Contents

Introduction

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As part of the preparations for the United Nations Conference on Science and Technology for Development, to be held in Vienna in August 1979, the U.N. Advisory Committee on the Application of Science for Technology to Development (ACAST), with the cooperation of the U.N. Office for Science and Technology, organized a number of symposia involving the world scientific community and non-govermental organizations to discuss some of the major issues.

The first symposium was held in Tallin, U.S.S.R., on January 8-12, 1979, on Science and Technology for Solving Global Problems Facing Mankind; the second at Singapore, January 21-28, 1979, on Science and Technology for Development; the third in Kuala Lumpur, April 27-30, 1979, on Science, Technology and Development: Views from the Developing World. A fourth symposium, on Science and Technology in Development Planning, was convened in Mexico City, May 28 to June 1, with the joint sponsorship of ACAST, the U.N. Development Planning Committee (CDP), the U.N. Department of International Economic and Social Affairs, the Secretariat of the U.N. Conference on Science and Technology for Development, and El Colegio de Mexico, with the collaboration of the Mexican National Council for Science and Technology.

Reports from these symposia are being issued as part of the documentation of the International Colloquium on Science, Technology and Society; Needs, Challenges and Limitations, also sponsored by ACAST, to be held in Vienna on August 13-18, 1979. The Report on the Mexico Symposium will be available to the Colloquium, as well as to the Conference and for general circulation, together with a second, short document entitled "The Dynamics of Science, Technology and Development Planning". The Symposium was attended by 44 participants from different parts of the world, from both developed and developing countries and both market-economies and centrally planned economies, and 17 representatives of international organizations. It was the first occasion, under United Nations' auspices, in which development planners (several of them members of CDP) and those specialized in science and technology policy (including members of ACAST) met to discuss the interactions between science, technology and development planning. That is, the main focus of the Symposium was on planning rather than on development in general, recognizing the complex link between such planning and the trends and policies in matters of science and technology.

Although discussion was not limited to the case of the developing countries - in fact, experiences of both developed market-economies and centrally-planned socialist countries were taken into account - the main emphasis was on the issues as they present themselves in the LDCs. In addition to general interactions and the particular problems connected with the planning of science and technology in developing countries, attention was paid also to these relationships in sectoral planning (e.g. energy, food, health and capital goods) and to the use of new techniques in development planning (information services, systems analysis, technology assessment). Finally, consideration was given to aspects of international cooperation.

The present volume contains a selection of the papers contributed to the Mexico Symposium, under the five agenda items, intended to convey to the reader the main lines of thought brought to the Symposium and to illustrate various approaches. Together with contributions to the other symposia, ACAST expresses the hope that the material which follows will enrich the discussions at the Vienna Colloquium and the U.N. Conference and help clarify issues which are basic for the development of LDCs and for a more balanced and equitable international economic order.

FOOTNOTE

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PART I

The General Context: Interaction between Science and Technology and Long-range Development Goals and Strategies

1. Science and Technology Planning: Possibilities and Limitations

GERARD K. BOON

INTRODUCTION AND SUMMARY

The aim of this paper is to explore the possibilities and limitations of the planning of science and technology. To facilitate the discussion three basic questions are posed:

Should science and technology be planned?

Can science and technology be planned?

How should science and technology be planned?

The first two questions are answered for both developing and developed countries. The last question, which is the most difficult of the three, is answered only for developing countries in general. Also, in answering this last question, the discussion considered technology planning only due to limitations of space. Technology planning is more urgent, of more short and medium term significance and more complex than science planning. Further, only the case of the market regulated economies is analyzed. Planned economies also by definition plan their science and technology but I have insufficient information available to report on the successes and failures in this kind of planning.

Although the term appropriate technology is used sparsely, the concept is implied in much of the discussion in this paper and it is therefore useful to define it: appropriate technology is a means of production or know-how which minimizes, from a private or social point of view, sacrifices for given benefits or maximizes benefits for given sacrifices, given its compliance to a number of essentially varying conditions. (1) The conditions may refer to those relevant in a micro and macro setting and can be of any nature: technological, economic, socio-political, cultural, and so on.

It is important that we note that this definition covers private and social appropriateness. Given the reality in which a considerable portion of the technology traded is transferred on the basis of a market mechanism, the issue is now can a choice and change of technology be tailored to a greater social appropriateness. This definition and the interpretation given to it underlie the discussions presented in this paper.

Briefly, the paper is summarized as follows. I believe that science and technology should be planned in both developing and developed countries. Nevertheless, the word planning is very broadly defined and includes informal, indirect guidance by various ways and means. However, whatever the type of planning it should be based on a comprehensive conception of present and future needs of society.

It is argued that science planning is in certain aspects more simple since in most countries it is financed almost entirely by public funds, implying a certain control and influence. Technology planning is more complex because its choice and change largely occurs in private enterprise.

The second question is also affirmatively answered for both developed and developing countries. Broadley two types of technology are considered: 'more static' and 'dynamic'. There is an interdependent effect between technology and its change in time and society. However, dynamic technologies tend to influence and to shape society more than static technologies. The net impact of the latter technologies is such that they are more conditioned by society than society by them. The reverse is the case for dynamic technologies. In the developed societies it is therefore essential to guide or control, respectively by direct or indirect ways, the changes and innovations in the dynamic technologies or at least to follow closely their developments and to evaluate at an early stage their possible impacts on society. There is much less need in the developed societies to guide the 'more static' technologies in their development because they are conditioned to such an extent by society that their characteristics, merely by indirect influences, reflect society's needs.

In the case of developing countries it is useful to differentiate technologies further between those traded and allocated through a market mechanism and those which have a monopoly character, in various degrees, in their availability. Most often dynamic technologies are characterized by a more monopolistic transfer. Nevertheless there are certainly means of planning in the sense of influencing and controlling their transfer and even of the location of their R and D. The 'more static' technologies encounter a greater need for planning in the developing countries than in the developed ones. The reason is that most developing countries depend on the First World for this technology.

Since the 'more static' technologies are very much conditioned by society in their place of origin, they are less suitable for societies with different conditions. This, in principle, increases the need for influence and control of these technologies by countries that depend on their foreign imports.

The last section of this paper tries to be more specific in answering the question 'How can technology planning in developing countries be fulfilled?' A sectoral breakdown is made: formal, semi-formal (semi-industrial) and informal. The two-dimensional technology concept (more static, dynamic) only needs to be introduced for the formal sector. An answer is attempted for a two-dimensional time concept, the present, the choice of technology and the future, the change of technology, for all three sectors. A comprehensive technology planning needs a number of objectives which need to be consistent with the overall development objectives. Essentially this aspect is socio-political. The major parameters and conditions which influence the choice and change of technology at the micro level are listed. Accordingly, the choice and change of technology can be influenced by manipulating the controlling variables and conditions comprehensively and consistently.

SHOULD SCIENCE AND TECHNOLOGY BE PLANNED?

The question whether science and technology should be planned can be answered in general terms and also more specifically. In the latter case the question to be answered should read: 'To what extent is there a real need for science and technology planning?' This question needs more information and a more detailed analysis and is answered in the next section together with the possibility or feasibility of science and technology planning.

To answer the general question posed above three of the six words used in the question need clarification. What is meant by planning? Aspects of this concept concern: (i) its level of aggregation or detail; (ii) its degree of institutionalization; and (iii) its degree of effective power as to its potential penetration into the decision process of entities of a lower and a different legal nature. In this paper planning is conceived in a wide sense including a type which has only advisory and indirect means of guidance and control at its disposal.

As far as the terms science and technology are concerned it is not only necessary to differentiate between the two but also to stress that there is no need to use both words in conjunction. Certainly as far as this paper is concerned, it is necessary to separate both concepts. Although there is a certain inter-relation, both concepts are different, following distinct processes of creation, and are mainly sensitive to different conditions and parameters. Science refers to a more general infrastructural condition of non-applied knowledge embodied in the relevant literature and in a number of individuals.

The ability to apply scientific knowledge to solve practical problems is the necessary step to gain know-how which is specific. This stage may or may not be followed by the creation of technology, which is applied know-how in a physical or chemical form. In the creation of know-how one needs a scientific infrastructural base. The development of a scientific infrastructural base is a costly and time-consuming process. Countries that wish to develop economically and industrially usually do not have the time ot wait for the formation of this scientific infrastructure which may easily take a period of several generations, and they therefore start to rely on foreign science infrastructures and foreign developed technology. Science and technology each in its own particular way are imported.

All countries clearly want to reduce their dependence on foreign science and technology. To this end, almost all countries have some plan of action to cope with this particular problem of dependence. Since the desire to reach development, or to maintain a certain level of development, is currently felt so strongly, it is hardly possible to leave this very basic infrastructure building for science completely to spontaneous forces. The time limit set for concrete development results implies that the development of the scientific infrastructural base and the technological capability of the country has to be planned to a certain degree. Hence, although it is true that science and technology in the Western World developed for centuries without any planning, the situation in today's world is different mainly for two reasons: firstly, the desire to achieve in one generation what before took hundreds of years; and secondly, today's science and technology issues are far more complex than when the developed countries started to build their infrastructures. In such a situation only wise, realistic and careful planning may avoid bankruptcy, anarchy and revolution in the developing countries.

Although the above remarks refer only to developing countries, a need for a certain planning of science and technology may arise in developed countries even if they have a market regulated economy. The educational system needs almost constant adjustments to allow for apparent changes coming from both supply and demand. Certain scientific developments are achieved very quickly and several developed countries have difficulty in keeping abreast of what is going on elsewhere. Although small countries possibly have to specialize to a certain extent in scientific education and infrastructural facilities, such decisions themselves require a comprehensive view, a plan, a strategy and a policy. It is certain that a country which permits its scientific base to erode and to rely increasingly on a foreign developed science and technology will become subject to a process of underdevelopment.

Planning of the scientific infrastructure of a country is a necessity and totally distinct from manpower planning. Manpower planning merely tends to coordinate future demands and future supplies of students in all the various levels of education and to consider the implications of these future educational market conditions on the supply of teachers and educational facilities. The planning of science and scientific infrastructural facilities refers more to changes in the margin of the existing infrastructure concerned, to the assessment of areas for future potential rapid scientific changes and breakthroughs, and to the choices to be made of certain science planning senarios.

The planning of technological development should first start with the realization that, in contrast to science which in almost all countries is a public affair, technological choice and development in the First and Third Worlds occurs in private enterprise to a large extent. This is further analyzed below because it concerns whether or not technological choice and change or progress can be planned. Addressing first the question, 'should technological choice and change be planned' the answer is YES to the extent possible.

Why is the answer yes, and does this answer refer to both First and Third World countries? Indeed the affirmative answer, I believe, refers to both developed and developing countries. The reasons are the following: Firstly technology is an important variable affecting society to such an extent in many aspects and dimensions that no single government can complete ignore it or leave it solely to private enterprise to take care of. Hence technological choice and development should directly, although most indirectly, be controlled. The extent and nature of this control should be planned according to a number of criteria and objectives. The control mechanisms are not necessarily part of a direct planning system; they are more part of a policy on technological choice and development which should be consistent with the country's overall development objectives. Such a policy could be compared with a financial policy, which manipulates the money supply indirectly influencing the inflation rate. The latter is one of the important variables to control in a society. There are several options for controlling the inflation variable. The financial policy of a country is an indirect means of control but is not necessarily part of a formal planning system. Similarly a technology policy is an indirect means of control for the variable of technological choice and change, but is also not necessarily a direct part of a formal planning system.

For developing countries the control of technology is possibly even more necessary than for the developed ones, for the simple reason that these countries are mainly supplying their technological needs by imports of foreign technology - technology which is made within another environment and for another level of industrial and economic development. Indiscriminate imports of technology can be destructive to the society of developing nations and may create more problems than it solves.

The answer to the general question whether science and technology should be planned is therefore affirmative for both developed and developing countries, although the type of planning applied may be very informal and indirect and be restricted to controlling the choice of technique and influencing the path of technological change only by a rather overall science and technology policy. In the fourth part of this paper, which deals with the question 'How can science and technology be planned?', a more detailed discussion considers the need for a science and technology planning for a few technology categories in a number of settings.

CAN SCIENCE AND TECHNOLOGY BE PLANNED?

The answer to this question again mainly depends on what is considered to be planning and what kind of society will be involved. Every country can design a plan for science and its development in time. On the basis of a number of qualitative and quantitative targets, a plan may be formulated and policy guidelines expressed. By means of financial allocations for physical and human facilities certain science areas may be activated or stimulated while others may be restricted. Since most of the basic science-related activities are financed by the public administration, in principle, there is control and little problem in implementing a plan for its future course and development. In practice, there may be many problems since academic scientists are not particularly the type of people who can be pushed around, and structural changes in the scientific base of a country may be quite difficult to implement due to vested interests and subsequent rigidities in the existing structure.

However, more attention in this paper is given to the question of the planning of technology and its development and change over time because the technology of plannint issue is more sensitive, of more immediate importance, more concrete and more complex, due to its decentralized, often private firm, acquisition and creation, than science planning.

Technology planning is still in a stage of discussion; few countries have a consistent technology plan, even fewer countries have it in satisfactory operation. Since technology's change and progress is so vital to mankind, it cannot be left only to the responsibility ot private enterprises, working on the profit motive to create it. On the other hand, direct interference may considerably hamper the decentralized technological creativity. Besides, the criteria as well as the direct mechanisms for interference are quite complex. Possibly one of the main reasons why an adequate technology planning aiming at direct interference nowhere functions satisfactorily is the complexity of technology and its enormous diversity. Governments are unable to mobilize the know-how to come to a technological assessment which is needed to formulate direct, concrete directives manipulating technological choice and change at the firm level. Certain technologies, indeed, are exclusively developed by powerful multinational companies. Outside these multinationals, even at the universities, important details of these technologies are not known.

Nevertheless governments increasingly realize that technology, particularly future technology, needs to be manipulated with respect to its <u>direction</u>, in the sense of the particular branch or activity, its <u>speed</u>, the time <u>lapse within</u> which changes materialize, and its nature, as to its <u>substance</u> relative to the use of primary and intermediate inputs. However, there is considerable ignorance on how to go about this technology manipulation process. Therefore, before discussing whether technology can be planned, the subject matter must be defined more precisely. First, technology planning concerns two distinct aspects: the <u>choice</u> of existing or available technology and the <u>development or the change</u> of <u>technology</u>, by means of adaptations, innovations and <u>modernization</u>. In the discussion of this subject it is meaningful to distinguish two types of technology: 'more static' and 'more dynamic'.

More static technologies are those which are subject to evolution and which are designed to supply basic human needs. They embody manufacturing technological principles known and applied for centuries. More dynamic technologies are those which have been developed in the last hundred years or so with a very rapid revolutionary development in the last forty years. Examples are chemical, petrochemical, electric, electronic, nuclear, space and aviation technology. The degree in which the market regulates the supply and demand of technology differs greatly among technology types. Certain technologies are designed, created, produced in volume to be marketed. Other technologies are developed by big and powerful firms, often of a transnational character, for its own production needs. Therefore these technologies are not produced with the exclusive purpose of selling them in a market. They are produced to be used, in first instance, exclusively for internal company use. The technology is the exclusive property of the producer-user and therefore strong monopoly elements dictate its availability.

These two different types of technology freely offered for sale in a market and those which are not, with intermediate possibilities, and the distinction between more static and more dynamic technology do not fully match. In other words, dynamic technologies are not necessarily monopolistic in their supply. Finally, it should be remembered that part of the technology is not produced by private firms but by state controlled or state owned institutions and usually does not enter in a market either.

The choice and change of technology affects the society and the society affects in its turn the choice and change of technology. This interdependent relationship is of great importance to keep in mind and to analyze. I believe the impact of the more dynamic technologies and its changes on societ is most likely stronger than that of the more static technology. The latter technology is more subject to change in society. Hence, although difficult to quantify or to measure precisely, the net interdependent effect of the more dynamic technologies on society is such that they influence society more than society influences them; with the more static technology it is the reverse.

Particularly referring to the more static, market traded technologies, there is already in all societies much more conditioning in technological choice and development than generally believed. Considering a society which adheres to a kind of market economy for regulating the allocation of final goods, including technology, capital and labour, the choice of technology is almost a completely conditioned process. How is it conditioned when enterprises are free in their choice? It is conditioned by internal and external factors and by the entrepreneurial and technological behaviour of the firms. (2) First of all entrepreneurs do not optimize but, as Simon seems to have said a long time ago, satisy. Not necessarily all possible alternative technological options are considered, not necessarily all calculations are made but nevertheless many considerations, particularly of a qualitative nature, enter in the choice of technique. (3) First of all the output mix of firms on which the technology mix depends is conditioned by the nature of the final product market - the size and number of suppliers, the number of buyers, the income distribution, the fiscal system, the import regime, and many more factors such as the political and cultural regime, fashion and prestige trends and so on. By choosing technology, the conditioned output mix determines the technology mix in case of existing firms, where the choice concerns replacements of technology and technology increments due to capacity expansions. Further, in this situation, each firm has a history, a tradition, a technological and human capability which fixes the choice of technology and supplier almost entirely without any considerations about capital-labour prices. Nevertheless, the latter do play a role, particularly in the more static technologies.

If capital rates are high while a reduction is anticipated, the acquisition tends to be postponed. Almost all firms, wherever they are located, like to minimize on labour not only because its direct cost is often high but to reduce the dependence on the human input which is considered to be less stable and more troublesome than the capital input. Physical factors stemming from the quantity and quality output mix, such as the physical characteristics of the product, rate of output and its fluctuations, the homogeneity of the output, and the fluctuations in its diversity in time as basically the most significant parameters considered in the choice of technique. (4) These parameters are largely determined by the output mix which is conditioned by a number of complex factors. Changes in the import or fiscal system relating to the final output may have a profound influence on the choice of technique for producing this final output. The introduction of mandatory profit sharing arrangements for labour, for example, may lead a firm to choose the most automated technique available. It should be emphasized that no judgment is given here about the substance of fiscal, import and profit sharing measures in a political sense; only the effect of such measures and policies on the choice of technique are considered. Factors that are external to the firm include the range of alternative techniques available in the country, the import regime concerning these techniques, the number of sup-liers and the conditions quoted by these suppliers in the transfer of technology.

Most of the conditioning factors for the output and technology mix are outside the control of private enterprises. To plan the choice of technique or to influence or manipulate it, we first need to know which are the parameters and conditions playing a role in the orientation, evaluation, selection and acquisition of technology at the firm level (5); then their relative importance and how each of these parameters and conditions are influenced; and finally, how these influences can be controlled and manipulated with the aim of intervening in the choice of technique at the firm level.

This know-how is vital when implementing a technology plan and policy. The necessary insights and information are now largely available. (6) A major point to remember is that no government can formulate any regulation, decree or law without assessing its impact on the choice of existing techniques and on the choice and development of future technology. The social-economic institutional framework at the national and international level has a major influence on the technology issue as to its choice and future development. Even non-institutionalized factors and expectations of the future evolution of society influence technological matters much more than usually thought. Technology, more than science, is therefore very much a result of complex socio-economic, cultural and political factors, totally outside the strict technological field. Even without any planning and control, new technology of the more static type is more responsive to overall considerations in the wider sense than generally known. These points are further discussed in the next section which deals with how technology choice and change should be planned.

First we need to ask whether or not technological change can be planned. The change of technology is also conditioned, just as is the choice of technique. Both are geo-conditioned'. (6) Geo-technological change creates a geo-technology. Geo-technological change is a technological change which reflects the economic, socio-political, cultural and all other relevant conditions of the area where the technology is created. These same conditions in the area where it will be put to use also have an influence. However, there has to be a similarity in the conditioning factors in the area of creation and production and the area of use. If there is a large discrepancy, the producing area is not the most appropriate one to supply the using area with the technology it needs and the latter should either start to produce its own technology or look to an area with more similar conditions.

Economic research on innovations has so far found that in economics regulated by the market, innovation is market induced. For example, Jacob Smookler has convincingly shown this to be the case. (7) Nathan Rosenberg has shown that the speed of the technological progress often depends on the solving of scientific and technological bottlenecks in other seemingly non-related fields. (8)

I have confirmed both these findings for the technological progress in the polyester, textile and apparel industry, but this latter research has also supplied other evidence concerning aspects not mentioned or at least not empirically shown of significant importance before. (9) The geo-conditioning of technology and technological change concerns a different aspect of the innovative process and is partly in disagreement with the market inducement of technological change. Is market inducement an explanation for the innovative response of private technology creating firms, is the general state of the overall art of science and technology, to a certain extent, an explanation for its speed? The geo-conditioning of technological change is an explanation for its substance and nature.

The geo-conditioning of technology and technological change means that the economic, socio-political and cultural conditions prevailing in a area are fully reflected in the technology produced in that area and that therefore technology is the most appropriate to apply. This statement can agree with the market inducement explanation. It agrees if the market demand of a certain area for technology creates its own supply in that same area. In that case the conditioning factors in the supplying and demanding areas match completely. In reality the technical capability to produce a certain final output is more easily transferred than the technological capability to produce the technology with which this final output is made. This implies two fundamental aspects of the whole technology issue: firstly, it explains the phenomenon of technological dependence and, secondly, it implies the problem of the discrepancy in the appropriateness of technology between areas with different levels of economic and industrial development, factor endowment and socio-political, cultural and possibly religious conditions.

