are appropriate for the basic needs and conditions of the region; that the infrastructures are highly elitist and promote the unfounded presumption that creativity is a special domain of a limited group of people; and that the service and regulatory elements of the infrastructures have been very slow to alter their functions to favour systems boundary expansion or concern for immediate environmental stresses. 14/ It should not be surprising to find a narrow technocratic approach to technological change suffering from the lack of political support within countries, and unable to defend national interests externally.

A third model is the most aggressive in favour of self-reliance and appropriate technologies. 15/ This model requires, first, a complete change of educational philosophy and systems so that cultural experience and individual

/creativity are

creativity are emphasized more than universal concepts; second, participation by all segments of the community in defining technological problems and selecting solutions; and third, recognition that any community can legitimately challenge popular hypotheses or paradigms by citing its own experience or by insisting that additional socio-economic factors be taken into account in reformulating such paradigms. It is also recognized that an approach to science and technology, and to environmental problems, which emphasizes individual and community innovation, and which caters to the basic needs of marginal groups, cannot accommodate the transnational development style and its modernization cycle.

There has been an unfortunate and premature popularization of the ideas of self-reliance and appropriate technologies, so that rather than develop and refine a viable model true to these goals, there is the danger that these themes will be co-opted. Even the international financial organizations and professional associations in the region which publicize the fashionable concern for appropriate technologies, continue to support narrow professional prerogatives, to defend overspecialized paradigms and to base investment decisions on technological utility and economic efficiency instead of a broader technology assessment. Appropriate technology thus becomes relegated to a minor role or a backward linkage in relation to the "modern" technologies.

Under present conditions, this third model is beset by a number of limitations. Although it does not advocate a total de-linking with cultures which apply other models, few governments are willing to sponsor the required dosis of temporary de-linking. Those governments which have done so, such as Cuba and Tanzania, were able to promote very interesting home-grown technologies with many advantages for their cultures and economies, 16/ but there is concern that the new technocrats being graduated in those countries may be less committed to a model of self-reliance and appropriate technologies and more inclined to other models as they confront the need for technological inputs for a full employment economy. Also, while self-reliance might seem to avoid the danger found in the other models of bureaucratization and rigidities over the long run, the self-reliant community is not immune to exclusive politics and fixation on a particular way of doing things once the euphoria of unleashed creativity begins to wane.

Proponents of this model assume that it is relatively favorable to the environment, inasmuch as it seeks a constant innovation and adaptation and a recycling of residuals of production and consumption at the community level. The answer here to environmental problems, as opposed to that of an environmental impact statement prepared by an outside expert, is: we know better than anyone what it is we really want, and thus the matter should be left to us to work out and decide which technologies to develop and which to bring in. It is the community that must live with the problem, and with the

/solution, and which

solution, and which has the greatest experience of coping with the ecological conditions of its own geographical zone. But no amount of self-reliance can protect the community from contaminations from the outside, nor can assure the community awareness of all the stresses and degradations which are threatening its habitat.

#### F. COEXISTENCE AND CONFLICTS AMONG THESE MODELS

The three models of technological change each approximate some of the conditions of technological development, but do not satisfy all of them. The more emphasis given to accomodation to the "realities" of the present power configurations and to the politics of professional and technocratic groups, the more elusive the goals of technological development and environmental development.

A middle-range projection of present tendencies might be merely the co-existence of the three models, each specializing in certain geographical areas or sectors, and in either high-level or low-level technologies. All three models take issue with earlier approaches to technological development in Latin America, by asserting that technology is an intervening and not an independent variable, and that the pervasiveness of the modernization cycle is explained more adequately in terms of institutional, social and cultural initiatives than in terms of a technological imperative. <sup>17/</sup> All three models recognize the cultural content of technology, and the artificially limited options offered under the modernization cycle. <sup>18/</sup> Apart from these areas of agreement, the models support the present co-existence of very different economic and political structures in Latin America.

It would be consistent with commonly-held assumptions about inherent differences among subsectors of the economy, as to technology structures and requirements, to posit that the technological change models would tend most naturally to specialize. For example, the first model would be associated with turnkey transfers of certain techniques for the mass production of consumer goods and of technology for producing and distributing energy resources; and the self-reliance model would be associated with such low-technology activities as artesian industry and truck farming.

However, such associations reflect exaggerated assertions about inherent differences among the technologies themselves. <sup>19/</sup> The social and productive organization of a technology is the result of a series of political decisions, such as those described by the "modernization cycle", and reasoned arguments can usually be made for alternative organizations of components, for varied designs and applications and thus for alternative institutional arrangements for financing and managing any technology. Thus there is more flexibility than is admitted normally for the widespread adoption of any of these models, and their co-existence is not a technological "necessity" or even a most efficient resolution of a technological dependence situation.