Although developing countries are becoming increasingly more important markets for technology, technology is seldom designed to meet their specific requirements. The reasons are partly the market inducement factor, partly the geo-conditioning factor. The demanding parties in the developing countries often believe that they require basically the same technology as the First World. Since their demand is marginal but consisting often of a very important increment to the total demand, there is not a clear necessity for the suppliers to attend to the basic and specific technological needs of the Third World. The technology therefore remains geo-conditioned by the producing area, that is the First World.

Technological breakthroughs in dynamic technologies have often been forced by conditions in society, the most apparent being those of a political and military nature. In nuclear physics, the atomic and hydrogen bombs; in electronics, the development of transistors and so-called electronic chips; rapid developments in aviation and space technology breakthroughs: all these can be traced to military and/or political considerations. This shows that although technological breakthroughs do not necessarily have to be planned, they <u>can</u> be planned.

Ample funds, talent for creating dynamic conditions and motivation, lead to technological breakthroughs. The lapse between initiating a basic research project and obtaining the desired result is a function of the factors mentioned. The relationships are proportional: more funds, talent and motivation more results or less time needed to achieve the objective. The function also depends on the 'state of the art' in related, and even in seemingly non-related, scientific areas. The relationship between inputs and research results may even be exponential. This probably depends on whether or not the more or less constant factor, at any given moment of the state of the scientific art, is not influencing the progress in the particular research to any significant degree. This type of basic research can be planned by allocating funds or other incentives to universities, private firms or state research laboratories. If a country does not have the scientific specialists available, talented people have to be sent abroad to acquire the basic know-how. Hence for dynamic technologies, the breakthroughs can and should be guided or planned since technological change and innovation tend to influence, and to a certain extent shape, society much more than is the case with the more static technologies. These latter technologies in their change and development depend more on the evolution of society and make a less direct impact on society. The planning of technological development takes place at the micro level and there seems to be less of a need for a direct macro planning of the technological innovations in the more static technologies. These latter technologies in market regulated economies are so conditioned by society that the desired, appropriate technology for the demanders in the major market is coming into force. I have collected evidence for this in the international supply of textile technology research study part of the project mentioned above. (10)

Briefly the evidence refers to the following: spinning and weaving technologies unerwent rapid technological changes in the last 25 years but the basic technological principles characteristic for these technologies remained unchanged. The techniques became more efficient, more productive and more capital intensive. Operational speeds, quality outputs and, in weaving, output versatilities increased considerably. At present, however, the objectives of the planned technological change at the micro level, that is at the level of the individual technology producer, do reflect strongly the needs and the conditions of Western Europe, i.e. the area where these producers are located. This can be substantiated by the following. The labour saving objective is not of dominant importance at present. The aims are to make the work less skilful and to make the technology as safe and as pleasant to work with as possible. Further important objectives are energy and raw material saving and to make the technology ecologically sound. Reduced maintenance and repair requirements and improved machine quality, improved final output capability and in weaving increased output versatility are further objectives. Essentially most of these objectives reflect typical European conditions.

Developing countries need machines for mass production, the First World for a diversified output. The First World, and for spinning and weaving machinery Western Europe, can only profitably produce high technology and/or high quality intensive machinery which requires a strong input of high professional and highly skilled personnel and of high quality raw material. This is also precisely the machinery which Europe and the First World need. Hence, without any direct planning and mainly through indirect influences such as worker safety regulations, ecological regulations and standards, as well as by institutionalized and non-institutionalized conditions in the labour, energy and the final output market, a First World appropriate technology is coming into force. This technology is a geo-technology, appropriate to produce and to use in the area of origin. It is not the appropriate technology for the Third World. There is certainly therefore a planning need.

According to this geo-technology concept, the appropriate technology in the Third World ought to be produced in the Third World. However, because of the lack of know-how and skills, of technological capability and of scarcity in high risk capital, of vested local and dominant foreign interests, and of a general dependency mentality, this local production of the Third World appropriate technology has not been realized, or at least not with any sufficient degree and speed.

Therefore for the more static technologies there definitely is a need for technology planning in developing countries. In these countries a variety of more static technologies is needed for the major production activities reflecting the needs of the formal, semi-formal and informal sectors. Whether the choice and chance of the more static technologies can be planned in the developing countries is dealt with in the next section.

A complementary remark is needed in relation to the categories distinguished, more static and dynamic technologies and their changes over time and the impact these changes have on the society. Although the changes in the dynamic technologies are believed to have a greater net impact on society than those in the more static technologies, it should be realized that their greater impact may result from the applications of the new development in the dynamic technology to the more static technologies. The cross breeding of the breakthroughs in the dynamic technologies with the more static technologies may result in a powerful new generation of these more static technologies which may have profound effect on the national and international society. An example: that micro-electronic chips may open up possibilities for computerized industrial machinery in the metal, apparel, textile, footwear and other so-called labour intensive manufacturing processes. This possibility may make these manufacturing processes again feasible in high labour cost areas reversing or at least bringing to a standstill current trends in the international division of labour.

HOW SHOULD SCIENCE AND TECHNOLOGY BE PLANNED?

This question should be answered for the two types of technology, more static and dynamic, and for the choice of technology and the change of technology, that is the innovation path desired by society. Of the two degrees of development of society mentioned, the setting of the underdeveloped or better less-developed country is the basis of discussion. Ideally, the question of technology planning should cover the formal, semi-formal and rural sectors. The subject matter is quite wide even though simplications are introduced: a two-dimensional technology only, a two-dimensional time concept (present and future), for countries only two levels of development (developed and less developed), and within countries a three sector division (formal, semi-formal and informal). Nevertheless only the developing country setting is analyzed here. The two-dimensional technology concept needs only to be introduced in the formal sector, which further narrows down the discussion.

As far as the choice of technologies is concerned in the formal sector the question immediately arises of how it is possible given a market regulated economy to plan the choice of technique by private firms. Firstly, it is clear from the assumption of a market regulated economy that the choice of techniques at the micro-level, in the sense of an allocation mechanism cannot in all but a few cases, directly be planned in an operational way.* It can be planned in a more indirect and less detailed way by influencing the major parameters affecting the choice of technique. Hence the parameters playing a role at the micr-decision level, that is at the individual firm level, should be manipulated.

At a more aggregated level can the government influence the choice of technique? Assuming, as in most developing countries, that there is a considerable dependence on foreign technology, the country may screen the technology import. In principle, this is one of the most powerful means a developing country has to influence the choice of technique; namely, to decide among which alternatives the choice has to be made. Although the technology import policy seems to be on appropriate and powerful instruments to influence the choice of technique it also is a difficult and dangerous one. This is so because clear criteria for assessment and evaluation of technology are needed to guide the import policy. The economic, social, political and cultural aspects of the technology issue are so complex that a technology assessment at the macro level, needed as a screening for the decisions to be taken at the micro level, is a major obstacle. For this reason very few countries have manipulated comprehensively the import policy on technology. Several countries have been able to institutionalize the screening of the import of know-how by means of registering licenses and technical assistance contracts. However, these contracts are evaluated more on their financial and economic fairness than on their technological content and appropriateness. This indicates the inherent difficulties with the latter evaluation.

Nevertheless, some guidelines and criteria can be worked out which are of use in formulating a more consistent technology import policy. First of all, in the area of technology planning and policy, a country needs a development plan or at least some form of development ideology of philosophy. It is here where the problem of the technology planning starts and politics enter. Nevertheless, most countries have now formulated a number of development objectives or even a development plan or policy, and the technology planning or its policy formulation should basically be in agreement with the larger overall development objective and policies. Nevertheless, the technology plan needs also the formulation of a number of overall objectives which should be consistent with the overall development objectives but which clearly should be more specific in relation to technology. A number of relevant objectives referring to both the question of technology choice and the guidance to be given to the change and innovation of technology are given below. An overall objective and policy guideline is:

> A technology should be acquired which furthers the economic and social development objectives and which can be implanted without major cultural and political disruptive effects in the society. Further, the technology to be acquired should improve and stimulate the domestic technological capability and therefore reduce the dependence of the developing countries on foreign technology.

From this overall objective more specific objectives can be derived such as:

> The technology acquired, either by domestic production or by means of imports, should reflect the plurality of the productive society as to its various degrees of development. Thereto a diversity of technology should become available for the production activities in the formal, semi-formal and informal sectors of the economy of the developing countries.

These objectives imply a number of characteristics of the appropriate technology to be acquired:

> For each production branch and activity there may be a need, according to existing or potential multiple tier production activities, to acquire a technology with <u>various degrees of technological sophistication</u> that <u>is varying as to their degree of labour</u> and <u>capital intensity</u>, <u>multiple skill requirements, as to their raw material input and final output physical characteristics</u>, and as to their <u>direct and indirect interdependence and</u>

linkage with outer parts of the economy.

From these it follows that the technology to be acquired also improves and stimulates the domestic technological capability and so reduces foreign dependence on technology.

Certainly on the basis of these objectives and characteristics a more concrete and specific formulation for policy making and implementation is needed to influence the choice of technique at the micro level, at the macro level by means of imports and on the level of technological change and innovation.

Starting with the technology imports, various approaches are possible using more general guidelines or a more detailed approach which can be both qualitative or quantitative. Considering first the qualitative approach, the more general guidelines may refer to specifications on the origin and the price of technology, more specific guidelines may touch on the make, even on the models by make per branch. Clearly an operational technology-import policy requires considerable know-how and consultations with the users of the technology are imperative. For important branches, a useful approach could be a tripartite *ad hoc* consultation mechanism in which the government, employers' organizations and trade unions are represented.

Using a quantitative approach, desirable technology could be exempted from import taxes and technologies considered to be less contributive to the technology and development policy objectives could be heavily taxed by means of import duties.

The importation of technology by means of licenses or patents and non-patented know-how of technical assistance and trade mark agreements and the like, should not only be evaluated on their economic and financial fairness, or on their negotiating support the official registering of these agreements gives to the nationals dealing with foreign firms, but particularly also on their technological implications and consistency with the technology plan and policy.

Planning the choice of technique at the micro level in a market-oriented economy should follow a more indirect approach, although a more direct influence may be exerted by the allocation of import permissions for technology at the individual firm level. The indirect approach means a manipulation of the key parameters and conditions considered in the choice of technique at the micro level. The question is what are these parameters and conditions and how can they be controlled or influenced?

In Scheme I, 15 major internal and external parameters and conditions are listed which affect the choice of technique at the firm level. It also indicates how these parameters and conditions possibly can be influenced. From these it is evident that few of them are directly linked to the technology issue; nevertheless, these few are crucial. It concerns the quality of technology and its after sales service, the price of technology and the conditions determining the market of used machinery. Hence the government has a direct possibility of influence by means of its import policy on new and used technology.

It is assumed here that the major supply of technology is obtained by imports. For some of the larger and more developed Third World countries this is not a fully realistic assumption as they have also domestic technology supply and production. However, this domestic production is usually under license from First World firms and concerns models encountering heavy domestic demand, and essentially it is imports substituting domestic production. The authorization of starting domestic production of certain technology types can be guided by the same rules and principles as the import of these technologies.

How important are the parameters and the conditions under the direct influence of the import policy of new and used machinery relative to those other parameters (among others the labour and capital rates) which can only be influenced by more general policies? Although economic theory only mentions the labour and capital rates as influencing or even determining the choice of technique, these parameters are not, in a direct sense, usually the most important ones. (11) For a firm, labour and capital rates are almost outside its control, although indeed by choosing among alternatives a more labour or more capital intensive technique can, in principle, be made. However, the level of appropriate technological sophistication from a private point of view is almost entirely determined by the firm's internal parameters, several of which are also determined by external factors. Some of those in the long run can be changed by the government, such as the overall quality and quantity output mix, and the size of the internal market by means of the income distribution and the export promotion system.

Indeed, for the more static technologies, the parameters of quality of technology and after sales service, the price of the machinery, the credit facilities and the availability of used domestic or imported technology are the major parameters affecting the choice of technique and supplier. (12) Usually small firms are financially weak. To them the price of the machinery is the determining factor but for larger, financially stronger, firms it is the quality of the technology and its after-sales service. However, for both types of firm the import of quality used machinery can be important and may reduce the need for imports of new machinery. For each branch, two or tripartite ad hoc commissions may reach consensus about type, model and make of the First World technology suitable for import. The technology chosen in this way will be a compromise between private and social appropriateness but an operational compromise may be preferred over an absolutely non-operational idea which by necessity has to remain a vision.

Nevertheless, labour costs, social security costs, dismissal clauses, profit sharing and other regulations naturally influence the choice of technique at the firm level also. Excessive wage demands by trade unions in the formal sector may increase the discrepancy between the formal and informal sectors. However, profits of enterprises in developing countries are often excessive, due to the protected nature of the market. Excessive profits induce excessive wage demands. Excessive profits can be indirectly taxed by the price of technology. More labour intensive techniques taxed by lower import duties may force entrepreneurs to that choice, which will, if wage demands do not fall in line, initially reduce their profits, increase employment and in a next round result in more modest wage demands. This implies a move to more appropriateness in the choice of technique and to a more balanced and equitable development. Capital rates also have an influence, however: in the sensitivity of the entrepreneurs to the machine price and, since capital for small entrepreneurs is not available, to the credit facilities offered by the supplier. So far we have discussed the choice of technique of the more static technologies in the formal sector. In the short term this technology choice can be planned indirectly principally by means of the import policy on new and used machinery. In the long run a more fundamental influence on the choice of technique at the micro level can be exerted by bending the country's output mix to a greater appropriateness and by a corresponding labour and financial policy. This can be accomplished if the government has a comprehensive view and understanding of the technology question which, preferably, is commonly shared by other similar countries.

The dynamic technologies to be used in the formal sector are more difficult to plan since usually the degree of monopoly is much larger in their supply and in some cases one can no longer speak of a market mechanism in their allocation. Nevertheless, a few facts should be remembered:

(i) The supply has often much less a monopoly character than believed; that is the number of the potential suppliers may be larger and their nature may differ.

(ii) Dynamic technologies are often innovated and developed by small enterprises, as far as the uSA is concerned, which are neither terribly powerful nor mighty transnationals. (13)

(iii) Developing countries are not necessarily weak in negotiations if they prepare their positions with care.

(iv) Developing countries should carefully evaluate whether the acquisition of these dynamic technologies is as desirable as they think. Such an attitude strengthens their negotiating position.

(v) If Third World countries act concertedly certain technology designs and transfer conditions can be negotiated with multi-national and international technology suppliers from a position of strength. Then both parties can, to a certain extent, plan the development and design of technology together. Also the terms of the transfer of technology can be a part of such a collaboration.

(vi) Further, several developing countries already have a mechanism at work to evaluate the import. Although this evaluation is more economic and financial, it can and should be complemented with a technological assessment. Also, many developing countries have laws or regulations on foreign investment which provide additional means of directly influencing the inflow the dynamic technologies.

Influencing the choice of techniques in the semi-formal sector, which by nature concerns only the more static technology, can also follow a direct or indirect approach. The starting point is the economic and financial position of these producers. This position is weak for obvious reasons. Their financial means for investment in machinery are very limited. These producing units supply their needs with second, third or fourth hand equipment, employ only family labour or hire labour at very informal conditions, paying wages often substantially below the minimum wage, and do not comply with the social security and other regulations. (14)

Given the great importance of the semi-formal production sector in developing countries from an employment, from an on-the-job training and from a technological adaptive and innovative point of view, the government should not pressure this sector too much into complying with the formal wage and labour regulations. Up-grading this sector can do this by means of supplying new simple technology, provided it exists at an attractive price. This possibility should be considered even if it means a subsidy or offering very attractive credit facilities, including the risk that only a part of this loan will be repayed. Hence, the major channel of influence is also through the supply and its conditions and indirectly through keeping the semi-formal sector as informal as possible.

The urban informal sector uses little technology and is concerned mostly in services such as shoe shines, sales of lottery tickets and other marginal commercial activities. The rural informal sector uses a traditional technology mixed with some new modern technological elements. Introduction of more efficient labour intensive techniques can best be achieved by an extension of these services.

Influencing technological change

The planning of technological adaptation, innovations and change can, in mainly market regulated economies, take place indirectly. The process concerns the users of the technology and the producers of the technology. In most developing countries the technology is mostly imported and there is little, under present conditions, which developing countries can do to influence the innovative process and technological development path at the firm level of the overseas producers. To the extent that technology is designed and produced locally, more means of influence are available in developing countries. The government may stimulate R and D by exempting this expenditure from tax; costs of training or overseas study financed by the firm could also become exempt. Other more indirect means include stimulating competition rather than reducing it. Most innovative effort in private First World firms is induced by competitive forces. Although it is valid to protect an 'infant' industry, too much protection or market regulation will kill the innovative potential of private firms.

The government can have a more direct influence by using procurement programmes. The size and duration of government orders as well as their specifications may make innovation mandatory and economically feasible for the private firms. A well planned procurement policy affects not only the direct supplier but also all the subcontractors. (15)

Geo-technological change can indirectly be stimulated by making the overall output mix of the country more appropriate, and this involves the policies of federal, state, provincial or municipal governments. Also, the import policy of new and used machinery plays an important role in influencing technological change. Restricting the import of a specific technology may induce an adaptive, innovative drive to modernize the available technology. This strengthens the innovative, adaptive process with the users of the technology and also creates small engineering firms which specialize in the overhaul, adaption and modernization of the existing equipment. (16) Little by little a domestic technological capability is created which may become the base for a more active domestic technology. Similar effects may be obtained by concentrating on the import of used machinery: used machinery needs more attention for maintenance, repair and overhaul. An intelligent and therefore selective import policy of technology, new and used, may greatly influence the domestic adaptive innovative capability. As mentioned, most of the R and D and innovative effort of the dynamic technologies is taking place outside developing countries. Nevertheless, governments of developing countries, in their fiscal policy, may make domestic R and D by multinational firms attractive. Third World countries, by strengthening their negotiation base individually, can influence collectively the multinationals' effort and policy as to content, location, etc.

Also, by hampering the development of the semi-formal sector as little as possible or by stimulating it, for example by de facto accepting its formerly illegal operation as to taxes, wages and labour laws, an important source of minor practical innovation is preserved or stimulated. The same attitude is needed for the informal sector, although a more active stimulation and outside assistance in the technological development is desirable. The design and development work of engineering students in developing countries should at some stage include the solving of the technological problems of the semi-formal and informal sectors.

All these suggestions are indirect ways of influencing the intensity and the direction of innovation, but there are also more direct means of forcing a desired change of technology. Technological change can be obtained by amassing enough financial and human resources in a certain direction. If a government decides that it wants to become independent of foreign technology in a particular area, it can establish a specialized, public research institute for basic and applied research. Foreign specialists may temporarily be hired as advisers; in the course of time the objective of technological change will be achieved if sufficient funds and above average salary scales are made available.

Sometimes an economic-political decision to nationalize a certain industry or firm forces that branch to solve its technological problems mainly on its own.

CONCLUDING NOTE

How do the above discussions relate to development planning? Usually the first step in development planning consists of a few approximative exercises at the macro level in which the overall labour productivity is considered. The labour productivity is approximated by projections, on the basis of which a feasible target for this value is determined. Important elements which influence the labour productivity are the nature of the technological change, the increase of knowledge, and also the increase in the effectiveness of the labour force by a process of learning by doing. Clearly in long term planning more detailed targets can be set if at the sector and project level an operational technology planning and policy is in operation. Multi-sector planning models could differentiate these projections of the technical progress, either explicit or implicit in the labour productivity projections, by sector.

In the determination of sectoral development priorities, based on comparative sectoral evaluations, sectors could first be ordered into those applying more static technologies or dynamic technologies. The formal sectors could be further subdivided into a formal and a non-formal sub-sector. Quantitative sectoral assessments often use the input-output method to estimate the direct, indirect and cumulated effects of a final output increase. (17) Introducing for the static technology the application of a two or possibly even a three tier breakdown of sectors, according to the formality of the economic activities involved, would yield extremely useful and interesting insight into the various effects the application of alternative appropriate technologies has. (17)

Also, for the qualitative assessment of sectors, the introduction of more static and dynamic technology using sectors and the breakdown according to degree of formal integration is extremely operational. This is particularly so since it is possible to quantify the qualitative considerations. (17) This method can also be combined at a lower level of aggregation for the technological assessment of alternative technologies and such various assessment-methods are possible, including the DOS method. (17)

FOOTNOTE

* For larger firms the government may influence the choice of technique by means of allocating import licences for specific technologies only.

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SCHEME I

Parameters and Conditions Affecting the Choice of Technique at the Firm Level

Firm Internal	Firm External	Possible Means of Influence
1. Firm's output mix	——→ *	General economic, financial, fiscal industrial and import policies
2. Technological and human capability in place		
3. Firm's origin and ownership:	——→ *	Government policy on a mixed economy foreign investment laws and regulations
3.1 private, public mixed 3.2 domestic, foreign, mixed		
4. Firm's market: 4.1 state share 4.2 domestic, foreign	——→ *	Regulations on price control Export promotion system Size of country, number of inhabitants, income distribution
5. Firm's size	——→ *	Industrial promotion and incentive systems. Type of final output market, number of demanders relative to number of suppliers
6. Firm's history and traditions		
7.	Quality of technology	Technology import policy, affecting foreign technology supply
8.	Quality of after-sales service	Same as 7
9.	Price of machinery	Same as 7
10.	Credit facilities	Public sources of credit and their institutional and factual availability. Suppliers credit
11.	Labour rates and implied costs, social security leg., dismissal clauses, profit sharing, inclination to strike, etc.	Minimum wage, social security, labour law regulation, their enforcement potential in semi-formal production activities

SCHEME I Cont'd.

Firm Internal	Firm External	Possible Means of Influence
12.	Capital rates	Financial policies
13.	Availability of used machinery:	
13.1 13.2	o domestic o foreign imported	Fiscal rules on depreciation, amortization Technology import policy with regard to used machinery
14.	Technological progress:	
14.1 14.2	o domestic o foreign	Domestic science and technology policy Given but should be followed and information should be provided
15.	General conditions:	
	o present o future	By means of providing overall stable conditions in a political, financial, economic sense

* Note: Both firm internal and external parameters and conditions

2. Planning — Prospective Analysis and Science and Technology Policy

FRANÇOIS HETMAN*

SCIENCE AND TECHNOLOGY IN THE GOVERNMENT

Policies for sciences and technology

Science policy is generally defined as a deliberate and coherent basis for national decisions influencing the investment, institutional structure, creativity and utilisation of scientific research. The expression "science policy" should be taken as an abbreviation which means policies for science and technology (S & T). More recently, the term science and technology policy has been introduced both in national and international organisations to acknowledge that science and technology form complementary parts of a single system; science producing new knowledge and technology supplying knowledge to create new ways of instrumental know-how.

The boundaries of the science-technology system are difficult to delineate, not only because of its intrinsic complexity but also because it pervades all aspects of contemporary society. Science and technology are the main sources of innovation and social change. Functionally, the S & T system can be defined as a set of institutions and mechanisms geared to the production, diffusion and application of knowledge.

These institutions include the universities, the research laboratories of industry, mission-oriented research centres of government and many private organisations. They do not, however, belong solely to the realm of S & T policy. Thus for example, universities have a primarily educational function and industrial research centres or units cannot be dissociated from the production of goods and services. The areas of intersection with other sub-systems of society cannot be governed by policies determined for S & T alone. This places the S & T policy in a pivotal but difficult position: although it is increasingly looked upon as an essential political function, it depends widely on ends and directions pursued in other sectors.

Development of specific institutions

Institutionally, during the period from the end of World War II until the early 1960s, science policy was regarded mainly as part of educational policy. There were ministers of education or the equivalent in all the industrialised countries, but few science policy institutions. In 1963 OECD published a report (1) calling for the establishment of central mechanisms in each country to review the state of science and technology, the allocation of resources, and the relationship of science and technology to national problems. At the first meeting of the ministers for scientific affairs, only four countries had such positions. At the time of the second ministerial meeting, two years later, already three-quarters of the OECD Member countries had ministers of or for science. From the mid-1960s started a period of an intense experimentation with various science policy mechanisms.

During the 1950s and 1960s the rapid development of scientific research and technical innovation and the growth of R & D institutions and scientific manpower was accompanied by a belief that the S & T system was a primary mover in economic growth and international competition. This led to the view that R & D should be supported as a potential source of future gains in productivity and sustained economic growth. Taking as an example the United States ratio of R & D expenditure to gross national product, many western European countries fixed it as a target for their own science policy, often without detailed specification of the purposes.

*/ The opinions expressed by the author are his own and do not commit the Organisation to which he belongs.

However, it became clear at the end of the 1960s that the rapid economic growth and technical change threw up new problems, often of increasing gravity, such as environmental quality, inflation, unemployment, energy, shortages of basic materials, etc. Science and technology, considered as main driving forces behind these developments, were charged more fiercely than other societal functions with being the insidious and main cause of such a sudden and drastic reversal of the situation.

Joint responsibility

After a period of what has been called the disillusionment with science, many of the hastily formulated grievances have given way to a more sobering view of the role of science and technology but also to a more demanding attitude with regard to the responsibility of the S & T system and its contribution to societal problems.

As a recently instituted mechanism of government, S & T policy continues to evolve in an unsettled climate, with respect to both its contents and organisational structure. S & T effort in the industrialised countries is increasingly dispersed and politicised. On the other hand, R & D is associated with a fast-growing number of government and non-government activities with the widening of the range of objectives assigned to science and technology. On the other hand, the magnitude of the resources demanded by projects in all disciplines now compels political choices.

It seems necessary, therefore, to break down the barriers between different sectors of government action. It has clearly become essential to assess the effects of technological change on the environment, on the economy and on society in general to prevent harsh or irreversible impacts. Only strong institutions can be in a position to establish working links of interdependence between S & T policies and the other sectors of government concern and to influence the budgetary process so that it takes account of the specific character of S & T activity.

Institutions, however, merely provide an instrument and a potential; they do not, by themselves, guarentee success. The general tendency now is make S & T more responsive to other areas of government policy. The euphoria of unrestricted expansion has been replaced by a target-oriented and programme-tied attitude. Instead of awaiting automatic returns to R & D the emphasis is on making its results usable and on ensuring that they are really put to suitable use.

The experience of the OECD countries leads to a serious caveat: 'While science and technology must indeed be more strictly oriented than in the past, we must be careful not to sterilise them by stifling them in a bureaucratic straitjacket. If it is to be readlly "useful" research must be fully associated not only with the execution but also with the formulation of the policies it has to serve. An evolution of this kind is bound to be slow and difficult since it implies first and foremost a new style of relations between the scientist and the politician: it assumes in effect that the politician accepts that his decision can be challenged by research and that the scientist agrees to abandon the comfortable ideology of the neutrality of science. (2)

FUNCTIONS OF SCIENCE AND TECHNOLOGY POLICY

Parameters of S & T policy systems

Research on research and studies of S & T policy systems have led to the identification of a number of aspects and possible criteria such as: fields of R & D; methodological approaches to R & D; types of research (basic, applied, development); scientific disciplines; size of projects; sociological aspects; operational tasks; permanent objectives; inputs/outputs; performing institutions; sectoral breakdown of R & D activities, etc.

However, taking into account all the identifiable criteria (parameters) would involve such an enormous number of interrelationships and their interfaces that no coherent policy action would be possible. From the point of view of S & T policymakers not all these criteria have the same degree of relevance. Only some of them can be usefully applied as strategic or government-level criteria.

Systemic approach to S & T policy

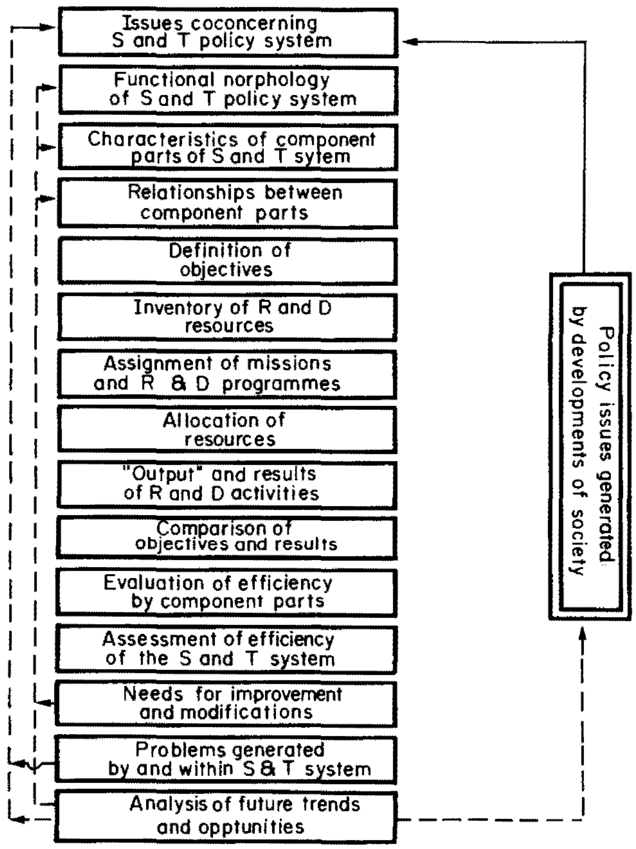
A useful approach is a systemic outline of S & T policy. (Figure 1) The starting poing is the cluster of issues that are generated by economic, social, policital and cultural developments of national community, society at large and the international environment. A number of these issues are within the scope of a S & T policy system. To deal with new issues an adequate morphology of the S & T system is necessary. If it is to arrive at appropriate responses and actions it may have to adapt existing mechanisms or to create new ones.

Smooth working of the system can be assured only if decision-makers have a good knowledge of its strategic components and their main characteristics from the point of view of their relevance for the functioning of the whole. Such an articulation of the system makes it possible to determine fundamental relationships between the components and this is a prerequisite for any effective action on the system.

On the basis of a given constellation of system components, objectives can be defined in general terms. These objectives are then compared with available R & D resources broken down by operational categories. The next step is definition and distribution of missions among the various components of the system and programming of R & D activities and projects. After a series of iterative assessments, the allocation of resources can begin.

The expected outcome of the R & D process is to use available resources in such a way as to obtain relevant results for the pursuit of policy objectives. Results range over the whole spectrum of scientific and technological knowledge, both basic and applied.

SYSTEM OUTLINE OF S & T POLICY



For reasons of budgeting and management, all societal processes are divided into periods to give a regular time dimension to the decision-making process. Policy makers are expected to given an account of their activities which is based upon the comparison of results obtained with objectives planned. Striking such a balance is a key element for evaluation of the effectiveness of the components and the whole system.

Significant failures and discrepancies are then analysed with a view to suggesting modifications. New problems thus arise with the system itself which act upon the components, their relationships and the morphology of the system.

By its very nature, S & T policy system is orientated towards issues concerning societal futures which determine, in their turn, its own future directions. Its permanent preoccupation is therefore to discern future potentialities, to point out the possibilities for action and to feed back all new knowledge into the continuum of evolving societal issues.

Main S & T policy functions

The systemic flow-chart of S & T policy makes it possible to derive the main tasks or "functions" of the policy from the basic conceptual and procedural stages of the decision-making process. Seven major groupings of S & T policy functions can be distinguished. (Figure 2) These functions are performed by a number of various institutions which play a structuring role in the overall constitution of the S & T policy system. Through the interaction of functions and institutions, dispersed R & D activities can take the shape of an objective-oriented whole and all other categories of criteria receive their meaning and relative importance.

The other two important categories of criteria are objectives and means (resources and operational procedures). With these elements at hand, the analytical framework of S & T policy can take the form of a matrix where functions are linked to institutions and through institutions to objectives and to means.

S & T policy functions within the "institutional space"

With respect to government decision-making S & T policy functions are located within an "institutional space" which can be represented in the form of a diagram. (Figure 3)

SCIENCE AND TECHNOLOGY POLICY FUNCTIONS

I - ADVISORY AND CONCEPTUALISATION FUNCTION	Analysis of past, present and future issues Trends in R & D Identification of options Contribution of R & D to economic and social development
II - STRATEGIC PLANNING AND DECISION MAKING	Examination of alternatives Choosing among options Planning and budget priorities
III - CO-ORDINATION	Co-ordination of programmes and activities, particularly among different government departments or ministries
IV - OPERATIONAL RESPONSIBILITIES	Control and evaluation of programmes Determination of means of S & T transfer Functional assessment of R & D activities
V - PROMOTION	Promotion of basic and applied research Allocation of resources among specific projects and institutions
VI - PERFORMING FUNCTION	Carrying out research programmes and activities by the various institutions
VII - LEGISLATIVE CONTROL	Control exercised by the Parliament usually through budgetary control

The strategic planning and decision-making function holds a central position both institutionally and with regard to the timing of action. In the upper part of the institutional space is the advisory and conceptualisation function and the co-ordination function, both logically preceding the decision-making stage to which they are linked as inputs. In the lower part of the institutional space, the strategic planning and decision-making function is linked to the operational responsibilities' function which constitutes an intermediate link to the promotion function and to the performing function.

Through operational responsibilities (ministries and government agencies) the strategic planning and decision-making function is subject to the legislative control function, presumably independent from the Executive.

FORMATS OF SCIENCE AND TECHNOLOGY POLICY

Pluralistic pattern - authoritarian pattern

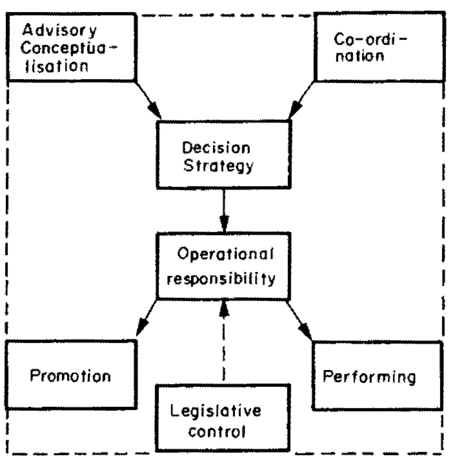
The institutional space pattern makes it possible to organise the analysis of national science policies around a range of model science policy formats - from the extreme of decentralisation and autonomy of science policy functions to the other extreme of completely hierarchical and authoritarian system.

The pluralistic pattern is characterised by an autonomous institutional mechanism for each single function so as to guarantee a reasonable degree of independence with respect to various pressure groups and the central government itself. Although not necessarily of the same status and importance, all functions stand by themselves and are interdependent.

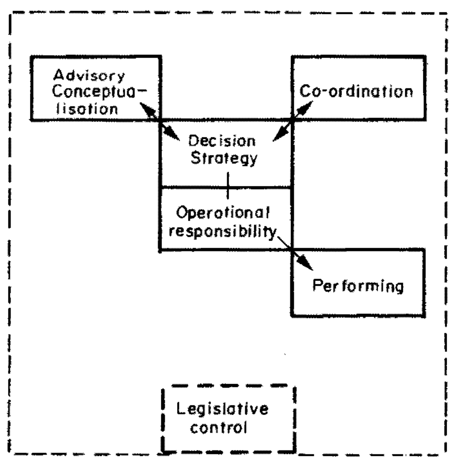
The authoritarian pattern has an in-built tendency to link all functions to the central government so reducing to a minimum the margin of autonomy of functional mechanisms which are hierarchically subordinated to the central decision-maker. The strategic planning and decision-making function is overwhelming: it more or less absorbs the advisory function and the co-ordination function and extends its direct authority to operational responsibilities and the performing function. The promotion function becomes purposeless and the legislative control loses all real significance.

"INSTITUTIONAL SPACE" OF S & T POLICY FUNCTIONS

Pattern of a pluralistic system



Pattern of an authoritative system



Typology of S & T policy formats

On the basis of the aforementioned analytical tools a comparative study of national science policies can be carried out by examining the specific institutional setups in response to the same functional needs. This analysis takes account of country reviews of most of the OECD countries, USSR, eastern European countries and communist China. (3) Starting from the extreme institutional space patterns and taking as a scaling criterion the increasing degree of government intervention, there are eight model science policy formats ranging from almost spontaneous regulation to authoritarian centralism:

contextual stimulation
sectoral orientation
pluralistic incentives
decentralised interventionism
symbiotic subordination to national objectives
centralised interventionism
authoritarian planning
authoritarian centralism.

Leaving out the two authoritarian forms and concentrating on the experience of the OECD countries, only a broad summary can be given here of the main differences and similarities between the countries whose science policies range from contextual stimulation to centralised interventionism.

Areas of diversity

In the general context for S & T policy the primary areas of diversity which are most relevant include the following: population, level of education, level of economic development and industrialisation, level of R & D effort both absolute and in relation to the gross national product, political and social philosophies, political structures, perceptions of science policy and of R & D process, major sources of R & D funding, major R & D performers and level of excellence, pattern of R & D funding by objectives, relationship between government and universities, relationship between government and industry.

The United States' government plays a much larger role in the funding of R & D than governments in most other countries. Government is the primary source of funding in the United States, United Kingdom and France, whereas business enterprise plays the greatest role in Japan, Western Germany and Switzerland (as it does in the Netherlands, Sweden, Italy and Belgium). As to the relationship between government and industry, the closest understanding of purpose seems to exist in Japan. In the United States, a "big science country", much of industrial R & D is through government funding with government and industry in a more contractual type of relationship.

There is also a pronounced difference in funding of university research between the United States' practice of competition for individual research grants on the basis of merit and the European customary practice of undifferentiated institutional financing.

Balance between basic and applied research

As far as the basic principles for S & T policy are concerned, the major industrialised countries have been grappling with many of the same issues.

The most difficult and predominant problem is the desire for better application of research to national problems in striking the proper balance between basic and applied research, between long-term promises and short-term benefits. On the policy level this problem is manifested in the difficultues that countries had in setting R & D priorities and new directions through the budget process; on the institutional level it is the tug between governmental departments and semi-autonomous research institutions. Caught in the middle is often the science policy unit of government which is more effective when close to the decision-making levels of government yet needs to have some independence from narrow government perspectives to recognise the broader interests of science.

The conflict is perhaps best illustrated by the great debate within the United Kingdom and also in other European countries over the degree to which the "customer-contractor" principle should be used for applied research and to what extent should government departments define and supervise R & effort relevant to their operational activities.

Common needs - diverse institutional arrangements

As to mechanisms and the institutional machinery of S & T policy the countries exhibit a large communality in their needs for such basic functions as the advisory function, co-ordination, policy planning, promotion of university research, aid to industrial research and performing of new fields of R & D, but there is a great diversity in institutional arrangements.

In countries with a pluralistic or decentralised political system the current practice is to keep the central machinery at a minimum; these countries have generally a science adviser or a science policy body with an official head. In countries with a more centralised form of government the practice is to have a minister for science along with a separate policy-making body. The strategic planning decision-making function is generally located in the cabinet or council of ministers. It may also include various advisory interdepartmental committes with or without a consultative body of scientists. In some countries several elements of the various science policy functions are delegated to research councils (United Kingdom, Sweden, Norway, Denmark), acting as intermediary bodies with a more or less wide range of choice within general programmatic parameters.

The science policy advisory and conceptualisation function may be in central advisory bodies at a high level of government (e.g. Science Councils of Germany and Canada) or in a weaker position. In other countries it is located in consultative committees reporting to ministries with major operational responsibilities in science policy (France, United Kingdom) or in a mixture of consultative bodies for various ministries and specialised agencies (United States, Japan).

In several European countries science and education are located within the same ministry in which case the term science encompasses mainly or exclusively university research. In some cases this has led to a split between science and technology, this latter one being incorporated within the Ministry of Industry or the Ministry for Research and Technology (Western Germany). More recent development is the establishment of a ministry or a secretariat of state for science and technology without portfolio or operational responsibilities whose main task is to co-ordinate government R & D activities and programmes (Canada, Netherlands, Italy).

In all countries co-ordination is the most difficult and permanent problem. This is reflected in the continuing restructurisation of existing institutions or the experimenting with new bodies and in the wide diversity of national approaches. The general tendency is to multiply co-ordinating units at the level of government departments or committees of an interdepartmental character since many emerging problems involve intervention of several departments or specialised agencies.

S & T POLICY AND STRATEGIC PLANNING

Main thrusts of the OECD countries experience

Some general lessons can be drawn from the science policy experience of the OECD countries:

(i) Science policy mechanisms must be flexible and responsive to changing national science contexts and needs, yet too frequent changes in institutional structure can be disruptive to the evolutionary development of these mechanisms and to good working relationships between government and the scientific community.

(ii) To become an influential part of the government, the science policy apparatus must have an independent but real capability of analysis and original thinking; this capability must be recognised by the highest level of decision-making as being instrumental in bringing in fresh views and in usefully assessing opportunities and priorities.

(iii) The principal advisory body for S & T policy operates effectively when it is an autonomous organ representing a broad spectrum of knowledgeable people from the scientific and technological community and when it has an access to the central decision-maker.

(iv) Pluri-disciplinary and pluri-departmental approaches are required for tackling complex contemporary problems; this calls for greater horizontal and vertical integration of R & D activities and an improved dissemination of R & D results.

(v) Medium-term and long-term planning and co-ordination of R & D budgets and programmes is needed not only to reduce duplications and improve management of scarce resources but also and even more to link the R & D effort to major concerns of national policy.

(vi) This implies that the scientific community is expected to play a more active role in society and the economy, recognising its accountability to the objectives of society. This leads to the need of, and intense and regular communication between, researchers and the policy-maker in the areas of policy relevant research.

In all cases, a necessary and fundamental complement to formal organisation of S & T policy is the interest and lasting implication of the policy maker.

Purposive relationships with national goals

New national needs or national needs now perceived with a renewed force tend to create new organs concerned with providing new insights, guidelines, arguments or briefs to assist governments to come to grips with these new challenges. This is indicative of a growing realisation by governments of the many-sidedness and complexity of S & T policy issues. More generally, the growth of the new S & T policy mechanisms demonstrates a need now clearly recognised in all countries for means whereby scientific and technological effort can be brought and kept within a more coherent and purposive relationship in line with the way national goals and objectives are selected and pursued.