/The simultaneous



The simultaneous implementation of these models would mean the reinforcement of the very different production and consumption patterns (i.e. dual economies) which the models support, of marked differences regarding the rôle of science in relationship to technology 20/ and of very divergent approaches to education. The models also vary considerably regarding rules-of-the-game for State action, for the utilization of transnational capital, for the concentration or movement of local capital, for technical assistance and consulting work and for local political organization. The assumptions about individual creativity, the importance of transnational technological inputs and environmental and cultural factors, are clearly different. Thus it is difficult to imagine much interaction (including mobility or migration) among the sectors or regions affected by the different models.

There are a number of arguments against the coexistence of the models, especially given the varying degrees of accomodation by these models to the modernization cycle. Theories of dependence would point out correctly that dependent relationships tend to create and expand a concatenation of structures at all geographical and institutional levels. Theories of imperialism argue that there must be a very strong antidote to counteract the insistent expansion of capital accumulation and technological domination by the centre. Humanistic theories oppose the subjugation of any segment of the population to mere objects of benevolence or overlooking that each person is a creative being and should participate fully in his destiny. It doesn't make sense for a part of the economy to select technologies on the basis of profitability, and another part to use criteria of basic needs. 21/ In sum, continuation even on a limited basis of transnational community prerogatives and of the modernization cycle precludes technological and environmental development.

The formulation of an effective strategy must choose not only from competing models of technological change, but also from different points of view regarding the sequence of activities which would be most effective in overcoming the lethargy and opposition against technological development. Herrera and Sagasti, for example, agree that a change in development style is a requisite to a real commitment to technological development. They both argue for a "national project" in this sense, and each proposes a more limited action which would establish a beachhead for such a program. Herrera would concentrate on the frontiers of existing paradigms in a single sector, most logically (to him) the rural sector, and promote community participation in the development and selection of appropriate technologies. Sagasti is more insistent on the need for regional cooperation in order to assure the minimum critical mass of scientific and technological activity and sufficient negotiating force to override the powers which favour technological dependence. 22/ The literature is replete with recommendations of tactical moves towards technological development, which in practice have proven often to be disappointing and even to reinforce new dependencies. 23/

/Nonetheless, the

Nonetheless, the debates on tactics should not be stymied by the apparently insuperable dilemmas. Enough experience with recommended tactics has been accumulated, so that the real barrier to development is not the lack of ideas which demonstrate feasibility, but rather the lack of careful planning and decisive action consistent with the goals which are sought.

Dilemmas can be mere thought artifacts which permit short-run considerations to override longer-term values. For example, arguments for heavy industry in Latin America face counter-arguments against the impact of heavy industry on the environment, against deferment of satisfaction of the basic needs of the population, on the difficulties of access on satisfactory terms to advanced industrial technologies and on the need to recur abroad for the heavy and costly equipment for the new industry.

As opposed to the position that Latin America should leapfrog into heavy industrialization, being able to avoid a trial-and-error design process and to incorporate the most promising and proven advanced technologies, a longer-term perspective may favour a slower approach which permits the retooling or adaptation of the production structure to meet basic needs of the population (rather than elite consumption) and the adoption of local technologies for industry which do not depend on raw materials, labour skills and energy sources which are high-priced due to scarcity or cartelization. The selection of "more appropriate technologies" could mean that the industry would be more competitive internationally in the long-run.

#### G. ESSENTIAL MEASURES REGARDING TECHNOLOGY FOR DEVELOPMENT

National projects intent on technological and environmental development will differ considerably as to specific elements and tactics for guiding scientific and technological activities. The variation of "dependent structures" among the countries of the region, in part because of the tremendous flexibility of the transnational corporations to adapt their tactics to circumstances, means that tailor-made solutions often are necessary. 24/

Nonetheless, from the foregoing discussion it can be concluded that some general conditions are important throughout the region:

1. An ideal delimitation of final social and economic outputs, in terms of living and environmental standards for the entire population, needs to be made. Priorities would be given to access for each citizen to satisfying labour, adequate nutrition, health, education, security and peace, housing, participation in deciding his own destiny, and outlets for and constructive responses to his own creativity. Services, products and capital requirements not included in these factors are of priority importance only if they are instruments for the outputs stated above.

/2. All sectors

2. All sectors should be assigned production and performance targets in function of priority social outputs. Transportation and energy sectors, for example, could not claim contribution to the society in terms of their own output, but only by demonstrating the contributions to priority social results. The most difficult aspect of this is the need to redesign the information systems to report on production and performance in social terms, directly comparable with the output targets.
3. The difference between this ideal "budget" of allocations, and the actual allocations in the national accounts, is an index of the distortions caused by an inappropriate development style. Less important than the estimated discrepancies between the ideal and actual outputs, is the obligation of the sectors to justify requests for new investments or their selection of technologies, either as direct contributions to ideal outputs or as necessary to "retool" in order to contribute to such outputs. <sup>25/</sup> A real revolution in the allocation and application of resources would take place even in mixed economies, if the State apparatus had to justify its investments and regular expenditures in such terms.
4. The entire chain of relationships between paradigms, scientific research, development style, policy decisions, technological innovation and the ecosystem should be examined to see where it is most effective to pinpoint science and technology policy inputs. These inputs can be made on the process of technology generation (by encouraging innovation activity in the whole population), on policy-making (by social appraisal insisting on a broad socio-economic review in socio-economic terms of packages, indivisibilities, dirty technologies, products, etc.), on information inputs (setting standards for appropriate sources of information used in technology assessment), on the consideration of local materials and conditions, and directly on the ecosystem (by setting up monitoring systems). Most importantly, the multiple effects of an investment in technological development are greatest when the creative potential of the entire population is reinforced. The creation and selection of appropriate technologies are responsibilities of the entire State apparatus, and the resources for these activities are spread widely in any population.
5. The process of technology assessment (Graph 1) should be complete, and should be inverted so that social relevance and political acceptability have equal and simultaneous bearing with technological utility on the choice of technologies, or the choice of R&D foci. In this way, the ideological and cultural content of the technologies becomes clarified.

/6. Hard and expensive

6. Hard and expensive technologies are to be avoided unless it is clearly demonstrated that the results could not be achieved by means of the reorganization of work, that the new technology does not "require" unreasonable performance from the workers and other environmental elements in order to meet the projected results, and that the technology does not "require" extraordinary complementary investments which are not justified in terms of social opportunity costs.
7. On the other hand, the soft technologies (e.g. management and information systems) are acceptable only if there is prior research on the real factors that obstruct the administration of programmes, and on the social functions of the programmes and of the apparently negatives qualities of administration of these programmes. Administrative problems may be none other than reflections and even the partial absorption of broader problems of the society, and the increase of productivity in narrow terms, may only result in irrelevance. 26/
8. The technologies which are most important to help the developing countries towards technological and environmental development, are training and educational programmes and information systems. These are basic for all decision-making and progress in any sector. They should be the first technologies considered for any particular problem and to assure a capability in the long-run for problem-solving. Yet educational and information technologies are also the most obvious vehicles of alien values which contradict real development, and it is imperative that national projects and policies are most explicit and realistic about the political power and ideology which such vehicles represent. 27/
9. Continuous development of theory is basic to any national project for technological and environmental development. This is the orientation of basic scientific back-up which is most important to assure integration of empirical feedback and the constant adaptation of policies, to avoid "mystification" of ideas while taking advantage of new innovations on the world market, to spur an evolution of concepts of appropriateness of technologies (and of environmental mutations which they might affect) and to move a country from a dependent structure to different stages of self-realization. 28/
10. The use of cost-benefit comparisons is implicit, if not explicit, in most community and technocratic decision-making regarding the selection of technologies. There is no manner known by which such an approach can be made adequate to assessing key environmental consequences, 29/ and there is always legitimate grounds for questioning the conclusion of any cost-benefit analysis due to the subjective choice of variables, due to the generally unsystematic selection of sources of information

/for the values and

for the values and due to the great amount of leeway which the analyst has in combining acceptable variables and ranges of values. At best, the use of cost-benefit analysis should be structured as if it were a free-wheeling pedagogical exercise. 30/

While these conditions are clearly antithetical to those of the modernization cycle, for the most part they could be compatible with any of the three models which have been described here as alternatives to the modernization cycle. The problem of these models is that they posit additional conditions which actually sustain dependent structures and thus reduce the possibilities of technological development or environmental development.

In conclusion, development has been assumed here to combine diversity and social meaning, individual creativity and community protection of ecosystems. This mixture of goals could benefit from an eclectic selection of tactical elements from the different models of technological change. However, a sharp break with present modes of technology assessment and transfer must be made.

Less decisive than the apparent conflicts between technological, environmental and economic development goals, are the real conflicts between interests which would pursue economic development goals their way and the lines of action which are consistent with technological and environmental development.

It is not clear that there is a substitute for revolutionary action, which regenerates popular confidence in individual and community creativity, and which is as tolerant of the small errors made during such creativity as the world is now of large-scale degradations and environmental stresses.