A striking example which illustrates this way of thinking is the adoption by the United States of a new public law (4) which brought the re-establishment of a formal science and technology policy mechanism within the Executive Office of the President. But its historical importance lies in the fact that it outlines a new legal basis for setting priority goals for science and technology. In its explicit enumeration of the goals of S & T policy, it covers the whole spectrum of human activity and societal issues and is thus the most comprehensive inventory of what science and technology may be expected to achieve. Of course, it remains to be seen to what extent such a revolutionary statement of intention is connected to the real course of policies.

Restructuring of industrial patterns

In all countries there is a tendency to strengthen the role played by S & T activities geared to economic development and particularly to tackling the problems raised by industrial, business, monetary, energy, socio-cultural, international and other uncertainties that the world is currently having to contend with. The main economic strategies that are likely to call for an increased contribution of S & T are: a) sustaining the rate of economic growth; b) limiting dependence on external sources of energy, raw materials and manufactures; c) strengthening competitive advantages on foreign markets; d) shifting priorities to more socially oriented goals. The probable short and long-term effects of the different possible directions which the R & D efforts may take with respect to these various economic strategies will embrace inflation, employment, industrial structure, external balance and new patterns of socio-economic responses and behaviour.

In several OECD countries, governments are trying to formulate an overall policy of industrial restructuration which involves the radical transformation of traditional industries and expansion of technology-intensive industries by means of an original R & D effort.

It can be observed in this connection that many countries take measures: a) to strengthen links between basic research, applied research and experimental development in order to take systematic advantage of ideas which can give rise to processes and products suitable for patenting (ventical transfer of technology); b) to encourage research aimed at adapting domestically-produced processes used in one sector for use in other (horizontal transfer of technology within the same country); c) to enhance the value of domestic and foreign R & D findings by means of a S & T information policy integrated with S & T policy. (5)

Greater social relevance

Another important issue is the demand for greater social relevance and for a societally more useful R & D. This has already led to some shifting of research priorities resulting in an appreciably larger share of public R & D expenditure in sectors which may be said to come under the heading of quality-of-life: health, protection of the environment, town and country planning, social development and welfare services. The problem of generating research of societal relevance raises the question of available methods which can be applied to the identification, selection and design of research. Of course, it is much more basically a question of human and societal values and of the corresponding political concern to put S & T effort to new uses.

This aspect can be illustrated by the "Scandinavian model" of S & T policy which endeavours to strike a new balance amongst three broad policy aims: improvement of production processes and structures (economic), promotion of the "welfare state" (political) and the betterment of working life and working conditions (social). Particularly interesting are the R & D efforts devoted to this last area which includes, among others, problems of occupational health, safety, job satisfaction, etc.

Still another concern is the effectiveness of R & D concerning all components of the S & T system. Generally speaking, problems of evaluation are of increasing importance, since in many countries the resources available to the R & D system have come to a standstill or have even decreased relatively to the gross national product. In the near future, national authorities hardly expect R & D resources to enter a new phase of growth but rather count on an effort to optimise the allocation of resources through better programme management, stricter control of means and a more rational use of research findings.

Finally, there is the question of public concern about science and technology and of public participation in issues bearing on these matters. Various groups are now claiming social or political competence to evaluate the acceptability of science and technology and want to have their say on policies which have traditionally been regarded as the exclusive province of scientific or technological expertise. Such challenging is expressed in litigation, local government action, parliamentary activity, referenda and political demonstrations.

MODES OF INTEGRATION OF S & T POLICY IN GENERAL POLICIES

Short-term action, long-term perspective

All these new exigencies call for a reassessment of the place of science per se and science as the root of new technologies, both in socio-cultural and socio-economic terms. Those responsible for S & T policy have to be more clearly involved in the setting of national goals and the priorities between then, if the goals are to be realistic and the system of S & T made able to respond fully to them.

However, the long-term function of science and technology policy, inherent in the character of the scientific investigation and innovation process, in general seems to be at cross-purposes with the urgency of the short-term economic and social problems arising in all areas of government policy. The effect of such urgency is that science policy is increasingly being pressed for prompt answers.

To bridge this discrepancy new mechanisms for a long-term view of society and a continuous prospective planning are needed which would be able to identify the points where R & D and S & T policy can be conciliated with the constraints of political action both in the short and medium terms.

Many governments, increasingly aware of this need, have restructured some of their existing institutions and introduced new forms of action. These new mechanisms differ both in the acknowledged role of S & T policy and in the balance struck between the tendency to decentralise responsibilities at the operational level and the desirability of having a centrally articulated hierarchy at the level of objectives.

The most interesting initiatives taken during recent yeast can be briefly reviewed under the following headings: i) departmentalisation; ii) sectoral approach; iii) prioritisation through major programmes; iv) planning towards the top; v) integration within general planning.

Departmentalisation

The basic reationale of "departmentalisation" is to channel R & D findings towards the closest possible type of operational application. It is to be understood as a reaction to organisational forms which tend to favour dispersed research of a not directly applicable nature.

The aim is not so much to decentralise R & D activities as to strengthen existing structures without seeking to establish an overall view of priorities for the entire field of S & T policy. In the United Kingdom where this type of organisation has been taken the farthest, the attitude of the government can be summed up by the "contractor-customer" principle, i.e. the most possible direct link between research units and potential users.

This type of organisation stresses the applications of R & D and the extensive use of its results at operational level. It presupposes and requires the creation of R & D divisions or at least distinct units within the Ministries concerned. These are most frequently linked or attached to planning services so as to be better in a position to plan the research requirements and programmes of the functional directorates of the ministry.

The departmental approach has been adopted also in other oECD countries, although less systematically. It seems to have been instrumental in associating government laboratories and research centres with the functional tasks of each single ministry. However, it seems to lead also to excessive fragmentation and isolation of the R & D effort. Such a decentralised form of organisation relies on an efficient planning within functional departments, but it makes it difficult to identify and assess the effects of overall policy issues on patterns of science and technology.

Sectoral approach

To avoid this drawback several countries (Netherlands, Belgium, Switzerland, Japan) have implemented the so-called "national research programmes". The nature and scope of these programmes vary from one country to another. But the concept common to all action of this type is to establish a link between research and certain social objectives or needs which cut across the various government ministries.

Taking the Netherlands as an example we find major multidisciplinary research programmes concerning problems of national importance. The implementation of these programmes requires the co-operation of different ministries. They involve the concentration of the country's research potential on a given problem thus requiring the reorganisation of existing research activities by the participating bodies.

In a sense, this experience of national research programmes can be viewed as an intermediate stage between the departmental and the sectoral approach. This latter encompasses major socio-economic issues which have to be dealt with at a much broader level than that of a single ministry.

Such a sectoral approach based on "social priority areas" is at peesent being implemented in the Netherlands. It implies that national R & D effect as a whole, apart from university research, be divided into broad policy areas within which it would be desirable and possible to establish a "sectoral" view of S & T policy. For each of these sectors a national sector council would be set up charged with giving advice on research planning matters. There councils would be set up by the Ministry responsible for the field concerned in agreement with the Minister for scientific policy and other ministries concerned.

Another form of cross-fertilisation through co-operation between politicians, government agencies, public laboratories, university and private research centres is being experimented in Sweden. Instead of sector-oriented it is problem-oriented with a view to studying major problems which have been revealed as particularly important with the aid of prospective analysis. The pivotal link and source of initiative is the work of the Secretariat for Future Studies. Future dynamics is thus the starting point for formulation of research projects.

Prioritisation through major programmes

Prioritisation through major programmes is a type of organisation based on a pragmatic approach to problems clearly defined and stated in operational terms. West Germany can be given as an example of this problem-oriented approach.

Each federal ministry is responsible for its R & D activities and programmes. However a co-ordination concept has been developed: each ministry has appointed a research co-ordination officer; they draw up statements of their activities and they meet as an inter-ministerial committee under the chairmanship of the Federal Ministry for Research and Technology (BMFT). All their R & D projects are reported to the co-ordinating data bank DAVOR which is run by BMFT. The major research institutions supported by the Federal government draw up programme budgets.

"Performance plans" are drawn up according to a uniform target-oriented pattern, usually for five years. The same pattern is used for presenting the activities by institutions. The performance plans are articulated at three levels - programme, sub-programme and activities. The focus is on the programme level where - starting with a given initial situation - the long-term goals and tasks of the beneficiary sector are listed and reasons given for government support of the various R & D measures.

A pivotal role is played by BMFT, which is not only responsible for the overall co-ordination but is also a powerful operational body which can avail itself of considerable budgetary appropriations. Among others, its operational responsibility extends to large researchprogrammes in fields of particular importance, like nuclear energy, space technology, computer development, ocean resources, etc. Due to its unique position, BMFT exerts a strong influence on the formulation of government

R & D programmes and has also the means to gear R & D activities towards the aims and objectives of government policy.

Planning towards the top

An interesting type of organisation - which can be characterised as "planning towards the top" - has been experimented with in Norway. The attempt to link S & T policy to government policy as a whole is undertaken not by the government but by a research body, the Norwegian Council for Scientific and Industrial Research.

This body has expanded greatly, a fact which, in view of its links with industry and the economy, gives it considerable influence both in the field of science and technology policy and in that of economic policy. The scope and complexity of its activities have led the Council to introduce an integrated forecasting and planning system which is unique in that it attempts, of its own accord, to act in the light of "national objectives".

The main features of the integrated system are:

(i) prospective analysis: every five years each sectoral planning committee (20 sectors) carries out an exploratory study of possible technological developments over the next ten to fifteen years;

(ii) identification of "national goals": in the absence of an official statement the Council defines them on the basis of all available sources of information (parliamentary debates, political party programmes, economic forecasts, etc.);

(iii) rolling medium-term programmes: taking into account the "national objectives" and the sectoral futures studies, these programmes are drawn up as four-year "planning frameworks" with a low and a high limit to meet as flexibly as possible future changes in priority.

Integration within general planning

In most cases, action designed to ensure the relevance of research to major socio-economic objectives remains one-sided in that government policies are hardly formulated and put into effect with reference to science and technology developments. To remedy this general shortcoming the most comprehensive type of organisation is to integrate S & T in the formulation of policies in ensuring within general planning the two-way link-up of S & T policy and the other components of medium and long-term government strategy.

This approach is based on two complementary ideas. The first is that to be relevant to society S & T policy must be attuned to concerns and objectives as expressed in a comprehensive national plan. The second idea implies that this comprehensiveness and the overall coherence of the plan cannot be fully realised without integrating science and technology in the economic, social and cultural development of the country.

One organisational form - applied in Japan - involves constant interaction and co-ordination between the R & D plans and the economic plan. The national plan reflects the programme of the government and is revamped or replaced with each change of Cabinet. Operational programmes are drawn up by individual ministries and public bodies which are progressively seeking to harmonise their programmes so as to make them acceptable within a broader scheme. In this case, action goes basically from institutions to objectives.

Another organisation form - as applied in France - follows a different path. The planning process starts with a government statement outlining in broad categories the basic directions of national economic and social development. There are several institutional levels of contact between planners and organs of S & T policy. In the 7th plan (1976-1980) a considerable effort of "concertation" has been organised at the sectoral level so as to take into account expert opinions on the prospects in each field. In French planning, S & T policy is considered a priori as a component part of the general plan and is treated, at least in principle, as one of the functional elements of the planning process which flows from objectives to institutions.

Most countries continue to experiment both with S & T policy institutions and mechanisms of planning and prospective analysis designed to relate S & T policy to government policies. There are many obstacles to their relevance and effectiveness.

Some are conceptual and methodological in nature, particularly in the difficulty of identifying long-term features of economic and social problems so as to establish suitable objectives for R & D activity and that of introducing long-term perspectives into policies which are applied on a day-to-day basis. Others relate to the practice of government which is centered on short-term operational periods and narrow departmental responsibility. Even where scientific and technological perspectives and the needed resources have been taken into account in formulating medium and long-term programmes, such programmes are hardly related to economic and budgetary policies. The driving force behind these policies is short-term demand management based on models in which science and technology change is treated as an exogenous factor.

Finally, both in the field of general policies and much more particularly in that of S & T policy, the prevalent institutional set-up is the result of peacemeal steps to deal with new problems. Frequently the easiest way was to establish mechanisms or procedures for limited purposes, superimposed on or added to existing structures. With time, each system tends to develop its own rigidities and becomes less receptive to central decision-making and its global view of S & T policy.

Three basic tendencies emerge from the recent experience of the OECD countries. Firstly, most member countries have become increasingly critical towards the idea of a comprehensive national plan incorporating, among other components, a scaling of priorities for R & D programmes. Instead the concept of "flexible planning" is advocated, although the contours of such type of planning are still ill-defined.

Secondly, the general endeavour is to make R & D results relevant to potential users and to justify R & D activities in economic and budgetary terms. This is reflected in the reinforcement of departmental R & D and planning units and in the new generalised practice of medium-term sectoral plans. These are mainly indicative and are a direct result of budgetary procedures. R & D expenditure is a component part of these and is determined by reference to the operational targets of ministerial departments.

Yet constant emphasis is placed on the need for a long-term view of society. However the discrepancy between operational tasks embedded in short-term political cycles and the need for long-term future research makes it difficult for ministerial departments to undertake systematic long-range studies. They tend to contract such studies to outside institutions or think-tanks. In this way, they avoid direct responsibility for the contents and are free to exploit the studies as they like. "Prospective analysis" or long-term future research becomes thus a foresight and early warning function. Since it is only peripheral to operational responsibilities of political bodies it can be used without risk of untimely commitment but purposefully and with great flexibility.

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3. Long-term Planning, Technological Forecasting and Underdevelopment: Thinking on the Unlikely?

JOSEPH HODARA

INTRODUCTION

In many situations, "planning" is in the realm of sacredness. Despite that it denotes a "general commitment to rational analysis" (1) and "a goal-directed decision making process" (2), planning appears to have now entered a "magical" universe.

Perhaps Waterston was thinking of this paradox when he said: "national plan appears to have joined the national anthem and the national flag as a symbol of sovereignty and modernity". (3) I suggest that this shift of significance ceases to be paradoxical when both the original context of and the present mood (and assessments) on planning are taken into account. In effect, development planning sprang from a collective intent to impose some sort of rationality upon a non-rational environment. This environment was characterized by market imperfections, severe discrepancies between public and private interests, "perverse" repercussions of trade, technology, financing, and aid on national policies, etc. (4) Moreover, planners had to face in the underdevelopment matrix intrinsic difficultues (such as capital and information shortages) which hindered the implementation process. (5)

On the other hand, planning performs some non-explicit functions (a rallying-point for political mobilization; a basis for claims regarding foreign aid, etc.), with attendant consequences. These lead in turn to twists of logic and meaning as to key-terms such as "rationality" and "optimality". (6)

It is no wonder that planning is now at bay, affected as it is by a status of "untouchable" (i.e. a central) national myth, by ideological agitation, and by gloomy assessments.

Nonetheless, the sacredness permeating development planning and contradictory evaluations on it fail to jeopardise irreversibly this principled premise: that planning is a multi-purpose, plurilevel, and historically-conditioned tool, badly needed by less developed countries (LDCs).

In some circules, technological forecasting (TF) is also a "magic" word. In contrast to development planning, TF presumably stems from a pure, rational universe (i.e. the scientific method). Yet, like planning, TF stirs debates which hinge around many axes. (7) I will refer to some of these below.

My aim in this paper is to present some thoughts on long-term planning (LTP) and TF, considered in a development content. The course of my discussion will be guided by two key theses: a) that LTP and TF represent structural (i.e. strong, self-sustained) requirements of any contemporary society; b) that LTP if properly linked to TF, can correct, orient and demystify development planning.

I will try, first, to characterize the "underdevelopment condition". Second, I will point out certain advantages and merits of LTD. Third, TF will be introduced in order to build some bridges between the two.

Above all, I shall try to be brief, relying on remarks and bibliographical indications at the end of the paper to qualify some rather sweeping statements. All along I have also taken into consideration key issues to be discussed by the coming United Nations Conference on Science and Technology for Development. (8)

UNDERDEVELOPMENT: AN UNBLESSED CONDITION

LDCs have been portrayed in different ways. (9) Most of them seem to fall between two extremes. One method of describing them consists of the use of "indicators" which are designed to show to what extent, and in which respects, LDCs lag behind industrial societies. For some analytical and comparative purposes this approach may be justified. But its pitfalls are also evident: It prompts, on the one hand, lineal and mechanistic appraisals; and, on the other, an a-historical and, ultimately, self-defeating policy-making. (10)

The other extreme is related to broad categories such as "colonization" and "neo-colonialism", "exploitation", "alienation", etc. With these categories in mind some authors claim both to depict the underdevelopment conditions as well as to suggest the proper policies to overcome it. (11) In my opinion, these categories imply more an ethical indictment against the industrial (particularly capitalist) civilization than an analytical device. Moreover, they tend to be also mechanistic and a-historical, since they barely acknowledge both the specifics of local conditions and the intellectual heritage from which they ungraciously draw.

Between these extremes I suggest that "underdevelopment" can be characterized through complex variables. By "complex" I mean that these variables can be, in principle, quantitative (i.e. "operationalized") and qualitative; static and dynamic; and, finally, subject both to historical analogies and to unprecedented circumstances.

The variables are: strategic vulnerability; societal disjointness; and non-integrative policy-making.

Of course, the variables have been chosen while bearing in mind linkages and tensions between LTP and TF in LDCs, but I am convinced they possess a fair degree of generality.

Strategic vulnerability means and implies several things widely discussed in the literature dealing with LDCs, for example: non-compensatory dependence on external growth and trade fluctuations (12); a large meagre capability for responding to threats and opportunities; an acute shortage of key information (13); and narrow room for national manoeuvering.

But one feature of this dimension, important to our discussion, has barely been touched on. It is the large dosage of risk and uncertainty that the condition of underdevelopment entails. (14) I will deal with it in due course.

Societal disjointness means severe discontinuities (physical, social, and psychological) within the national fabric; disfunctional heterogeneities produced by an unequal diffusion of technological changes; and self-perpetuating distances of cardinal collective parameters, such as income, education, health, and power. To these traits - again, widely discussed in the literature - I would add the predominance of vertical communication which has hindered thus far both planning processes and the spread of bottom-up innovations. (15)

Finally, non-integrative policy making involves a state of perpetual disorganization and re-organizing; sudden ruptures and arbitrary "jumps" in the public decision process; a deep-seated neglect of global consequences of seemingly isolated actions; and "a common-sense" (at best) perception of a world which is rapidly becoming "counter-intuitive". (16)

Two reservations are in order. These complex variables do not characterize all LDCs to the same degree; factor endowment, geopolitical status and perception, elite' composition and turnover, and development goals may temper - or aggravate - their effects. Otherwise put, these variables depict a condition which may take many shapes and degrees.

Nor do they characterize exclusively the LDCs. Industrial societies may also be (or become) "vulnerable", "disjointed", and "chronically disorganized". Yet these traits are not produced in the same context; they persist over long periods; and they do not lack - and this is the main point - counterbalancing forces. (17)

Having schematically portrayed "underdevelopment" and intimated some of its inherent constraints for planning (as well as for endogenous technological advance) let me now examine long-range planning.

THE CASE FOR LONG-TERM PLANNING (LTP)

To date LTP is more an intellectual abstraction than an empirical, well-established entity. In not a few LDCs it constitutes a sort of "social UFO", which stirs fantasy and magical thinking. Nevertheless, LTP - or better, a long term vision - is becoming a structural need for societies responsive to, or affected by, technological imperatives. Among the latter it is worth mentioning: the lead time of innovative processes; the second and n^{th}... order consequences and ramifications of technical changes; the impact of some "socially sadistic structures" (18), etc.

By definition LTP may embrace different time-spans, like 10, 20, 50 or more years. (19) A personal choice on this matter, if well grounded, may be fully justified.

An alternative criterion consists of determining the lead-time of certain prime sequences (for instance, mega-innovations, allocative decisions affecting complex systems, the probabilistic path of a "planetary" problem - food, energy, water) and then fixing LTP on the basis of "weighted averages". (20)

It might also be acceptable to choose a non-positive approach. That is, LTP encompasses that time-span which is beyond any intentional design. It provides, however, clues as to what not to do, and about what not to expect. (21)

At any rate, I believe that LTP contains many potential functions in an underdevelopment content, functions which, is obtained, may favourably change the normative, cognitive and institutional climate surrounding development planning.

The ensuing list is not, of course, exhaustive; merely illustrative. Some functions are inter-related.

a) To identify alternatives on a macro decisional level, that is, on that level which holds determining factors of collective viability and vitality. Examples: alternative ways of designing "technological styles"; heightened sensitivity to optional "world images"; differential conceptualization of "relative advantages", etc.

b) To reduce uncertainties. This is indispensable (remember "strategic vulnerability") in a world both interdependent and asymmetric. Moreover, this is a cognitive and management requirement for overcoming "turbulent fields" (22) to which LDCs are particularly vulnerable and in which they are already enmeshed.

c) To appraise time-leads of key processes. To some extent this is a corollary of the last point. However, it contains an important and specific message: that prime processes (particularly those scientifically and geopolitically inspired and propelled) evolve at unequal rats and mostly in a non-lineal way. This perception may be both heuristic (23) and didactic for many policy designes in LDCs inclined to static, spasmodic and lineal manner of thinking. By all means the same lesson is relevant to policy makers in DCs.

d) To search for functional equivalents. If we assume that the development path of LDCs cannot be similar to that established by DCs (due to circumstances which range from different "initial conditions" (24) and the unequal dynamics of trade, technology, etc. to the presumably finite character of known resources and its attendant "revolution of declining expectations"), it then becomes necessary to look for either "short-cuts" or "another development". But neither of them is achievable without a long-range view.