FOOTNOTES

- 1/ The concepts of ascending and dominant styles, and the definition of the ascending style in terms of four components similar to those set out in Chart 2, are proposed by José Villamil in a working paper for this project.
- 2/ Osvaldo Sunkel and Edmundo Fuenzalida, "Transnational Capitalism and National Development", in José J. Villamil, ed., TRANSNATIONAL CAPITALISM AND NATIONAL DEVELOPMENT, NEW PERSPECTIVES ON DEPENDENCE, Harvester Press, 1979.
- 3/ Karen Remmer, "Evaluating the Policy Impact of Military Regimes in Latin America", LATIN AMERICAN RESEARCH REVIEW, XIII (2), 1978, 39-54.
- 4/ This section is adapted from, Win Crowther, "Problemas relacionados con la transferencia internacional de tecnología: La experiencia de América Latina y analogía con aquella de los países del Pacífico occidental", in Francisco Orrego Vicuña, ed., CIENCIA Y TECNOLOGÍA EN LA CUENCA DEL PACIFICO, Santiago, Chile, Universidad de Chile, Instituto de Estudios Internacionales, 1976.
- 5/ Ibid.
- 6/ UNITAR Project on the Future, TECHNOLOGY, DOMESTIC DISTRIBUTION AND NORTH-SOUTH RELATIONS, Progress Report, August 1978.
- 7/ The very widespread imagery of blame on "politics" as imposing unfortunate constraints on technological progress, shields the inherently constricted nature of this progress under the modernization cycle. Actually, it may be a "politician" or bureaucrat, or a popular rebellion, which forces the technocrats to consider new potential uses of a technology. All of the steps in technology assessment (Graph 1) are political acts, with group and personal interests "represented" in each decision that is taken. The discarding or selecting of "characteristics of suitable technical variants" often is a precipitated act of defining the technology, and subsequent social and political interventions may correctly question this selection.
- 8/ Development models often treat technology as a wholly exogenous phenomenon. In some cases, however, rather specific positions are taken regarding the role that technology should play. This is evident in each of the three "southern" (developing world) scenarios or perspectives of development as summarized by the UNITAR project on the future. These three scenarios, of the New International Economic Order (NIEO), of "collective self-reliance" and of "Unequal Exchange", differ according the relative emphasis placed on technology for heavy industrialization (including for export-led policies), new appropriate technologies with a

/tendency to concentrate

tendency to concentrate on basic sectors and redistribution, and the control of technological transfers from the more industrialized (Northern) countries. See footnote 6.

- 9/ It is basically this model which has guided the negotiation within the United Nations of a code of conduct to be observed by transnational corporations. The Third World states are trying to use international regulation as an instrument to reinforce their individual bargaining with the transnational corporations, but neither the international regulations nor the national socio-economic planning threaten the world corporate system. One reaction to the dismal results of the second model which will be described here, of a local science and technology infrastructure, and to the fact that (as the results of the Science and Technology Policy Instruments project demonstrate) in "none of these countries was modern industry developed gradually, based mainly on local indigenous innovations", is to conclude that "industrial growth and technological development in LDCs is dependent upon the openness of the governments in the international market", as long as a "techno-economic" approach is taken and scientific and technological activities are programmed for broader proliferation and stronger modification than would be the inclinations of the transnational corporations. Kun Mo Chung, "Making Industry Competitive", in David Spurgeon, GIVE US THE TOOLS: SCIENCE AND TECHNOLOGY FOR DEVELOPMENT, Ottawa, Canada: IDRC, 1979, 49-66.
- 10/ In practice, the protection of the environment is of low priority among matters taken up with the transnational corporations by the Latin American governments which adopt this model. But such concerns could be an issue at the insistence by such "corporation States" ("Estados empresariales"), and subject to "concessions" by the transnational corporations. The model, as it has been practiced in the region, is described by Guillermo O'Donnell, REFLEXIONES SOBRE LAS TENDENCIAS GENERALES DE CAMBIO EN EL ESTADO BUROCRATICO AUTORITARIO. Buenos Aires, CEDES, 1975; Fernando Henrique Cardoso y Enzo Faletto, "Post-Scriptum a ' Dependencia y Desarrollo en América Latina'", in Daniel Camacho, DEBATES SOBRE LA TEORIA DE LA DEPENDENCIA Y LA SOCIOLOGIA LATINOAMERICANA, San José, Costa Rica: EDUCA, 1979, 95-135; Peter Evans, DEPENDENT DEVELOPMENT: THE ALLIANCE OF MULTINATIONAL, STATE AND LOCAL CAPITAL IN BRAZIL, Princeton University Press, 1979; Norman Girvan, CORPORATE IMPERIALISM: CONFLICT AND EXPROPRIATION, New York, Monthly Review Press, 1976.
- 11/ For example, this is the focus of the United Nations' Economic Commission for Latin America, CONSIDERATIONS ON SOME RECENT EXPERIENCES IN THE PROMOTION OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT IN LATIN AMERICA, ST/CEPAL/CONF. 53/L.4, Meeting on Science, Technology and Development in Latin America, 19 November 1974. Also Carlos Tunnermann B., "Fundamentación del programa centroamericano de desarrollo científico y tecnológico", REVISTA CENTROAMERICANA DE CIENCIA Y TECNOLOGIA, I, January-June 1978, 11-26.