In other words, from the premise concerning differential development styles it follows that a systematic search for alternative ways of doing things, for overcoming collective insecurities, and for reducing error-factors are badly needed. LTP may offer helpful guidance in this context.

e) To enhance the likelihood of desirable futures. This stems from what has been stated thus far. Nonetheless, it seems worthwhile to make it explicit in order to set forth the following premise: that the "underdevelopment condition" does not imply a zero degree of freedom and manoeuverability. I spell this out because I think that some "vulgar" versions of the so called dependency theory (25) can lead ultimately to a "sophisiticated - though self deprecating and primitive - form of fatalism.

Of course, the shortcomings affecting LDCs are many; their fragility with respect to external cycles and factors is profound: and it might be that certain LDCs (disregarding a global catastrophe or an extremely fortunate twist of present circumstances) are "terminal" cases of stagnation and injustice. However, I think that degrees of decisional freedom do exist in most of them, and that through intelligent LTP it is possible both to increase the probability of desired futures and to reduce commitments to a "evil" present. (26)

f) To encourage public experimentation of new lifestyles. As has been suggested, LTP can pinpoint probable and desirable scenarios. But some constraints inherent in underdevelopment may turn counter-productive (or highly risky) in an all embracing attempt to avoid extrapolative courses. Under these conditions, a peacemeal social experimentation seems advisable in order to anticipate perceptions of opportunities and risks. In this case a sort of micro long-term planning will be needed.

g) The last function of LTP (I repeat: this is not a full list) is to try to identify and reconstruct the intellectual framework which guide the policy making of hegemonic governments and multinational enterprises. This function is as complex as it is necessary. Let me give two provocative examples in this regard.

Malthussian and neo-Malthussian schemes may indeed preside over that policy making (as well as over socio-economic structures of many LDCs). One interesting question is whether in a world of finite resources, escalation of threats, and technological protectionism, these schemes can ultimately bring about a "planetary Darwinism" (certainly, a Darwinism highly negative because not the best would survive), or a new genre of humanism. I argue that a penetrating examination, and a public debate on (27), intellectual frameworks for policy designing may anticipate clues on this question.

It will give a second example which is related to a different yet relevant universe of discourse. Some people say (including myself) that neo-classical premises cannot explain satisfactorily cardinal aspects and problems of LDCs. From the perspective I am referring to, three intriguing questions emerge. First, whether these premises - insufficient now - would hold true for LDCs in the future under altered conditions. Second, whether the behaviour of advanced capitalist countries is really fitting neo-classical postulates, or whether it has changed (or is going to change), with or without an ideological account of this turn. Finally, whether the behaviour of advanced socialist countries is in fact governed by a neo-marxist discourse, or whether it has turned (or it is going to turn) to some neo-classical premises. (28)

This disciplined identification of cognitive elements is not a futile exercise from an LDCs viewpoint; nor does it aim at demonstrating the "end of ideologies". On the contrary, it highlights the permanent importance of intellectual frameworks and paves the way for discriminating normative and behavioural components in the decisional design and rationale of overpowing entities.

THE CASE FOR TECHNOLOGICAL FORECASTING (TF)

The "art of anticipation" has evolved rapidly in the last years. (29) As a discipline it already presents some defining features: a body of knowledge and methods; institutional (academic and non-academic) supporting arrangements; formal requirements for professional identity; contesting schools; group rituals; and even hints of coming paradigmatic revolution. (30)

Unfortunately, the bulk of LDCs have remained aloof to and unaware of this evolving discipline. (31) Without attributing to it 'magical powers', I believe that this attitude has aggravated the effects of passivity, inertia, and uncertainty which plague many LDCs.

Of course, I favour any form of forecasting (social, political, economic, cultural) provided that this form be cultivated with scientific and social responsibility. Here I will limit myself to the technological dimension in order to sharpen the statement of some issues connected with LTP, development planning, and R & D policies.

What is TF? "A description ... of a foreseeable technological innovation ... that promises to serve some useful function, with some indication of the most probable time of occurrence". (32)

In this brief characterization I encounter the main components of TF for our discussion. (33) Some might refine it; while others might reject the very idea of forecasting. My stand is eclectic. I believe that this is an evolving and promising discipline, which fully justifies taking professional and institutional "risks".

What are the functions and tasks of TF in an underdevelopment matrix? Again, my list will not be complete; only preliminary.

a) TF permits the reduction of specific uncertainties linked to the upsurge of and the demand for new techniques. As it is well known, LDCs have had plenty of unfortunate experiences in this regard, codified in a semi-esoteric language (e.g. "low price elasticity of demand"; "international demonstration effect"; "barriers to entry"; "cultural mimetism", etc.). I do not assure that through TF these perverse phenomena can be averted; other conditions are necessary too. But at least the understanding of what is occurring - and of the main trends - might improve; perhaps, in this way, some preventive or anticipatory policy-prescriptions could be implemented.

b) TF offers illumination of the lifetime of technologies, its phases, diffusion curves, and cycles, thus paving the way for more effective and discriminating technology policies.

Regretfully, the LDCs' grasp of technology sequences and "missing links" is weak, and tends to confine itself to remarks on "institutional and communication gap", "poor infrastructure", "lack of critical mass", "need for endogenous growth", etc. All these explanatory and exhortive categories are correct; they reflect realities and aspirations. But they are not enough. (34) They permit neither a well articulated theory of technological advance in LDCs nor well-balanced policy making. TF can moderate - and perhaps reverse - the process of declining social and analytical utility of those loosely, connected notions.

c) TF facilitates a finer distinction among "minor", "major", and, particularly, "mega" innovations. (35) By mega-innovation I mean two things: i) a cardinal breakthrough which engenders a great number of effects and consequences (i.e. integrated circuits; telecommunication devices, etc.); ii) a cluster of innovations which jointly shake and invade a market (or any social sphere) changing it radically.

d) TF allows the determination of specific levels of support for R & D, including personnel, equipment, and organizational environment. Moreover, it sensitizes policymakers both to marketing risks and to the need of finding "market niches" in keeping with dynamic advantages of LDCs.

e) TF renders less difficult the political understanding of technology-related processes and decisions which are taking place in the global and national arena. This point merits here some scrutiny.

I shall take the New Economic International Order as a crucial case, and within its framework, the attitudes of some big powers towards the new sea legislation advocated by LDCs. In my opinion, to state that these powers are not ready to accept that legislation out of "malice" is very naive. I rather believe that industrialized nations will "give in" to LDCs on this question after they have made optimal use of sea resources (the predicted date for this turning point is set in the 1990s). (36)

Perhaps the same may be true regarding the whole NIEO, which is particularly sensitive to technological evolution and considerations. Namely, the DCs would accept new institutions and procedures after proper accomodation and when this Order becomes obsolescent (or perhaps better, "obsolescible") (37) from their technology-based point of view. Of this happens, NIEO will strengthen the powers that be, both on a global and national level.

It is clear that a more refined potitical understanding gained through (by no means exclusively) TF may produce - if the TDCs have indeed the political will for doing this - new concepts, goals, tactics, and instruments. (38)

f) TF may prevent "self-reliance" from becoming, with time and regardless of the will of its original advocates a self-strangling and segregating policy practice. In other words, by facilitating an early detection of new uses of processes, products and materials. TF can lead to a constructive division of technological labour among and within countries, coupling hopefully growth with equity.

In short, TF has no "magic powers" nor has it yet entered the sterile realm of institutional-emotional sacredness, as some other concepts have done in LDCs. It is plainly a helpful instrument for a new style of policy making. Moreover, properly linked to LTP, TF may prevent dangerous tendencies to "re-enchant" (in Weber's sense) the world through seemingly rational devices as development planning. I will now address myself to this question.

LTP, TF, AND DEVELOPMENT: LINKAGES AND TENSIONS

Some links between LTP, TF, and development planning have already been touched on. Most functions attributed to LTP and TF help ameloriate the condition of underdevelopment. To mention some examples: the identification of alternatives and the reduction of uncertainty diminish, in my view, the "strategic vulnerability". Furthermore, the appraisal of time-leads and the encouragement of "public experimentation" stifle counterproductive effects coming from prevalent policies.

Put more explicitly, social, cognitive and managerial links between lTP and TF can invigorate development planning through: i) internalizing "world images"; ii) cultivating sensibility to error/risk factors; iii) sharpening the eye for geopolitics; iv) encouraging bottom-up orientations in planning; v) getting away from too facile reductionisms and simplifications.

Does this signify that there are no tensions (i.e. instability inducing mechanisms) between LTP/TF and development planning?

I am inclined to answer conditionally to this question. If I were a "true believer" in the intrinsic "benevolence" of the State, my response would be positive. That is, if LTP and TF are capable of transforming "underdevelopment" into a historical memory, and if development planning (the State included as its main component) really moves to overcome backwardness, then a successful convergence could be produced among the three.

But if development planning represents at bottom a "social pacifier" and a way for mobilizing external support and fragile national consensus, then LTP and TF, if adopted by any public agency, will become sources of group animosity and, ultimately, of structural tension.

To recapitulate: if the present talk on science and technology for development is serious; if LDCs want in earnest to moderate and reduce the perturbing effects of transnational environments and factors; and if development planning represents a rela commitment to rationality, growth, and equity, then LTP and TF may become powerful tools for achieving these ambitious goals. But if all is a matter of ritualism and cynical knowledge; if external and national entities converge in supporting rigidities and inertias; and it development planning is merely either a passing mood or a fallying cry, then LTP and TF will become subversive, perturbing and impertinent guests. At best, both will provide, to a small band of thinking people living in LDCs, a poignant form of social autism.

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(16) On "counter-intuitive" trends see J. W. Forrester; for instance his "Planning under the Dynamic Influences of Complex Social Systems", in E. Jantsch, op. cit. Besides, this is the main line of reasoning of P. K. Rohatgi, among others. See his Potential Use of Long-Term Studies by Development Agencies, The World Bank, Washington DC (mimeo) w/d

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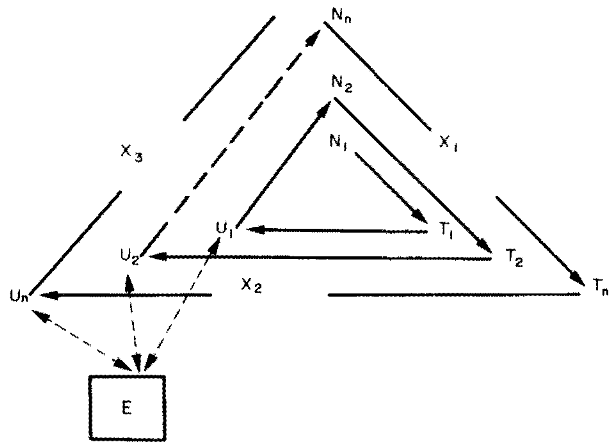
4. Programming and Guiding of Science and Technology Development: Some Global Problems with reference to the International Development Strategy

JOSEF PAJESTKA

It can be assumed that in the historical development process there have appeared dynamic interrelationships between human needs and conditions of human activities on one hand and technological patterns of economic activities on the other. These interrelationships can be simply presented by the following diagram.



As shown in the diagram, human needs in an initial period, $\underline{N_1}$, give birth to a corresponding set of technologies, $\underline{T_1}$. Technological change leads to a change in the economic structure, $\underline{U_1}$; one can mention here the acquisition of new sources and forms of energy, of new raw materials, increasing the volume of output, changing costs and price relations, introducing new products and services, changing forms and structures of employment, changing human skills, changing demographic patterns, etc. These economic changes affect, and are also influenced by, environmental conditions $\underline{E}$. The new economic and environmental structure produces, in turn, new human needs, both individual and collective, $\underline{N_2}$, and this leads to new generations of technologies, new impacts on the economic and environmental structure, etc.

In this process of change three basic relationships merit attention:

(i) The relationship between needs and technologies, $\underline{x_1}$, whose main feature should be seen in a functional role of technology in relation to the human needs. It is not asserted here that this functional role of technology is always smooth and undisturbed, but this is its only rationale.

(ii) The relationship between technology and economic structure, $\underline{x_2}$, which is seen in the historical process mainly in form of socio-economic consequences of technological progress.

(iii) The relationship between economic, and environmental, structure and human needs, $\underline{x_3}$, which is seen in the historical process mainly in the appearance of new needs resulting, for example, from changed economic and environmental conditions.

Distinguishing these relationships shows that they form a general system of dynamic feedbacks.

Throughout centuries of development of industrial civilization, scientific and technological progress followed a rather spontaneous pattern. It has been influencing, ever more deeply and intensively, the process of socio-economic development - changing conditions of economic activities and their features, changing human needs, economic and institutional structures, etc. This has been taking place, however, with a relatively low degree of what might be called the conscious, long-term, purposeful and rational human behaviour. This is not to say that science and technology did not serve human needs. Still, it is worth observing that:

(i) The lines of scientific development and the patterns of applied technology, when looked at from how they served the human needs, $\underline{x_1}$, showed a dominant feature of a rather spontaneous development, pushed and shaped by various forces, often uncontrolled and even not well understood. It seems hard to apply, when describing the past process of scientific and technological development, the characteristics of a consciously guided process, oriented on long-run purposefullness.

(ii) The impact of new technologies on the economic and environmental set up, $\underline{x_2}$, was by and large not anticipated, and the adaptative processes were rather of spontaneous character, not based on prospective foresight.

(iii) The impact of a changed economic and environmental set up on the development of new human needs and civilization patterns, $\underline{x_3}$, was also not anticipated, and most often even not well perceived.

We can thus say that the scientific and technological progress had for a long time the character of a predominantly spontaneous process. This characteristic cannot, however, be understood as the undermining of the great, positive and creative role of scientific and technological progress in the socio-economic development process. It also showed certain negative impacts which we shall come to later.

In the course of further development in the capitalistic system, particularly more recently, the character of feedback between scientific and technological progress on one hand and socio-economic development on the other has been subject to an important change. This appeared mainly because R and D activities have become widely spread, have been carried out systematically in an organized way, and have become an integral part of industrial activities. Thus productive activities have become more science-based, particularly in certain sectors. All this has been changing the character of the feedback.

In consequence, the element of the feedback, $\underline{x_1}$, has acquired the feature of being more of an organized order. Indeed, planning of R and D activities developed, particularly within large business companies, and this was supported by interventionist action by various government agencies. The latter has aimed at both giving general support to scientific and technological progress, considered as an important factor of development, and givine specific guidance to scientific and technological progress.

Notice also that within large economic organisations, and also within the wider national and to a certain extent transnational scope, there appears a growing element of anticipation and purposeful adaptative activities with respect to the elements of the feedback, $\underline{x_2}$ and $\underline{x_3}$. It can then be rightly said that the spontaneous development of science and technology has acquired some new features - those of a organized, planned character. This statement does not exclude many reservations which can be rightly formulated in this context.

While stating that in the contemporary capitalistic economy of the developed countries the degree of planning of science and technology has noticeably increased, one has to stress that this is not tantamount to achieving the long run, social purposefulness and rationality of the development of science and technology. This proposition, distinguishing between planned character on one hand, and long term purposefulness and rationality on the other, may seem paradoxical, but it is not so. One may easily visualize a high degree of planning - in the sense of the conscious setting of objectives and efficacious ways of organized activities towards achieving those objectives. The objectives, however, may not conform to the social purposefulness and social rationality. Thus, for example, a war may be a perfectly planned venture, though devoid of any long term rationality.

The problem of long term social purposefulness and rationality of scientific and technological development has been put on the agenda of the crucial, global topics, discussed by the world community in recent times. Critical evaluation is given particularly to the following traits of science and technology development:

(i) Concentration of efforts and resources on military aims which leads to a great waste of the most valuable, creative human potential and creates a growing danger to survival of human civilization.

(ii) Patterns of scientific and technological development leading to strengthening socio-economic polarization within the world scale, deepening the discrepancies in efficiency patterns, innovative capabilities and living standards of the various nations, all of which if unchecked increasingly endangers the socio-political equilibrium, threatening world peace and order.

(iii) Patterns of scientific and technological development leading to wasteful use of the world's natural resources and to degradation of the natural environment, which endangers the long term prospects of human civilization.

(iv) Undesirable and sometimes openly negative influences on humans of new products, new needs and new living patterns, being the product of new scientific and technological developments and active marketing practices; if science and technology create new things, they are being offered, and sometimes "imposed" upon people with scant attention to their impact on people and human relations, particularly in the longer term.

These arguments on deficient global rationality in science and technology development carry very heavy weight. It is of a character that might endanger further prosperous development of human civilization. What we used to call scientific and technological "progress" may easily turn into "antiprogress" and certain symptoms of that are visible.

The socialist system brought into the historical process the idea of comprehensive development planning at the national scale, and supplied actual experience in that field. The planning and management system applied by the socialist countries was designed particularly to serve a main purpose: that of overcoming economic underdevelopment and creating favourable structural conditions for self-sustained socio-economic progress in the longer term. Planning of science and technology has been considered as an integral part of the overall planning. It has proved to be effective in certain crucial aspects.

The national development planning helped greatly in establishing the science and research infrastructure, in the form of the educational, scientific and research facilities. This infrastructure was geared to the programmed patterns of socio-economic development in the longer term. National planning assured the necessary coordination between the development of the educational system and science and research activities. It proved efficient in concentrating efforts and resources on certain lines of scientific and technological development, important for overall progress. Last but not least, it managed to adapt technologies to the socio-economic development conditions, and particularly to the strategic design of manpower utilization. Utilization of manpower resources was one of the crucial strategic concepts off for accelerated development in most of the socialist countries. The solution of this problem, to which the choice of appropriate technology played an important part, can be said to be a great socio-economic innovation of the socialist planning.

While the central development planning proved effective in shaping the macro-economic conditions for science and technology it has not, however, been so effective in developing the grass-roots innovative dynamism. This is currently a most important issue in socialist countries, and solutions need to be found. Those solutions are to be found primarily in the management system and in motivations.

Note also that socialist countries by and large have so far followed the technology and product patterns typical for contemporary civilization. Income distribution patterns and emphasis on the basic needs of the broad population strate have tended to shape differently the product composition. Still, the products have been chosen from the shelves typical of other industrial countries. That is why the socialist countries face similar problems in the wasteful use of naturat resources and in environment protection, as the onse indicated earlier.

Though understanding of the dangers of misdirected scientific and technological developments is growing steadily, drawing practical conclusions from them for assuring greater rationality in the global scale is still a rather open dilemma.

We seem to be still in an age when people consider that mastering of the material world with the help of science and technology is the highest virtue, having great merits in itself. There is therefore the wide opinion that the achievements of science and technology always have great value in themselves, and it is their application which may go wrong, due particularly to "bad" politics. This view does not leave much place for evaluating the purposefulness and rationality of the patterns of scientific and technological developments. It is my contention that it should be reappraised.

Science and technology are as much a product of economic and political relations as they are shaping them. As indicated in the first part of this paper, there exists an effective feedback between science and technology on one hand and economic structure, to which one should also add political relations, on the other. Changing the working of this feedback for some desirable purposes demands, firstly an evaluation of each of its component parts and, secondly, a certain guidance applied to each of them.

Science and technology are no longer "wonder products" of the human genius. They have grown to become a "mass product" type of activity. As such, they should be put under the rationality criteria, should become a subject of careful socio-economic evaluation and guidance.

Particular traits of scientific and technological development patterns are due to the capitalistic system. Apart from its impact on scientific development and technology patterns, it should be noticed that science and technology have been successfully utilized to support the domination of the highly developed capitalist countries over important parts of the world. Primacy in science and technology, and efficient control over them, has to some extent substituted the former political control, e.g. of the colonial type, yet working to the same effect.

One important feature in science and technology development merits attention. This development tends to proliferate under the dominant influence of the leading, creative centres. Achievements and patterns shaped in the leading centres tend to be applied universally. That is why the dangers of misdirected scientific and technological development are of a universal character. A number of factors work in this direction.

There appears, first, a strong mythology of scientific and technological progress. Scientists, research workers, busines people, politicians, etc., considered scientific and technological progress developed elsewhere, and particularly in the leading centres, as praiseworthy; it is taken for granted that new technological processes and new things are good in themselves and worth having. There exists a very unbalanced distribution of capacities for science and technology development; a strong polarization in that field. This leads to technological domination which, apart from economic and political consequences, brings uniformity and reduces diversity in technology patterns. The international market supports this polarization and domination, International competition, both economic and political, makes it important for partners to be in possession of technologies which may potentially prove crucial. Therefore, there is a tendency for countries to enter into new lines of science and technology on the argument that they are developed elsewhere. Last but not least, the economic organizations and countries which developed new technologies are highly interested in their spread, since this strengthens their influence and brings benefits. Because they are, as a rule, economically strong, their action towards this end is effective.