- 12/ Francisco Sagasti, CIENCIA Y TECNOLOGIA PARA EL DESARROLLO: INFORME COMPARATIVO CENTRAL DEL PROYECTO SOBRE INSTRUMENTOS DE POLITICA CIENTIFICA Y TECNOLOGIA, Ottawa, Canada, International Development Research Centre, 1978. Francisco Sagasti, "Esbozo Histórico de la Ciencia y la Tecnología en América Latina", INTERCIENCIA, 3(6), November-December 1978, 351-9.
- 13/ For example, Francisco Sagasti, TECNOLOGIA, PLANIFICACION Y DESARROLLO AUTONOMO, Lima: Instituto de Estudios Peruanos, 1977.
- 14/ Crowther, op.cit., 10-12.
- 15/ For example, Amilcar Herrera, "Desarrollo, medio ambiente y generación de tecnologías apropiadas", E/CEPAL/PROY.2/R.1; Project ECLA/UNEP, Development Styles and Environment in Latin America, August 1979. Also, Paulo Freire, PEDAGOGY OF THE OPPRESSED, New York: Heder & Heder, 1972 and Jeffery James, "Growth, Technology and the Environment in less Countries: A survey", WORLD DEVELOPMENT, 6, 1978, 937-65. Karl Deutsch has undertaken theoretical work on this, without arriving at a clear conclusion, THE NERVES OF GOVERNMENT, New York, The Free Press, 1963. A useful distinction between types of self-reliance is made by Francisco Sagasti, "Autodeterminación tecnológica y cooperación en el Tercer Mundo, ESTUDIOS INTERNACIONALES, 9 (33), 1976, 47-61.
- 16/ Oscar Varsavsky, ESTILOS TECNOLOGICOS: PROPUESTAS PARA LA SELECCION DE TECNOLOGIAS BAJO RACIONALIDAD SOCIALISTA, Buenos Aires, Ediciones Periferia, 1974. The difficulties of de-linking are evident in the reactions of technocrats who refuse to adjust to it. A case study is Rufo López-Fresquet, MY FOURTEEN MONTHS WITH CASTRO, Cleveland World Publishing, 1966. See also, Richard Fagen, Richard Brody and Thomas O'Leary, CUBANS IN EXILE, Stanford University Press. 1968.
- 17/ In Hetman's words, "It is not technology but man who shapes society". Francois Hetman, "Steps in Technology Assessment", INTERNATIONAL SOCIAL SCIENCE JOURNAL, XXV (3), 1973, 257-272.
- 18/ Marxist sociologists have noted that to explain underdevelopment, the transfer of the social organization of modernization, rationalization and dynamics of the capitalist society to the periphery is as important as the exploitation of the economic surplus in the periphery. For example, Gerard Pierre-Charles, "Teoría de la dependencia, teoría del imperialismo y conocimiento de la realidad social latinoamericana", in Daniel Camacho, DEBATES SOBRE LA TEORIA DE LA DEPENDENCIA Y LA SOCIOLOGIA LATINOAMERICANA, San José, Costa Rica, EDUCA, 1979, 45, 51.

/19/ These assertions



19/ These assertions refer to the existence of marked differences among sectors, subsectors and branches of industry, and argue that potential effectiveness of specific science and technology instruments in a sub-sector or branch of industry seem to be closely related to the degree of oligopolistic competition among companies at the international level and degree of propriety regarding know-how, and these in turn are related to the scarcity and nature of demand for the materials and information required by the technologies, the internal logic of core technologies and the degree of configuration or restriction in the scientific base of the technologies. Thus some technologies are considered to be more naturally suitable than are others for turnkey transfers and mass production techniques, and in turn are more or less susceptible to international cartelization.

See especially:

Walter Chudson, THE INTERNATIONAL TRANSFER OF COMMERCIAL TECHNOLOGY TO DEVELOPING COUNTRIES, UNITAR Research Report 13, New York, UNITAR, 1971;

Francisco Almeida Biato, Eduardo Augusto A. Guimaraes, and Maria Helena Poppe de Figueiredo, A TRANSFERENCIA DE TECNOLOGIA NO BRASIL, Brasilia, Instituto de Planejamento Economico e Social, 1973;

James Thompson, ORGANIZATIONS IN ACTION, New York, McGraw-Hill, 1967; and

Richard Whitley, "Types of science, organizational strategies and patterns of work in research laboratories in different scientific fields", SOCIAL SCIENCE INFORMATION, 17 (3), 1978, 427-48.

While admittedly it is difficult to sort out causes and effects among all these factors, it is unnecessary and unconvincing to ascribe to technology some attributes as being inherent, when in fact these attributes have to do with choices made regarding the organization, ownership and definition of a technological package. As to organization and ownership, transnational corporations have shown a high degree of mobility in changing the terms and sectors in which they concentrate their direct investments and indirect controls.

20/ Each of the three models of technological change makes different assumptions about science. The first model generally accepts the arguments for a liberal science, based on competition, ideological neutrality, universal validity, independence from technological applications, support for expensive research according to the scientists own interests and with a tendency to consider natural science and management ideologies as more pertinent than social sciences for fostering industrial growth and man's control of nature. The science and technology infrastructure model departs from liberal science, not in questioning its validity, so much as the freedom of choice of problems. Scientific research should be linked to priority social concerns and needs, a closer relationship should exist between science and technology, the ideological content of science should be clarified and the social sciences should be favored. The appropriate technologies model is more likely to question even the epistemological basis of science upon realizing the need to integrate cultural values and

/traditional approaches

traditional approaches to myth-making and problem-solving with the scientific approach. Truth is relative, conditioned by axioms which are chosen. It is not the prerogative or special concern of any particular group. See Oscar Varsavsky, "Ciencia, dependencia y estilo de desarrollo", REVISTA CENTROAMERICANA DE CIENCIA Y TECNOLOGIA, 1, Enero-Junio 1978, 37-56.

- 21/ For example, Samir Amin, UNEQUAL DEVELOPMENT: AN ESSAY ON THE SOCIAL FORMATIONS OF PERIPHERAL CAPITALISM. New York: Monthly Review Press, 1976. CPID/World Council of Churches and Association of Third World Economists, TECNOLOGIA Y NECESIDADES BASICAS, San José, Costa Rica: EDUCA, 1979.
- 22/ Herrera, op.cit. Sagasti, TECNOLOGIA, PLANIFICACION Y DESARROLLO AUTONOMO, op.cit.
- 23/ Thus some skepticism is justified about Herrera's preference for the rural sector for undertaking self-reliance programs, when one considers the tendency of the Integrated Rural Development projects, which are designed to encourage participation in the developing countries, but end up relying on planning by top-down expert-guidance and on a huge infusion of resources from outside; and the reaction of the rural aristocracy in Brasil and Chile to Paulo Freire's experiments. If the system is not really in favour of self-reliance, these isolated experiments remained contained, or simply are forced to withdraw.
- 24/ Pierre-Charles, op.cit.
- 25/ One point of view is that this is easier to control if the major economic activities are nationalized. However, that in itself does not assure a **solution**. State managers may pressure for freedom from import barriers on the grounds of social need, and actually engender an increase in irrelevant technology transfers.
- 26/ This is the danger of the management-by-objectives approach, as it is advocated, for example, in United Nations, GUIA PRACTICA PARA MEJORAR DE FORMA PROGRAMADA. EL RENDIMIENTO DE LAS ORGANIZACIONES PUBLICAS, ST/ESA/SER.E/9, 1978. In this methodology, expectations and pressures affecting an organization are only partially revealed or implied when the administrators are asked about their organizational problems.
- 27/ Warren (Win) Crowther, INFORMATION, DEVELOPMENT STYLES AND ENVIRONMENTAL PROBLEMS IN LATIN AMERICA, paper for this conference. Junta del Acuerdo de Cartagena, ANDEAN PACT TECHNOLOGY POLICIES, Ottawa, Canada: IDRC, 1976.

- 28/ Salvador Romero, "Aproximaciones en torno a las concepciones científicas en las sociedades en desarrollo", in Ataliva Amengual S. and Jaime Lavados M., EL ROL DE LA CIENCIA EN EL DESARROLLO, Santiago, Chile: Corporación de Promoción Universitaria, 1978, 47-58.
- 29/ James, op.cit.
- 30/ Aaron Wildavsky, "The political economy of efficiency: cost-benefit analysis, systems analysis and program budgeting", PUBLIC ADMINISTRATION REVIEW, December 1966, 292-310. Allen Schick, "Systems politics and systems budgeting", PUBLIC ADMINISTRATION REVIEW, March-April 1969, 137-151.

APPENDIX I

THE MODERNIZATION CYCLE

(Refer to Graph 3) 1/

1. Innovation and invention

- (a) As opposed to the thesis which argues that invention is cumulative in the sense that it is independent and motivated by technical necessity, it is more useful to consider the varied motivations and interactions of the inventor and the investor in situations where the latter is interested in cutting costs, winning wars, obtaining status or decreasing uncertainties of economic decisions. Improvements, in contrast to inventions, are normally directly related to immediate market conditions.
- (b) Prestige and information systems in the developing countries tend to be weighted towards the diffusion of innovations sponsored by transnational enterprises rather than innovations founded on the immediate experience and problems of the country itself. This means that there are more incentives, but not necessarily more opportunities, for creativity in more industrialized than in developing countries.
- (c) There is a considerable potential for on-going, in-plant, minor and incremental innovation in developing countries, which is frustrated by the nearly exclusive association of progress with injections of large-scale technological packages and R&D activities. 2/
- (d) A key factor explaining the lack of recognition of the innovative capacity and opportunities for creativity in most Latin American countries is the generalized attitude that technological stagnation is inevitable unless a plant or infrastructure is provided with a minimum number of what are considered "modern" elements.

2. The political definition of technologies

- (a) When a new or apparently technological item, such as a computer or locomotive, is offered in the international market, major interest groups study the manner to influence the definition of a technological packaged based on this item. They will try to affect the choices made regarding software types of personnel, marketing and access to capital markets which will be considered necessary for the application or use of the technological item. They will try to help define "computerization" for the computer, "dieselization" for the locomotive, etc. The particular problems, needs and resources of the societies

/or organizations which

or organizations which will receive the technological package are less important to these groups than are the conditions of the society or organization for accepting the technology.