Though these factors work differently in the various countries, they together intensify the universal pattern of scientific and technological development. Since the developed capitalist countries are most important leading centres of science and technology, the traits of their developments have great impact on the world pattern, which goes beyond the boundaries of political influence.

One conclusion from the above seems to merit particular attention. The universal impact of the patterns of scientific and technological development implies that they should not be treated as being of concern to the countries of origin alone. Some of their aspects should become of interest to the world community as a whole.

From the foregoing considerations the general conclusion that emerges is that there appears a growing need for the international community to evaluate the patterns and the prospective lines of development of science and technology, and to introduce some elements of guidance into those processes.

The international commuaity has already embakred upon formulating lines of international development strategy, IDS. The United Nations is rightly concentrating on this task. It would seem desirable to consider enlarging the scope and contents of this endeavour by including certain global issues of scientific and technological development. This should noe be seen as an attempt at introducing some kind of comprehensive, international "planning" of science and technology. That would be neither realistic nor desirable.

Still, it should be feasible and desirable for the international community:

(i) To define certain lines of scientific and technological development as highly undesirable. One can foresee here also international agreements which ban certain specific lines of research. Such cases will most probably grow in number in the future.

(ii) To define certain lines as being particularly desirable and important for achieving the objectives of the IDS. One can mention here, for example, research on adequate technologies for the needs of developing countries, research on energy conservation, natural resource savings, environment protection, health protection, new educational techniques, etc.

One should take into account that the international community, represented by the UN, can exercise a strong moral influence on the scientific and research circles by declaring what is desirable and what is undesirable in lines of development in science and technology. This may be supported by various forms of activities.

(iii) The UN family of organizations has at its disposal a developed institutional framework, cadres, and material resources. They should be used for supporting the defined lines of scientific and technological development.

(iv) Establishing of international rulesin the field of science and technology, e.g. for technology transfer, has been rightly considered as an important element of the New International Economic Order.

The above points may give an idea of what could be included into the IDS. They also give an idea of the character of global guidance for science and technology development.

The most crucial problem of the IDS is that of overcoming the glaring inequalities among the nations. This is also the subject of activities aimed at establishing a better international order.

It should be noticed in this context that in the various documents and interpretations of the IDS the role of science and technology in overcoming world poverty and establishing greater justice among the nations has been somehow neglected. It appeared as if this crucial factor of progress has been left aside of predominantly economic and political considerations. There seemed a lack of clear identification that science and technology can have a crucial instrumental function in achieving more purposeful and equitable world development patterns. This may be traced back to shying away from accepting the need and the possibility of evaluating and of a certain guidance of science and technology development on the global scale.

It seems worth stressing that it is not only purposeful to see in science and technology an important factor for overcoming the world economic and social inequalities, but also just and right to consider science and technology as a common heritage or mankind. Science is an historical product of centuries of human culture and civilization. It is absolutely right to use it for the benefits of all mankind. In the politico-economic relations an appropriation of sceintific and technological achievements is practised. Ways and means have to be found by the international community with the assurance that those relations do not hamper implementation of the IDS.

In considering the utilization of science and technology for the better progress of the developing nations, a strategic approach is required. It consists primarily in identifying the main lines of action which promises the desired results. This line should be seen in creating the developing countries' own capacity to use science and technology as a powerful force of progress, with all that this involves in developing the science and technology infrastructure. I would not hesitate to call this a crucial strategic line of the IDS.

It is justified for the international community, and for the UN in particular, to concentrate on proper implementation of this strategic line. It is justified to channel various forms of international aid - financial resources, cadres, equipment, results of research, etc., for this objective.

It is worth noting that international aid for the purpose of creating the developing countries' own science and research capacity should not be understood traditionally - mainly in the form of financial transfers. There is place and need for various forms of "transfers", providing that they contribute to the main objective and serve the purpose of the developing nations.

Doubts are sometimes raised whether creation of the developing countries' own capacity to use science and technology is a viable proposition. If this proposition would imply creation of new centres of science and technology, fully autonomous and independent of the existing world centres, it should certainly be considered unrealistic; neither would this be desirable.

Historical experience shows that each and any case of the successful development has been accompanied by the creation of self capacity to use science and technology. This is also the only line for developing nations to follow. There is no argument whatsoever that this might prove unworkable. Still, there are certain important problems involved. One of them concerns the basic concept of the patterns of science and technology suitable for the developing countries.

In the first part of this paper I outlined the basic feedback between human needs and conditions of human activities - and technological patterns of activities. While this has served to describe the general interrelationships appearing in the development process, the feedback applies to individual countries as well.

It is most important, then, that the technology be functional to human needs and adequate to economic and environmental conditions. Assuring the proper functioning of the indicated feedback is a basic condition of harmony and efficiency of the development process and of imparting selfsupporting, dynamic relations between science and technology and the socio-economic progress. One should accept this also as a most crucial premise of science and technology programming and guiding.

The necessity of technology patterns which suit the internal feedback does not imply "own" technology in the sense of originally invented, though it does imply "own" technology in the sense that it suits internal needs and conditions. It does not allow for wide imports of science and technology, though it requires careful screening and adapting of all imported technology. An order may be suggested in developing own capacities - evaluating, selecting, adapting, creating innovations. Most often, however, capabilities develop simultaneously in all of them.

The above seems the only defensible interpretation of the concept of "self-reliance" applied to science and technology. The main conclusion which can be derived from this concept refers just to the necessity of creating the developing countries' adequate, i.e. strong and efficient, capacity for using science and technology in a way suitable for their needs.

There is another requirement that is most important for the efficiency of the developing countries' activities in science and technology.

Scientific and technological development is subject to the rule of economies of scale. It follows that it is necessary to develop viable science and research centres, working within the scope of larger, international regions. This may encounter difficulties which can be easily visualized. The problem should not be treated, however, universally. Solutions should be looked for which suit particular, political and economic conditions of the various international regions.

PART II

Science and Technology in Sectoral Planning

5. Energy Technologies for the Third World

RUSSELL W. PETERSON

According to the distinguished geologist, M. King Hubbert, people born in the mid-1960s will see the world consume some 80 percent of its oil during their lifetimes. Hubbert calculates - and many other experts are in agreement - that world production of oil will peak out in the mid-1990s or sooner. If Hubbert is right, as he was in predicting the peak year for U.S. production, we are only about 16 years away from one of the major milestones in the history of humanity - the point at which the growth rate in the world production of oil executes an abrupt about-face and starts to contract about as rapidly as it had previously expanded. During the first two decades after oil production hits its peak, it is likely that world oil supply will drop by an amount equal to the world's total production today. Instead of doubling every 15-20 years, world supply will shrink in half every 15-20 years.

As the rising prices and recurrent "crises" demonstrate, the era of cheap and easy energy is over. A world designed - or aspiring - to run on cheap and easy oil has already run out of that kind of oil. The world oil price has increased more than eight-fold since 1971. In spite of this, world oil consumption still grows at an average rate of 4% per year, enough to double consumption in 17 years. Most of the nations of the world, developed and developing alike, have become dependent upon imported oil. And the exporting nations are becoming more and more aware that their own security depends upon their conserving more of this valuable national resource for use and sale in future years.

Increasing awareness of limits to the world oil supply and growing recognition by the oil exporters of the stake in safeguarding their supply will build pressure to continue oil price escalation.

This rapidly approaching oil crisis stands out as the single greatest thread to world-wide development.

Analysis of the growth in production and consumption of natural gas shows that it runs on a track similar to that for oil but a few years behind (3-5 years in the U.S.).

The utility of oil and gas is enhanced not only by availability but also by their fluidity. They can easily be transported and stored, can be piped to the point of use and are excellent portable fuels for transportation vehicles.

There are other means of obtaining fluid fuels but they have all been too costly in the past to compete with crude oil and natural gas. With the rising prices of oil these alternate sources will soon become competitive. These other sources are oil and gas from coal, shale, and tar sands and from tertiary resources from abandoned wells. It will require, however, hundreds of billions of dollars of capital and several decades of development to build an adequate supply of such alternate fuels to replace the projected depleting supply of petroleum and natural gas.

Liquid and gaseous fuels will be produced in increasing quantities from biological processes. The fermentation of grains and sugar cane to produce alcohol is receiving increasing developmental attention in several countries, especially in Brazil and the U.S. where it is being marketed in blends with gasoline for motor fuel. The long-term potential of this route is clouded by the increasing need for food production and the resulting competition for land use.

The bio-conversion of organic materials such as cow-dung, garbage and sea kelp to produce methane gas is of growing significance. It is too early to forecast with any certainty the potential for this approach.

Some optimists forsee, however, the world obtaining early next century as much as 20 percent of its energy needs from biological processes. I will discuss this in more detail later.

The solid fuels, wood and coal - mainstays of the past - are bound to play important roles in the decades ahead. This is especially true of coal, which exists in hugh quantities in a few areas of the world. The U.S., U.S.S.R., and Eastern Europe control 73 percent of the known world reserves. The quantity available could handle the energy needs of these areas for well over a century. In addition to being converted to liquid and gaseous fuels as described above, coal will be used extensively to directly fuel electric power plants, industrial steam generators and large space heaters. The mining, conversion and burning of coal can cause many serious environmental problems. But by strict governmental regulations controlling mining and land reclamation and stack gas scrubbing such as is now practices in several countries, the problems can be markedly alleviated.

The most critical of the potential obstacles to the vastly expanded use of coal and other fossil fuels is the build-up of carbon-dioxide in the atmosphere, which could lead to drastic climatic changes. Scientists still have much to learn about this build-up and its implications, but they understand enough to know that there is a serious potential for both a build-up of carbon-dioxide and a resulting climatic change, that the potential damages from that change are enormous, and that the prevention of such a build-up will be extremely difficult to achieve. The best bet for minimizing this build-up is to further energy conservation through reduced waste and more efficient use of energy. Some people believe the potential here is so great as to preclude the need for any growth in energy use in the developed countries.

Wood continues to be a major source of energy for cooking and heating in many parts of the world, but excessive deforestation, one of the world's most serious environmental problems, is rapidly diminishing the productivity of this energy source in many areas. On the other hand, the controlled farming of trees within the carrying capacity of the land is being projected as a growing energy source in some countries such as the U.S.

Nuclear energy is being counted on in many countries as a principle source of electricity, and many billions of dollars are going into providing nuclear facilities. In several developed countries 10-20% of their electricity already comes from nuclear reactors. Yet the rapidly growing concern of the people of the world about the safety of nuclear energy, about the long-term disposal of nuclear wastes, about the threat of cancer from radiation, about the potential for nuclear energy facilities to contribute to the military and terrorist use of nuclear weapons, is likely to bring the development of nuclear energy to a halt.

With the markedly reduced projections of energy needs that accompany the successes and promises of improved energy efficiency and the growing optimism for the development of renewable sources of energy, the long-term need for nuclear energy becomes less and less obvious.

If one had the choice of obtaining his energy from nuclear reactors or from a renewable source such as solar, it is hard to believe today that he would choose the former.

There is little doubt that growing uncertainties about energy supplies will have an important impact on international political stability during the rest of the century. Intensive efforts will be made by all nations to develop domestic resources and to ensure the security and reliability of foreign supplies. The latter objective, however, would appear to be increasingly difficult to achieve. The effort to assure supplies, and the vast transfers of assets between nations which occur in the process, can create economic dislocations in the industrialized nations and frustrate the aspirations of the less developed nations.

The less developed nations are, of course, most vulnerable to energy shortages and steep increases in energy prices. They are less able than the industrialized countries to compete for scarce resources and to bear the additional financial burdens. Their plans for developing their own industrial base and for modernizing agricultural methods have already been disrupted by higher energy prices. Many irrigation systems in South Asia, for example, stand idle because the fuels to operate tham cannot be obtained.

For the most part, the less developed nations have sought to emulate the growth patterns of the industrialized nations - patterns characterized by higher centralized, energy- and capital-intensive industrial structures which depend on cheap energy, especially cheap oil and gas. The economic assistance programs of the industrialized nations have been almost entirely geared to encouraging this kind of development. Now that energy is no longer cheap - and will inevitably become increasingly expensive - the less developed countries find themselves committed, in varying degrees, to patterns of growth that leave them just as heavily dependent as the United States on scarce energy resources but without the financial wherewithal to support that dependence.

All countries - industrialized and developing alike - have a vital stake in the overall expansion of world energy production (especially in the smooth shift toward more sustainable sources of supply), in the achievement of far greater energy self-sufficiency by the developing countries, and in the adoption of rigorous energy conservation measures by the industrialized world. To the degree that any country reduces its dependence on petroleum as an energy source, all countries have more time and room to make the difficult transition to a post-petroleum economy. For very different reasons, both the industrialized and the developing nations have a strong self-interest in reducing their independence on foreign sources of supply. For very similar reasons, both the industrialized and the developing nations also share a strong self-interest in the development, as rapidly as possible, of renewable sources of energy on which, sooner or later, all countries must rely.

There is, as I mentioned earlier, enormous room within the industrialized world - especially within the United States - for achieving dramatic reductions in growth rates of energy demand through conservation and greater efficiency in the use of energy. Last year, for example, a panel of the Committee on Nuclear and Alternative Energy Systems (CONAES) of the United States National Research Council concluded that the United States can achieve a "major slowdown in energy demand growth... simultaneously with significant economic growth by substituting technological sophistication for energy consumption". Indeed, the panel's analysis showed that "it will be technically feasible in 2010 to use roughly a total amount of energy as low as that used today and still provide a higher level of amenities, even with total population increasing 35 percent". Three things, the panel found, prevent the United States from making more rapid strides toward greater energy efficiency:

(1) Its refusal to allow current prices to reflect the long-term incremental costs of energy to society;

(2) The time it takes to replace energy-using equipment; and

(3) Its failure to change the many government standards, regulations and incentives designed to encourage the consumption of energy in the days when energy was cheap.

The drastic and rapid reduction of its reliance upon imported oil is undoubtedly the single most important step the industrialized world - and especially the United States - can take to help ease the impact of energy shortages upon the developing countries. Equally important, the industrialized countries must lead the way in developing efficient and affordable technologies that will enable the industrialized and developing nations alike to take increasing advantage of renewable sources of energy.

Indeed this effort is critical to the vast majority of developing countries without oil supplies of their own. These countries have a number of natural advantages that - with sufficient support of the right kind from the rich countries - would enable them to rely increasingly on renewable sources of energy. Since they have not, for the most part, already made the massive investments in oil-based energy infrastructures that industrialized countries have, they can easily and quickly take advantage of effective technologies for tapping renewable sources of energy. Many have more sunlight than the industrialized countries, and the vegetation for firewood and biogasification grows faster in their climates. Finally, since renewable energy technologies are generally small-scale, they are especially suited for the kind of decentralized, rural development effort that seems essential to improving the lot and the lives of the poor.

Quite clearly, if there is to be any real change of eliminating the worst aspects of absolute poverty by the end of this century, it does not lie along oil-intensive patterns of development. The only sensible course for any developing country is to build, as much as possible, upon its own indigenous energy resources - to take a long, hard look at its own resources and, with the appropriate and adequate help of the industrialized countries, make the most efficient, effective and equitable use of those resources in order to meet the needs of the vast majority of its people.

But pursuing that path will make a difficult and radical departure from traditional patterns of development. It will require placing far less emphasis on energy development in the Western style and scale, for that kind of development is becoming increasingly obsolete in the West itself. It will seek, instead, to take full advantage of the great potential of small and medium-scale technologies which feature the efficient, rather than the lavish, use of indigenous and, especially, renewable sources of energy.

This does not mean that industrialization is no longer essential or important for the developing world, for industrialization cannot be the private preserve of the wealthy nations or of the wealthy people within the developing nations. Some essential industries - steel production and electric power generation, for example - are inherently capital intensive. What is critical is that capacity in these industries be used as fully as possible and that their output be aimed at creating productive jobs and meeting the basic needs of the majority of the people.

It has become increasingly evident that, in terms of helping the poor majority of the world, the past and almost exclusive emphasis upon aid in the form of large-scale, capital- and energy-intensive technologies has all too often been misplaced. We are learning that, with social as with physical structures, we must build from the ground up, not from the top down - we must start where the people are with whaterever resources, skills, implements they have.

If the disappearance of cheap oil has had an especially devastating impact on the developing world, the widespread and rapid degradation of its natural environment and depletion of its forests and other natural resources has even more ominous implications for the already fragile hopes and aspirations of the poor. This second "energy crisis" - the diminishing supplies of traditional fuels such as wood, dung and straw - directly threatens the very survival of these poor. Throughout the developing world, deforestation and desertification, the increasing fuelwood scarcities and declining soil productivity they create, are eroding and undermining the ecosystem that supports village life.

Much of this environmental and ecological damage has occurred because of their exploding population rates and the accompanying desperate attempt of the poor to stay alive and stave off disaster.

The quality of life of individual human beings is, of course, dependent upon the amount of food, water, energy, land, and shelter available per person. Thus, the number of persons is a critical factor.

Any effort to improve the quality of life of human beings or to provide adequate energy per human being has to face up to the highest of priority factors - the growth in population.

Although much has eeen done to reduce population growth in many parts of the world, the absolute increase in the number of people in the world during the next two decades, according to the United Nations' minimum projection, will be greater than the total population today of all the developed countries of the world. The rate of growth will be especially high in Latin America and Africa.

Some people still contend that population growth cannot be reduced until the socio-economic status of the people is appreciably improved. This conclusion has been thoroughly discredited by the remarkable success in many poor areas - for example, in China, Hindu Bali, Muslim Java, and Catholic Costa Rica - in markedly reducing birth rates through voluntary family planning programs.

The United Nations has stated that it is a basic human right to be able to decide on the size and spacing of one's family, and a nation's responsibility to provide its prople with the knowledge and wherewithal to practice such right. Wherever the leaders of a country have on a sustained basis organized down to the village level to teach their people family planning techniques and to supply them free of charge with the means for carrying out such techniques, there has been a rapid decrease in birth rates. Family planning is certainly not the only route to raising the quality of life of the poor, but it should be included from the beginning as one of the principal tools of poor countries as they work to further their development.

Enough said about the number of users of energy. Let's get back to the supply side of the equation.

We need to know far more than we do about energy use, needs and resources in the developing countries, both individually and collectively. We have very little information on the potential energy resources in almost all of these countries, on how energy use is related to the needs of the poorest groups, or on how energy production and use is related to GNP growth. The development of an adequate and up-to-date data bank concerning all aspects of energy in the developing countries is clearly essential to any effort to flesh out an energy strategy thas has a real chance of working.

There are, in the more industrialized and urbanized areas of almost all developing countries, just as I described earlier for the developed countries, enormous opportunities for reducing energy demand by using energy more efficiently. In all but a few of the developing countries, the industrial sector consumes at least 30-40 percent of total commercial energy and offers extensive opportunities for modernizing inefficient facilities, switching to non-oil-based electricity and developing onsite solar systems.

Little or nothing has been done to determine the potential supply of oil or coal in the non-OPEC developing nations. Some authorities go so far as to assure us that over half the oil yet to be discovered will be discovered in the developing countries. Geologists also speculate that supplies of coal and lignite may be widespread through the Third World. To explore and exploit these resources will require a great deal of outside assistance in the form both of capital and of technicla manpower.

With some 70 percent of the world's major hydroelectric potential but only 20 percent of the world's installed capacity, the developing countries have a near monopoly of the remaining good hydroelectric sites in the world. There are, again, constraints in developing this resource, including the lack of capital, and some potentially serious environmental problems. The potential of so-called "mini" hydro stations is especially promising for rural and agricultural use. In China, for example, more than 60,000 such stations - usually with less than 50 kilowatts each - both regulate water supplies and produce most of the electricity for nearly three-fourths of all rural communes.

No matter what progress the developing countries may make in discovering and developing their own sources of conventional and commercial fuels, those fuels will come neither cheap nor easy. And they, like the industrialized countries, must base their long-term growth upon renewable sources of energy supply. Moreover, the vast majority of their people - the rural poor - will derive little benefit from the exploitation of conventional energy sources. Without cheap and locally available energy to augment their own human energy, the rural poor will find it impossible to raise their own standard of living even to minimally acceptable levels in the decades ahead.

Despite the rapid urbanization of the developing countries, the rural population still amounts to some 75 percent in Asia, over 90 percent in Africa, and 50 percent in Latin America. Most of these people - an estimated 2 1/2 billion - continue to rely on wood, dung, straw, human and animal power for their basic energy needs. Without dramatic improvements in the management of these resources, and in the efficiency of their use, the poor will face, not only increasing shortages of these resources themselves, but - as deforestation, erosion, desertification and other ecological damage continue to occur - they will also face an increasingly diminished capacity of the land itself to replenish these resources. This depletion of biomass resources, and the capacity of the land to create these resources, could cause a sharp rise in the demand for oil or other conventional fuels in the developing countries that are not major producers of these fuels. It has been estimated that the substitution of oil for biomass as the primary source of energy for the rural areas of the developing world could increase world oil demand by as much as 30 quadrillion BTUs per year - about as much as the current annual production of crude oil by the OPEC countries.