(b) A technological package incorporates instructions for its use, indications of what performance data should be collected, and a set of performance standards against which this data are to be compared. These data and evaluation components (i.e. know-how), which are part of any technological change (or it may be the core or the change), are designed to record and evaluate events as if the technology was being implemented in any culture. These criteria do not demonstrate whether or not the technology is suitable or appropriate, but rather to what extent the recipient society or organization meets modern standards, or has successfully applied modern techniques. The feedback is technique-oriented, not oriented to cultural or organizational purposes or opportunities. It is presumed that the society or organization needs to adapt. The data and evaluation components of technological packages are thus perhaps one of the most subtle and effective instruments of dependence. 3/

(c) Technological packages commonly include normative assertions that the technology "requires" certain conditions or complementary investments, which become accepted on face-value without empirical evidence.

### 3. The selection of technologies

(a) The selection of technologies in recipient organizations or societies is closely linked to the strategy of reducing uncertainty. For that reason, the selection is often influenced by the following attitudes:

1. Preference for hardware solutions, even for problems of organization and administration which have historically resisted resolution by the introduction of machines.
2. An emphasis on continuing large-scale capital investments, rather than on marginal less-costly changes.
3. Use of the technology for a particular set of services or products, rather than with the wide range of possible services or products which could be obtained from the technology.
4. A view of socio-political factors, and of labour, as forces to overcome or avoid rather than as sources of useful energy and checks to assure that the technology is relevant to social conditions and objectives.

/(b) Due to the process

- (b) Due to the process by which technological packages are commonly defined, the selection of technologies is confined artificially to a limited set of choices. Thus, while technological progress is the widening of choices which are theoretically possible, this progress can lead to the sophisticated presentation of a limited number of possibilities which are in fact considered. Key reasons why developing countries accept this are (i) the generalized belief that there are technological imperatives, and that these, together with rising expectations, practically make the production obligatory of determined goods and services, (ii) the attractiveness of analyzing a society's or organization's shortcomings in terms of the ability to adapt to a pre-defined technology rather than diagnosing problems and resources and choosing or inventing technologies appropriate for those problems or resources, (iii) the tendency to try to narrow the number of variables considered during the search for solutions ("problemistic search") and (iv) the defense by professional or other groups of an intermediary role with regard to technology, using the myth of "anti-politics".
- (c) Contradictions between the social implications of the technology which is selected and the pronounced global partisan ideology of the professional or technician generally go unrecognized by the professional or technician himself. The professional or technician disassociates three levels of ideology, not realizing that he is pronouncing and acting on contradictory principles. His global partisan ideology is normally associated with a political party or an attitude towards economic and political development. At a different level, he justifies and describes his professional or technical work in terms of social and economic consequences, often with only a vague relation to the global partisan ideology. Finally, detailed examination of the content of his work usually demonstrates a very different ideological orientation, often very surprising to the professional or technician when his attention is called to it. 4/
- (d) Particular criteria regarding the appropriate variables and values to be used in evaluations or analyses of technological alternatives usually accompany or become identified with the technological package. The "legitimate" range of values which can be assigned to such coefficients as useful life of the machine, residual value of machines that are replaced, investment/maintenance ratios and rate of return is generally quite ample (as much as 50% difference between the lowest and highest acceptable values). Almost any technological selection can be justified by the right combination of legitimate values for the basic coefficients, irrespective of the values which are obtained empirically for the other variables.

4. The agents and conditions of diffusion of technologies

- (a) The transnational corporations are prime promoters of technological packages, often with a direct economic interest in this diffusion. Four prime strategies are used. First, the corporations invest considerably in the diffusion and selling of symbols, including trade marks, of the technological packages. Second, they attempt to maintain an artificial scarcity of technological information, taking advantage of legal devices (such as patents) to create such scarcity, and refusing to sell only the information they control but rather insisting on the purchase of entire technological packages which include such information. Third, they multiply the benefits from their control of "know-how" by means of different royalties, overpricing and other devices, especially where foreign subsidiaries can be established, all of which has been analyzed in depth by previous documents. 5/ Fourth, the corporations have acquired increasing sophistication in their methods of obtaining general legitimization and acceptance of their own technologies. Recognition and support for the value of the technologies for universal application in the form that they are offered by the corporations, is obtained indirectly from banks and international organizations.
- (b) Professional groups in the organizations or societies which might apply or use a new technology identify themselves as the proper experts regarding the administration of the technology, to the extent that the technology appears to offer the possibilities of domination of a line of work which appeals to them and will not be disruptive of the stable environment which they consider conducive to their work. The professionals or technicians expand their work to incorporate new concerns and technologies usually in a long process of negotiation with their institutions of work and with other professions. Care is exercised to protect the exclusive "prerogatives" which have already been obtained by the profession to make decisions or studies, and to protect the "autonomy" of certain institutions (e.g. public enterprises) which the professionals or technicians come to consider as their own political domain.
- (c) The transfer of inappropriate technological packages, and the control of decisions regarding those technologies by professional or technical groups, depend on the existence of a national political structure favorable to such an approach to the selection of technologies. Among the structural factors are the following:
1. A tradition of assigning specific policy concerns to decision-making by professional groups. Career personnel systems and closed information systems, with special personal channels for access by elite groups to the professionals, are indicative of

/such a tradition.

such a tradition. Another indicator is the boom in State enterprises which try to imitate organizational standards of the transnational corporations and to monopolize an economic subsector in a country. Such enterprises, as noted above, often become dominated by professional groups.

2. A regular sequencing or incrementing of economic benefits which are made to the most powerful political pressure groups, for example by means of cyclical credit policies which lead to rather regular variations in inflation rates.
  3. A skillful centralized governmental apparatus capable of absorbing or repressing the pressures by newly mobilized pressure groups for governmental expenditures attuned to their more immediate needs.
- (d) There are certain economic policies which tend to reinforce the acquisition of technological packages, unless explicit corrective measures are applied. Among such policies is that of import substitution.
- (e) The modernization cycle is also reinforced by the following conditions:
1. The conditions of financing of development projects (e.g. tied loans), which require the use of the technology of the country making the loan. These same conditions are applied in a more subtle form, when the specifications of technology to be purchased under financing by international organizations are such that the recipient country is forced to recur to certain suppliers.
  2. Direct foreign investment leads to a stronger conformity, by the subsidiaries, with restrictive conditions, overpricing, clauses, etc. 6/ It also implies considerably less investment in the developing country in R&D. 7/
  3. The inadequate development of local scientific and technological research and development (R&D) reinforces the dependence on packages from outside.
  4. The public enterprises created to produce for export in combination with transnational corporations, and to monopolize local markets with regard to a subsector, will adopt the technological specifications and quality controls of the corporations. 8/

/5. Those economic



5. Those economic and technological factors which are conducive to a higher proportion of "commercial technology" (proprietary knowledge) in the technological package.

Footnotes for Appendix I

- 1/ The following points, with case studies and examples, are explained further in: Win Crowther, Technological change as political choice: The civil engineers and the modernization of the Chilean State Railways, Doctoral dissertation, Department of Political Science, University of California, Berkely, California, 1973, pages 393-801.

The idea of cycles of introduction of innovations by groups of professionals and technicians is also developed and studied in French enterprises, by Michel Crozier, The Bureaucratic Phenomenon, Chicago, University of Chicago Press, 1964. Theotonic DosSantos recognized early the new forms of dependence as the transfer of such innovations from the centre to periphery. EL NUEVO CARACTER DE LA DEPENDENCIA, Santiago, Chile, Editorial Universitaria, 1969.

- 2/ Stephen C. Hill and R. Martin Bell, "Paradigms and Practice: Innovation and Technology Transfer Models - their Unexamined Assumptions and Inapplicability Outside Developed Countries", Draft, Science Policy Research Unit, University of Sussex, August 1974, mimeo.
- 3/ Warren (Win) Crowther, "Information, Development Styles and Technological Problems in Latin America", August 1979.
- 4/ The ideological content of the technocrats' studies or decisions may be demonstrated in two ways. One method is to examine the variables which are taken into account. Another method is to examine the sources of the information which are used to determine the values of the basic coefficients involving space, time or the relationship between cost and benefit. In both methods, a particularly important factor is the group of beneficiaries, or users, which is implied. All technological decisions and projects involve redistribution of resources from one group to another. Very often the supposed beneficiaries are not the real beneficiaries, as can be determined by a careful content analysis.

/5/ Constantine V.

- 5/ Constantine V. Vaitsos, "Bargaining and the Distribution of Returns in the Purchase of Technology by Developing Countries", Bulletin of the Institute of Development Studies of the University of Sussex, October 1970, pages 16-23; Industrial Development Division of the United Nations' Economic Commission for Latin America, "La Transferencia de Tecnología Industrial Extranjera de los Países Latinoamericanos: Características Generales de Problemas y Sugerencias para la Acción", in Ensayos sobre Política Tecnológica en América Latina, edited by Karl-Heinz Stanzick and Peter Schenkel, Quito, Ecuador, Instituto Latinoamericano de Investigaciones Sociales, 1974. Luis Soto Krebs, "Tecnología en el Grupo Andino", in Ciencia y Tecnología en la Cuenca del Pacífico, edited by Francisco Orrego Vicuña, Santiago, Chile, Instituto de Estudios Internacionales, Universidad de Chile, 1976.
- 6/ Luis Soto Krebs, op.cit.
- 7/ Peter Evans, Dependent Development: The Alliance of Multinational, State, and Local Capital in Brazil, Princeton, Princeton University Press, 1979; Anant R. Negandhi and S. Benjamin Prasad, The Frightening Angels; a study of U.S. Multinationals in developing countries, Kent State University Press, 1975, 213-8.
- 8/ Raymond Vernon, "Storm over the Multinationals: Problems and Prospects", Foreign Affairs, 55 (2), January 1977, 243-262.