Energy from biomass now accounts for an estimated 50 percent of all energy consumption in the developing world (excluding China), compared with 14 percent for the world as a whole and less than 2 percent in the industrialized countries. Moreover, the useful work squeezed out of these biomass fuels may average less than 5 percent, compared with 20 percent overall efficiency in the use of commercial energy. Thus, what characterizes energy use by the rural poor is not simply the low amount of per capita energy use, although that is far lower than in the industrialized world, but even more critically the small amount of useful work they get out of the energy they use.

Nearly all of the energy consumed by the rural poor centers around the growing, the getting, the cooking of food. The poor literally live off the land and are, in many parts of the developing world, consuming the natural capital - the productivity of the land itself - to improve their lives. In order to provide a brighter future for the poor, it is on agriculture that aid and development efforts must concentrate. It has become overwhelmingly clear that, in the decades ahead, the food to feed the poor must come, not from the granaries of North America - although we must meet emergencies from these - but from their own earth and their own effort. An energy and development strategy that seeks to lift the lives of the rural poor must help them develop an agriculture that is both strong and sustainable.

With the Green Revolution almost at a standstill because of energy constraints, a major priority for the industrialized nations must be stepped-up research into such areas as improving the ability of crops to fix nitrogen biologically, transferring the genetic capacity for nitrogen fixation directly from bacteria to plants, and increasing the efficiency with which plants fix energy through photosynthesis. Any breakthroughs in these and similar areas could open up significant new possibilities for increasing food production without increasing the reliance upon fossil fuels.

For the immediate future, however, the energy for bettering the lives and agriculture of the rural poor must come from "traditional" sources. Because biomass already plays such a central role in the day-to-day life of the rural poor, improvements in biomass management and efficiency would have an enormous impact on the quality of their lives. Efficiencies are so low and the management is so sorely lacking that the opportunities for improvement are equally great.

In most developing countries, cooking generally accounts for over 80 percent of rural household energy use. The source for well over 50 percent of this energy is firewood - followed by charcoal, cow dung, crop residues. Cooking is generally done over open wood fires, which use less than 5 percent of the energy in the wood. These fires consume an estimated 3-6 times the energy of a modern gas stove to produce the same useful heat. It has been estimated that twice as much energy is used in the cooking as is used in growing the food being cooked. Easily constructed stoves can increase cooking efficiencies to 15-20 percent, and more sophisticated stoves could reach efficiencies of 30-40 percent.

Fuelwood plantations and village biogas plants - extensively used through China - also have enormous potential for conserving and increasing the energy resources of the rural poor. With the effective use of biogas and other similar technologies, the agricultural sector in many developing countries could not only take care of its own energy needs, but have some left over for the rest of the economy as well.

The United States Congressional Office of Technology Assessment is in the midts of a major assessment of energy from biological processes. One of the chief aims of that project is to determine what the practical resource base is for energy from biomass in the United States. The assessment also includes a survey of the actual and potential use of biomass for energy in the developing countries and an exploration of the most effective roles the United States might play in helping these countries develop and deploy technologies for tapping biomass energy.

While this survey is still in its early stages, some preliminary and tentative findings are available. They suggest that there is great potential for alleviating the firewood crises in the rural areas of the developing countries by:

i) increasing the efficiency of cooking fires;

ii) bioconverting local animal and crop wastes to chemical fuels and fertilizers;

iii) introducing woodlot management to maintain stable, accessible supplies of firewood.

The vigorous pursuit of these measures could do more to improve the overall condition of the rural poor than any other single action concerning their energy needs. Indeed, their general and effective adoption could well provide enough energy from locally available biomass to meet all requirements for cooking, space heating, lighting, and where applicable, for tube well irrigation in the rural agricultural areas in all developing countries.

Although the majority of the people in the developing countries now rely on biomass, the developing countries devote a relatively small share of their resources to the improvements of biomass production, conversion and use technologies compared to the resources they spend on energy technology for fossil fuels and, in some instances, nuclear energy. Although there are signs of growing interest in the development of biomass technology, current programs in the developing countries are small, understaffed, underfunded and have extremely limited aims.

Perhapt sht biggest obstacle to any effort to strengthen and spread the use of appropriate biomass technologies through the Third World is the absence of current and comprehensive information on the supply and use of biomass energy throughout that world. We have, for example, only the roughest figures on forest cover for most countries, and no detailed inventories of crop residues, animal dung or animal draft power. Concerning biomass consumption we know even less.

Experience thus far suggests that the major impediments to the introduction and adoption of biomass and other small scale renewable energy technologies in the rural areas of the Third World are not technical and economic but institutional and cultural. Most of the rural poor themselves have no way of learning about the technologies and practices that could enable them to make the most effective use of their local resources. It is necessary, therefore, to develop far more effective institutional and other arrangements and methods for transferring to the rural poor the technological knowledge they need and for helping them adapt that knowledge to their own actual needs and circumstances.

Sooner or later, the developing countries as well as the industrialized nations must return to the original source of nearly all energy - the sun - for a growing share of their energy supply. The sun is one of the few sources of supply available to everyone and in especial abundance to the developing countries. A U.S. Office of Technology Assessment study released last year showed that the solar technology needed to meet all residential, commercial, and many kinds of industrial needs in the United States has already been experimentally verified. The main barrier to practical use in the United States is not technical, but economic and institutional. The study also showed that, by the end of the next decade, small-scale onsiet solar energy equipment - equipment designed to be located on or near the buildings or groups of buildings it serves - should be economically competitive with nonsolar systems in energy markets representing nearly 40 percent of U.S. energy demand. If the United States undertook an aggressive program to support the development of solar energy, solar equipment for heating homes and commercial buildings could be competitive with conventional oil systems in the United States by the mid-1980s.

The small onsiet solar technologies considered in the OTA study should, for a number of reasons, be especially attractive to the developing countries:

i) These nations have generally not invested in an extensive network of transmission and distribution facilities and could avoid the expense and delay of building such a network by installing onsite solar technologies across widely dispersed areas.

ii) Onsite equipment does not require an enormous investment of capital in single project.

iii) The equipment can be built rapidly and produce power within weeks or months instead of years.

iv) Major banks are likely to be interested in loans to developing countries for capital equipment which does not commit the borrowing nation to large operating expenses. Solar devices easily fall into this category; generating equipment based on fossil fuels does not.

v) With onsite solar devices, generating capacity can be easily and smoothly expanded to meet growing requirements for energy. Large facilities produce sudden large increments in capacity which are difficult to manage and which often result in prolonged periods of expensive overcapacity.

vi) As a more labour-intensive means of power generation (both in terms of manufacture and installation), solar energy should help alleviate the endemic high unemployment and underemployment that plague most developing countries.

vii) Village siting of solar facilities would help raise rural living standards. This could, in turn, have the effect of reducing the rate of migration to urban areas in search of employment, which is often available only in urban areas because only urban areas have adequate supplies of energy.

viii) Solar energy facilities can be constructed from a variety of materials, many of which may be available locally.

ix) Developing solar energy would not commit those countries to forms of energy production that they may not be able to sustain because of fuel shortages or the lack of secure funds for operating costs.

Although operating costs are low, solar energy equipment requires a substantial initial investment which most small developing nations will find difficult to raise. Any major program for developing the solar resource in these countries will probably require external financial and technical assistance. However, it will undoubtedly be easier to obtain financing for many small, relatively low-risk and low-operating cost solar projects than for larger-conventional energy systems.

Solar and other small-scale technologies offer what may be the only realistic hope for enabling the rural poor of the developing countires to make substantial improvements in their standard of living. Indeed, these technologies may offer the developing countries the opportunity of avoiding substantial investments in an increasingly obsolete fossil-fuel economy, and of moving into the world of 21st century energy sources ahead of the industrialized world whose enormous energy investments and infrastructure are so heavily fossilized.

6. The Role of Technology in Planning for the Capital Goods Industry

FERNANDO FAJNZYLBER

INTRODUCTION

This article presents an analysis of the part technology plays in the planning process currently being carried out in Mexico for the development of the capital goods industry. Specifically, it attempts to identify those areas of planning in which technology is especially important, with comments on the way in which it has been introduced in each case. That the capital goods sector often acts as a transmitter of technological innovation makes the relationship between sectoral planning and technology particularly important, not only because of the content and extensiveness of technology in the particular case of capital goods but also because of the effect its widespread use has on the economy as a whole.

The article has been divided into four sections: the first summarizes the outstanding role played by capital goods in the development of advanced countries; the second seeks to outline the factors explaining the relative lag of this sector in Latin America; the third describes the various stages of the capital goods planning process in Mexico; and the fourth deals specifically with the role of technology in that planning process.

THE ROLE OF THE CAPITAL GOODS INDUSTRY IN THE DEVELOPMENT OF ADVANCED ECONOMIES

The development of the capital goods industry has played an enormously important part in the industrialization of advanced capitalist and socialist economies. In fact, it has been shown that the dynamism of this sector is significantly greater than that of industrial activities in general. (1) This is partially due to an apparently structural tendency for investment to grow at a faster rate than overall economic activity (2), and, in part, to the fact that within investment itself, the capital goods component grows faster than total investment. (3) These two trends are linked with both the rapid growth and the intensity of technological innovation experienced by the economies of advanced countries in recent decades. This same dynamism has simultaneously allowed a greatly enhanced growth of productivity and employment. Indeed, it has been demonstrated that in the capital goods sector, both productivity and employment have a higher rate of growth than that of overall industrial activity in those countires. (4) Moreover, this stimulating effect on employment has the added advantage of involving skilled labour; thus the development of capital goods has become an important source of training and specialization of labour whose benefits are eventually spread through industrial activity as a whole.

The process of technological innovation in the capital goods industry has not only been a source of increased productivity in the sector and greater incorporation of innovations in capital goods themselves, but has also played an important part in increased productivity in the rest of the user sectors. The orientation of the resulting technical progress has unquestionably been a product of the conditions under which such a process has taken place. (5) There is ample evidence indicating that the path taken by technical progress in advanced countries has been associated with a growing scarcity of labour and with its increasing relative cost. The latter consideration applies particularly to the advanced capitalist economies where, since the 1960s, wages have been rising at a much greater rate than productivity. (6) Another important factor has been the relative scarcity of raw materials and, hence, the imperative need for stimulating innovations in the field of synthetic materials. (7) The capital goods industry has had to adapt itself to the development of new synthetic products, both in terms of the new requirements in materials and in the search for feasible new manufacturing processes and diversification of the uses for existing products.

This process of technological innovation based on labour scarcity and high cost, shortage of natural resources and, in some cases, limited space, had been further stimulated up to 1973 by the use of cheap energy. That is to say, the content and orientation of the technical progress incorporated into capital goods has corresponded not only to factors within the industrialization process but also to external conditions that have had a decisive influence on that process.

Finally, it must be mentioned that in the international trade of advanced countries, especially capitalist countries, the capital goods industry functions as a payment mechanism for financing the acquisition of natural resources. It can be noted that the surplus generated by capital goods in these countries roughly corresponds to the deficit they sustain in the purchase of natural resources. (8) In other words, the technological advances involved in capital goods production capacity have become a decisive factor in neutralizing the lack of local natural resources. Obviously, these generalizations about the developed countried tend to negletc the heterogeneous nature of the group, and after the second world war there was an important relative change in the international trade of capital goods within developed countries which could be characterized by a trend towards specialization, on one ahdn, and a modification of the relative position of the different countries, on the other.

Nevertheless, accepting the general hypothesis that the capital goods industry has a deep involvement with technical progress and that it has played a central rôle in the industrialization of advanced countries, it becomes necessary to look into its role in Latin American industrial development.

CAPITAL GOODS IN THE INDUSTRIALIZATION OF LATIN AMERICA

Evidently the capital goods sector is suffering from a quantitative lag in the larger countries of the Latin America. (10), but it should be pointed out that the lag is even more critical in terms of quality; that is, in local capacity for contributing to the basic engineering design of complex equipment and installations. This being the case, some questions must be raised about the factors that have been responsible for the development of this sector during the rapid industrialization of Latin America in recent decades. At the moment it can be seen that certain countries in the region, especially those striving for a more autonomous development and a higher "national" component in their projects, have shown a growing concern for reinforcing the development of the capital goods sector.

The lag in the capital goods industry in Latin America can be traced directly back to the pattern of industrialization followed by the region in the last decades. A central element in industrialization policy was the quantitative stimulation of investment, especially private investment, and to accomplish this it was necessary to create conditions under which investments would have the lowest possible cost. This was achieved to a great extent by encouraging the import of capital goods. The production of non-durable consumer goods and, later on, durable and intermediate goods, was stimulated but the local production of machinery and equipment, whose initial phase would have raised the cost of investment, was neglected. Empirical evidence shows that the protection level granted to the capital goods industry is significantly lower than that enjoyed by other industrial activities. (11) To this basic situation must be added other factors concerning the user industries (i.e. demand) and the potential suppliers of capital goods. First, it is useful to distinguish between users in terms of public enterprises, transnational affiliates and private national enterprises.

For public enterprises, the main restriction in purchasing capital goods has been financial. One of the characteristics of decentralized public enterprises in Latin America is that they consistently have a deficit in the capital account; and this is because price policies of such enterprises are designed precisely to subsidize the acquisition of those goods and services provided by these same enterprises. The deficit in the capital account is neutralized by access to international financing which, as is well known, is associated with the import of capital goods. As a result, there is a structural and financial element in the functioning of public enterprises which impedes their dynamic particpation in promoting locally produced capital goods. There is a marked difference between this situation and the role that public enterprises have played in the development of the capital goods industry in developed countries. There, a collaboration between public enterprises and national producers has been stimulated in both commerce and technology, at times in response to questions of national interest. This has been the case in the energy, communications, transport and armament sectors, among others. As a result, a good part of the development of these industries has revolved around the central role played by this close connection between public enterprise demand and the larger national private firms of those countries.

The affiliates of transnational enterprises have a policy for the purchase of machinery and equipment that is part of the global policy of the enterprise at the international level. In some cases the equipment and machines they use have been specially designed for those enterprises and are patented by the user firm. This is seen more frequently in the case of the automotive, food and pharmaceutical sectors.

Moreover, the import of capital goods is the form in which direct investment to the country is expressed - not in the form of liquid financial resources but rather embodied in machinery and equipment. Also, the division of work established by the affiliates' policies means that for some products in the final phase of the "product cycle" certain production activities are transferred and, along with them, there is a transference of the necessary equipment and machinery from installations in developed countries to affiliates in developing countries. Due to these circumstances, even though the demand for capital goods corresponding to the transnational affiliates is a substantial portion of total demand, it does not really represent much support for local production.

Finally, in the case of private national enterprises, which are mostly medium and small-sized firms, the problem of the financing conditions offered in the purchase of capital goods is a decisive factor and the conditions offered by local producers are notably less attractive than those found on the international market.

In considering capital goods supplies, a differentiation must also be made between national and foreign producers. Originally, foreign producers had an open market for exporting goods from their country of origin. As long as this option was open their motivation for coming to developing countries to install local production centres was very low due to the lack of technical infrastructure and the idea that local markets were small and fractionized among large numbers of international producers.

Later, however, certain markets began to close because or rising protection levels or, in some cases, because some of the enterprises belonging to oligopolical structures in different subsectors of industry began to take advantage of their maintenance and repair installations to install local production units. The characteristic imitative behaviour of markets began to unfold and the rest of the members of the oligopolical structures sought to establish themselves locally, but without causing any substantial alteration of the stable export currents. This was accomplished by restricting their local production to the simplest sizes and kinds of equipment and by keeping the degree of local integration relatively low. For the foreign producer, the option of local production only became interesting at the moment when there was a risk of losing the market.

For national producers, the capital goods sector was just one of many investment opportunities and, for reasons mentioned above, was considered as a somewhat less attractive option from the point of view of profitability and its greater exposure to international competition where buyers were technically more demanding and more inclined (because of structural factors mentioned before) to satisfy their demand abroad. These considerations, along with the apparently greater technological complexity of the capital goods sector, tended to turn national private capital towards other sectors, making capital goods' production a relatively marginal component of enterprises whose main activities were concerned with other industries. (12)

The pattern of industrialization and the structural and institutional factors that have been mentioned tended to channel potential demand toward foreign sources and to discourage potential suppliers of local production. Together they make up the main factors explaining the weak development of the capital goods sector in Latin America. Thus, the development of the capital goods industry, far from being a simple matter that can be solved by merely dictating legal dispositions and specific policies, implies the need to introduce important modifications in the pattern of industrialization of the region's countries.

In keeping with the hypothesis that technological development is to a great extent incorporated into the capital goods industry, it must be concluded that the weakness observed in the technological sphere in Latin American is associated with the lag in capital goods sector. In addition, it becomes evident that to overcome this problem it will not be enough to simply create specific norms directed toward stimulating research and development activities at the enterprise level and to regulate foreign technology transfer, as long as all of the factors making up the "industrialization style" of Latin American countries remain unchanged. The solution to this problem is a challenge that must be faced if the capital goods sector is to be developed and the technology of the region is to be reinforced. It is not just a question of developing an industry that might have fallen behind because of technical neglect but rather of introducing well planned, coordinated modifications in the industrialization style which up to now has tended to reject the expansion of this sector.

PLANNING THE DEVELOPMENT OF THE CAPITAL GOODS INDUSTRY IN MEXICO

In 1976 a strategy proposal for the development of the capital goods industry was formulated. (13) A series of conferences for both public and private sectors was organized and gradually a political climate favourable to granting a high priority to the sector's development was formed. (14) The strategy proposal contained an analysis of the role of the capital goods sector in some Latin American countries, the international framework within which the capital goods industry functions, the present and future demand of this sector in Mexico, the economic, technological and financial characteristics of the industry and its present market and supply conditions. On the basis of this analysis, subsectors worthy of priority attention were identified, using the following criteria: size of present and future demand, extent of development of present supply, potential for international competitivity, share of public sector damand, technological importance, and degree of sectoral priority given by the country's global development strategy to those sectors that would be users of such goods. Also in view of the priority position of agriculture and energy within the global development strategy it was desirable to achieve a degree of relative autonomy in the investment process of these sectors which implied giving priority to the manufacture of capital goods required by them. This set of criteria, some of which were quantifiable and others involving qualitative descriptions and evaluations, led to the identification of the following subsectors: agricultural machinery, equipment for the petroleum and electrical energy sectors, equipment for the steel industry, widely used equipment such as valves, compressors and diesel motors, infrastructure goods for use within the capital goods industry itself such as machine tools, foundry, forge and thermal treatment and the technologically important subsector of professional electronics. One of the major conclusions of the development strategy proposal was the need for specialization in categories which could shape a productive structure capable of dynamic self-stimulated growth through the industrial inter-relations within the capital goods industry.

Another important part of the development strategy was concerned with the political instruments that would be needed to change the behaviour of public and private economic agents which has been reluctant to participate in the development of this sector in the past. It was necessary to influence both the demand sectors, taking into consideration the different behaviour of the public, foreign and private national enterprises described previously, and the supply sectors with their particular reasons for lack of interest in entering into capital goods production in the past.

Some of the most outstanding elements of this set of instruments were financial support mechanisms for the production and purchase of capital goods, norms for changing the pattern of behaviour of users in the public sector, fiscal incentives needed for stimulating private sector interest in the manufacture and acquisition of locally produced capital goods, instruments designed to reinforce the internationally competitive position of locally produced capital goods and instruments oriented toward promoting research and development both by manufacturers and by users. In 1977 work began on a deeper and more detailed analysis of each of the priority subsectors, estimating the demand for the next ten years and identifying the product lines which would provide concrete investment opportunities and permit the design of political instruments suitable for particular sectoral needs. (15) At the same time, proposed political instruments began to be put into effect, resulting in the modification of the operating rules of existing financial mechanisms, (16) design and implementation of fiscal incentives, (17) and formulation of norms for channeling part of public sector demand toward local suppliers. (18) In the sphere of protection measures, new criteria were designed to provide protection for existing industries stimulating an increase in their competitiveness, and to promote the development of new capital goods through selective and gradually diminishing protection; greater freedom was given to the import of those capital goods that within the framework of the strategy were not considered to have priority importance during the next few years. (19) In 1978, based on a hacklog of information which now included estimated demand figures for the next ten years, knowledge of supply obstacles and identification of investment opportunities, along with a set of instruments for modifying the behaviour of users and potential producers, work bagen on the elaboration of pre-feasibility studies for capital goods in the branches that had previously been defined as priority. (20) In 1979 work is continuing on new pre-feasibility studies and the systematic promotion of prepared projects has been initiated.

As part of this promotion policy, in 1979 and the coming years, technical information activities will be intensified and reinforcement given to the technological infrastructure of the capital goods industry both in the area of research and developmetn institutions and in quality control centres and engineering firms. This is the sequence that has been followed up to the present and the stages that are expected to be developed in the future.

In this analysis ample evidence supports the validity of the previous diagnosis to the effect that the lag in the capital goods sector has not been the result of a fortuitous series of circumstances nor technical omissions in the policies followed before, but rather that it is deeply rooted in the industrialization pattern that evoled in the past. Such a pattern has been characterized by the relative inertia and resistance on the part of different agents involved in production, distribution, design and use of capital goods to change their behaviour and make a dynamic contribution to the new policy. Nevertheless, the adoption of an integrated policy that covers all of the areas in which decisions are made regarding production and use of capital goods is having an increasingly positive effect on neutralizing the obstacles created by past actions. The development of the petroleum sector, with its stimulating effects on the rhythm of industrial growth, opens up new horizons that should help to spur the development of the capital goods sector as a whole.

One factor that could be decisive in the qualitative evolution of the capital goods sector is the relation between national and foreign participation in production. The policy of the Mexican Government grants majority participation to national public and private capital and in some categories of goods seeks to strengthen the participation of national groups with experience in those branches of production. Foreign firms on the other hand, knowing the size and dynamism of the marker, are involved in trying to reconcile the functions of importation and local production. The forces in play are powerful and are continuously entering into coalitions and conflicts that are gradually shaping the new capital goods industry in Mexico.

The planning of development in the capital goods industry has also exploded a few myths that formerly were widely accepted throughout Latin America. The first myth implied that the capital goods industry is an extremely capital intensive activity and thus unsuitable for the conditions of developing countries at this stage in their evolution. The fact is that the capital goods industry is relatively less capital intensive than most of the industries already established in the region. (22) This myth was to some extent responsible for reinforcing the notion that it was as yet too early to begin to initiate the local manufacture of capital goods. The second myth refers to market size: it was frequently affirmed that because of the size of internal markets, expansion of the sector would be inefficient and unjustified. The fact is that in countries such as Mexico, Brazil and Argentina, and in groupings such as the Grupo Andino, the size of internal markets is comparable to or greater than that of many of the small and medium-sized European countries which have achieved development of selective industries capable of competing on an international scale. (23) Of course the size of the potential market can rapidly become distorted if supply becomes fractionized (as has occurred in some industrial sectors) and the avoidance of this problem is one of the major challenges faced by the development policites of the sector.

The third myth concerns the supposed "technological complexity" of capital goods production; however on the level of specific projects, the technology seems to be comparable with or even less complex than that of some industrial branches that have already been developed in the region by both public enterprises (petrochemicals and steel) and foreign enterprises (automotive sector).

THE IMPACT OF TECHNOLOGY ON THE PROCESS OF PLANNING FOR CAPITAL GOODS DEVELOPMENT

A previous description presents some of the various stages in the planning process of the capital goods industry. At each stage technology enters in with a different degree of intensity and different kinds of problem. The following sections present some of the phases of planning in which technological development plays an important role.

The central objectives in the development of the capital goods industry

One of the specific characteristics of this sector is precisely the fact that within the development of the industry an important objective is the strengthening of technological capacity and accumulated data. (24) Since the sector is a transmitter of technological progess, its expansion implies a greater probability of participating in the process of technological innovation on an international scale. This is, however, by no means a direct implication; it cannot be assumed that national technological capacity can be strengthened by just any capital goods industry regardless of the conditions of its development (which economic agents is responsible, what are the manufacturing conditions, what is the degree of national participation in design). Likewise, not just any methodology used in developing the capital goods industry will automatically result in the achievement of the goal of local technological development. On the other hand, it is quite evident that the absence of the capital goods sector would make it very unlikely that the technological level of the country could be strengthened. In other words, the development of the capital goods industry seems to be a necessary but not sufficient condition for the strengthening of national technology. The specific decisions about technology made during the various stages of planning are factors that will determine whether or not the final results of the planning process will lead to the desired goal. There is no doubt of the importance of including technological development in industrial strategy as one of its primary goals. This can provide a necessary (though not sufficient) catalyzing element that stimulates the mobilization of the various levels entering into such development and makes it more possible to move towards the objective. The step from theoretical formulations related to science and technology to the actual recognition of the priority of developing a sector that acts as a transmitter of technical progress, is, in itself, a significant advance. This is the first phase in the planning process in which technology is explicitly included.

The identification of priority subsectors

One of the first stretegic decisions that must be made in the planning process for the development of the capital goods sector is the identification of the subsectors which will receive priority attention. The decision requires, among other things, a knowledge of the relative speed and direction of the technological evolution of the different branches. In fact, from the point of view of planning, it is important to know in which branches technology is very concentrated and in which it is more spread out, in which the concentration is increasing and in which the process of diffusion is becoming more intensified. The dynamism of the different subsectors also gives an indication of the rate of increase of productivity and this in turn is often associated with the rate of technological innovation. (25)

These factors, together with the degree of horizontal spread of technological innovation that characterizes the various branches, make up the minimum information necessary for including technology in the decision process related to each branch. This same process will also include the aforementioned considerations regarding growth of demand, structure and potential of supply, participation of the public sector, potential for international competition and others. In order to begin with such a task, analyses were made of trends in the international trade of capital goods, which included the dynamism of trade of the various subsectors, the degree of concentration of supply in different countries and variations of supply concentration in the different categories of goods. This approach attempted to take into consideration both short range requirements related to the feasibility of expanding capital goods production and the long range requirements focused on reaching a degree of relative excellence in given branches of the industry which would serve as the central pivot for an interrelated development of the sector as a whole. (26) Apart from this, literature about technological trends in different subsectors was analyzed with a view to enriching and qualifying the foregoing quantitative analyses. It is expected that the exploration of technological trends at the branch level will become a fairly systematic task since, as will be seen later on, it is an important element in the identification of lines of production within the branches. (27)

The industrial branch that is currently receiving most attention in developed countries is the microelectronics industry in which there is a high degree of technological innovation. Some authors include this branch in what has been called "information technology" where all of the advances in electronics, computation and telecommunications come together to make the work of organization, processing and transmission of information possible at a cost, reliability and energy use that would not have been dreamed of in past years. (28) The possibilities for applications of microelectronics and its most characteristic element, the microprocessor, have led some authors to claim that the world is on the threshold of an industrial revolution that will usher in the "era of information" to replace the "era of power". (29)

It is particularly relevant to mention this industrial branch not only as an illustration of the importance of keeping abreast of technological trends in specific branches but also because it reveals the strong support that the latest advances in technology receive from the governments of the developed countries. In fact, in contrast to the doctrine of "liberalization" and the curtailing of public sector activities so fashionable in Latin American countries today, the governments of developed countries, in a clear expression of interventionism and support of "national objectives", are giving direct and decisive support to the development of microelectronics on a national scale through public sector purchases, research and development contracts and direct financial contributions to enterprises. The United States' government is currently providing financial support for the semiconductor industry with annual resources of more than 500 million dollars. In 1976 the Japanese government approved a plan for spending 1 300 million dollars over 4 yeats for a "large-scale integrated circuit" project for use in computation and telecommunications. The government of West Germany has been supporting this industry since 1967 within an annual budget of approximately 245 million dollars, of which about one half is specifically earmarked for large-scale integrated circuits. The government of England, apart from giving support to a number of specific enterprises, adopted a decision in July 1978 to provide 126 million dollars in one year for the development of microelectronics. (30)

It is easily seen that the recommendations of "laisser faire" are not applicable in the developed countries, at least not in the area of the most advanced technology, and this has a direct effect on their capacity for competing in the international market. In the specific case of microelectronics, there is little question that the industry will have a decisive influence in computation, telecommunications, measurement and control instruments, machine tools and process plants as well as integrated health and education systems and, naturally, the military and aerospace industries. (31)

Identification of lines of production

In order to implement the strategy for capital goods development, it is necessary to go from the identification of subsectors to the identification of lines of production. One again, technology is a decisive influence. Within the selected subsectors, there are some lines of production that are in a semi-experimental phase, and these will probably show a rapid increase in technological innovation in the future but at the same time they are not devoid of certain risks of failure.

Another group of lines of production is a phase of technological maturation with a relatively rapid process of technical innovation in production growth and diversification. These are categories that face intense competition and whose appeal lies precisely in their high degree of dynamism. A third group of products is that in which technology has reached a stable and terminal stage in the technological cycle, where the rhythm of innovation has subsided and where international competition has probably increased due to free access to established technologies and excess use of installed capacity; in this category, the risk of future substitution by new products being developed must always be taken into consideration. (32)

The selection of products suitable and desirable for local production becomes a complex process of considering all of the elements that were described previously together with technological trends within the different subsectors. To illustrate this, a few paragraphs about trends in the machine tools sector are included. (33)

- The latest designs in machine tools are based on the building-block principle. In numerically controlled machines a greater degree of automation is achieved by adding units and, conversely, machines can be simplified and controlled by programs, cams or even left without any control element.

- There is a growing tend towards the use of display units to facilitate manual job control both for automatics and mechanical machines.

- There is a growing use of stepping or stepless DC motors in order to realize rapid traverse speeds, short positioning times and high positioning accuracy. Spindle and slide drives are increasingly driven by motors which can be controlled directly by varying the electrical input. This presents possibilities for simplifying or even cancelling gearboxes, clutches, etc.

- There is a remarkable increase in rapid traverse speeds. The present level is 10 to 16 m/min. and the trend is to increase this up to 20 m/min. to minimize the time for positioning and idle running.

- Numerical control systems will no longer be used only for directing the rools or the relative motion between tools and workpiece but will be used for directing whole subsystems (e.g. in electronically generating coupling for gear hobbing mechines of WMW).

- Software systems will be simplified more and more, through advances in microprocessors that will be used increasingly for numerical control systems.

- Machine tools will have two central systems for lubrication and cooling. Improvements in this area will be mainly focused on thermal control of coolands and hydraulic fluid in order to allow functioning close to the thermal-stable points of the machine tool. Automatic chip removal systems will be incorporated also.

- The manufacture of machine elements, mountable subunits and units, etc. will be increasingly precise so that the time for assembly will drop to about 25 to 30% of total manufacturin time. This will also be a result of increased use of handling systems, industrial "robots" (often used for dangerous or unhealthy work such as spray painting) and assembly equipment.

These technological trends are a basic point of reference which must be kept in mind when it comes to selecting the products most suitable for development and also for negotiations with technology suppliers.

Most of the literature about technology transfer places emphasis on the "conditions" of the transfer and the need for developing countries to avoid restrictive clauses and excessive costs. However it is equally or more important to consider the "content or quality" of the information that is being acquired, and this is to a great extent determined by the user's effort to study and compare his technical requirements and the available technologies on the international level, before entering into negotiations with a specific supplier.

This preliminary act of reflection on the part of the user should be converted into a definition of the technical nature of the project to be undertaken and will serve, in spire of its preliminary nature, as a guide for negotiations with the foreign technology supplier. It is often the case in Latin America that negotiations are begun without having invested the time and resources necessary to formulate such a preliminary concpetualization. Under these conditions, the technology supplier, interested in consolidating his position and avoiding competition, is often the one who proposes the technical conception of the project that will later result in a contract for technology transfer. And it is precisely this phase of technical conceptualization that to a great extent determined what technological contribution, in terms of design, process and manufacturing engineering, the project will make to the country. This phase and the definition of training programs will ultimately define the "content and quality" of the technology transfer. There is no doubt that the "conditions" under which the transfer is made should not be abusive, but it must be emphasized that no matter how favourable the conditions may be, they cannot offset the defects that might result from an inadequate project definition (e.g. use of unsuitable manufacturing design, process and techniques, over-sizing of certain lateral equipment, inadequate definition of the product lines, unfavourable proportion of in-plant and national integration, absence of supporting technical infrastructure and weakness of training programs).

In the light of these considerations, it was decided that before entering into any negotiation, a prefeasibility study would be prepared on the basis of information about the designs and techniques being used in leading international enterprises, compiled through visits to their respective plants. This does not mean that the most advanced technologies will necessarily be adopted in every case, but at least it provided the possibility of undertaking negotiations with a good knowledge of the available alternatives.

Conception of the productive structure

Having identified specific opportunities, it is necessary to go on to definitions related to the kind of productive structure that will generate these lines of production.

This stage is particularly important in the case of those capital goods whose production involves various different technical processes; in some cases the processes may all be located in the same plant, and in others there may be a horizontal structure which certain technical processes are utilized for the manufacture of different kinds of equipment whose final assembly is carried out in independent plants. Although this aspect is often left out of the literature on technology transfer, in practice it is a decisive factor in terms of the effects and potential for technological dynamism of the plant being considered. In fact, one of the peculiarities of this sector is that for some kinds of capital goods, plants have a certain degree of flexibility for producing different kinds of equipment. There is not a specific relationship between plant and product. Moreover, the manufacture of some kinds of equipment requires different manufacturing processes which may or may not be vertically integrated in one plant. As a result, the options chosen for the formation of the productive structure, both in terms of the variety of products to be produced in the plant and the degree of vertical and horizontal integration of the productive structure, seem to constitute a determining factor in innovation capacity at the plant level.

From the point of view of foreign firms who export to the national market and have been induced to establish production within the country, the most suitable kind of arrangement is that which provides a maximum of autonomy from the rest of the local productive activity and permits close ties with the plants established in the country of origin. This normally leads them to design vertically integrated plants which at the same time have a low degree of national integration; that is, part of the components used in the production of equipment would be imported and those manufactured locally would have to be produced in installations established in their own plant. In developed countries, an increasingly accentuated trend is toward specialization and "horizontalization"; in other words, the firms seek to reach a level of excellence in given kinds of machines whose main technological contribution lies in design, but for the purposes of production they prefer to use a horizontal structure, acquiring parts and components in the local or national plants which manufacture such goods in the most technically adequateway. From the point of view of government policy, there are two clearly differentiated options: to stimulate the kind of plant concept in keeping with the preferences of foreign investors who are the technology suppliers and whose proliferation usually results in supply fractionization and low national content. This option is the "path of least resistance" congruent with the will of the foreign supplier. The other option is one which seeks to shape a productive structure that is adequate to the internal expansion of capital goods manufacturing but at the same time attempts to raise efficiency through horizontalization of production. The technological element of each of these options can be decisive for the long range results obtained from the development of the capital goods industry.

In the specific case of heavy equipment manufacture in Mexico, a systematic comparison of these two alternative conceptions of productive structure was made including economic factors (investment, employment, foreign exchange) and strictly technological factors. It was concluded that the option implying a group of independent plants with higher in-plant integration and lower national integration required less investment than the "horizontalized" and specialized production structure with its lower degree of in-plant integration and higher proportion of national integration. Nevertheless, it was found that the difference in the amount of investment could be recovered in two years through savings on imports generated by the possibility of "internal articulation". Significant technological advantages were also obtained in terms of potential for developing design capacity, improved efficiency in the utilization of installations and an enhanced degree of specialization in production processes - all of this logically would result in lower costs and a greater capacity for competing on the international level.

The technological level of the user industries

One of the factors determining the possibility for channeling demand for capital goods towards national suppliers is the degree of technological development attained by the large user enterprises in the public and private sectors - particularly in the fields of basic and detailed engineering. This is especially true in the case of custom-designed capital goods and installations that have complex systems which include several kinds of capital goods. To the extent that the user enterprise delegates the responsibility for the technical conception of the projects to engineering firms or foreign manufacturers, it is correspondingly probable that local capital goods manufacturers will be limited to acting as sub-contractors for the simplest parts and equipment, leaving the manufacture and technical conception of the more important equipment in the hands of foreign enterprises.

As a result, the development of the technological level of the major user enterprises is a decisive factor in the potential development of the national capital goods sector. This has been empirically proven in the case of Mexico through a study which analyzes the effect that the development of engineering capacity in the Istituto Mexicano del Petroleo (Mexican Petroleum Institute) has had on the situation of national capital foods manufacturers. (34)

This factor confirms this paper's initial observation that the development of the capital goods industry must be approached on the basis of an integrated set of actions that can influence the complex decision-making system made up of national and foreign producers, public and private users, engineering firms, financial and commercial intermediaries and the whole of the supporting technological infrastructure.

The modification of the internal working of this system, in which technology plays an important role, necessarily implies altering to some extent the pattern of industrialization within which these economic agents, and the interrelations linking them, have evolved.

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(9) Idem note 8

(10) Idem note 8

(11) "El mercado de bienes de capital en algunos paises de America Latina" Mercado de Valores supplement No. 28, July 11, 1977. CEPAL/NAFINSA

(12) This would particularly be the case of metallic structures and light platework, construction equipment and some agricultural implements and textile machinery

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(15) Studies on capital goods demand in the sectors of petroleum, electricity, steel, pulp and paper, cement, foods, agriculture, mining and professional electronics, heavy platework, foundry, pumps, compressors, electrical equipment, agricultural machinery, professional electronics and machine tools, NAFINSA/UNIDO Joint Project, 1977-78

(16) FOMEX and FONEI

(17) See: Decretos de Incentivos Fiscales, March 6, 1979, Dec. 30, 1977 and March 31, 1978

(18) See: "Reglas para la compra de bienes de capital en el sector publico", Secretaria de Hacienda y Credito Publico, Secretaria de Programacion y Presupuesto y Secretaria de Comercio, Mexico, D.F., 1978

(19) See: "Cr iterios especificos de la nueva politica proteccionista y de precios oficiales" Lic. Rafael Castol Garcia, "Estudios sobre Proteccion" Lic. Daniel Robles Ferrer; Informe de los Trabajos Realizados por la Comision de Aranceles y Controles al Comercio Exterior en el periodo Enero-Junio de 1978. Conferences presented at the ANIERM Seminar on Customs Valuing and Import Duties, Feb. 7, 1979

(20) Projects for steam turbines, turbogenerators, hydraulic turbines and turbogenerators, heavy platework, heavy foundry and forge, service plant for heavy machining, gear manufacture, speed reducers over 300 HP, large volume low head pumps, turbo-compressors, turbine and turbogenerators up to 35 MW, pneumatic control valves over 2", shears, brake presses and rollers, hydraulic pumps for motive and control systems, osciloscopes, digital multimeters, frequency meters and wave generators, process and control panel instruments

(21) Horizontal boring machines, portal-type plano-milling machines and vertical turning lathes, radial and column drills, motor scrapers, scrapers and power shovels for mining, Caterpillar front-end loaders, trenchers and LHD equipment, crushing and grinding equipment for mining, equipment for the dairy industry

(22) See: Structure and Change in European Industries, United Nations, 1977, p. 16; and Mexico: Una estrategia para desarrollar la industria de bienes de capital, NAFINSA/UNIDO Joint Project, 1977, Chapter III

(23) See: Mexico: Una estrategia para desarrollar la industria de bienes de capital, NAFINSA/UNIDO Joint Project, Mexico 1977, Chapter IV

(24) See: "Plan Industrial" Secretaria de Patrimonio y Fomento Industrial, Mexico, D.F. 1979

(25) See: Structure and Change in European Industries, United Nations 1977, p. 16

(26) See: Mexico: Una estrategia para desarrollar la industria de bienes de capital, NAFINSA/UNIDO Joint Project, 1977, Chapter III

(27) See: Technological Forecasting in Perspective, Organization for Economic Co-operation and Development, Erich Jantsch, Paris, France, April 1977; A Guide to Practical Technological Forecasting, James R. and Schoman, Milton, E.F.A. Prentice Hall Inc., Englewood Cliffs, N.J. 1973; Technological Substitution, Liston Harold A., and Sahal Devendra, Elsevier New York, 1976; Stanford Research Institute, Industrial Robots, Report 432, California, USA 1971. Stanford Research Institute Industrial Automation in Discrete Manufacture, Report 570, California, USA 1976

(28) This is evident on comparing the characteristics of one of the first electronic computers, ENIAC built in the 1940s at a cost of several million dollars, with present-day equipment based on microprocessors which can be produced for less than 100 dollars and whose circuits would be 20 times faster than ENIAC, 10,000 times more reliable, and would require 56,000 times less power and 1/300,000 less space. See: "Intellectual and Economic Fuel for the Electronics Revolution", J. G. Linvill and C. L. Hogan, Science, Vol. 195, 1977, pp. 1107-1113

(29) Product and Process Change arising from the Microprocessor Revolution and some of the Economic and Social Issues, R. C. Curnow and C. Freeman, Science Policy Research Unit, University of Sussex, May 1978

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(31) The Impact of the Microelectronics Industry on the Structure of the Canadian Economy, Michael McLean, October, 1978; Microcomputers, C.G. Kean and Cullen R. Savage, Stanford Research Institute, Report 570, California, USA, 1976; G.E. Microprocessors, W. J. King, pp. 32-36 April 1977; "Ending the Islands of Automation", Dr. E. Sciberras, Dr. N. Swords-Isherwood and P. Senker, Manufacturing Engineering, Oct. 1978, pp. 64-72; Competition, technical change and manpower in electronic capital equipment: A study of the UK minicomputer industry, SPRU Occasional Paper Series No. 8, Science Policy Research Unit, University of Sussex, September 1978; The Impact of Microelectronics in the UK, J. M. McLean & H. J. Rusch, SPRU Occasional Paper Series No. 7, June 1978

(32) See: Application of Technical Forecasting to Investment Evaluation - The case of capital goods, NAFINSA/UNIDO Joint Capital Goods Project, Mexico, 1978. Using the methodology described, analyses were made of gas turbines, digital voltmeters and work processors

(33) Lineamientos para el desarrollo del sector de maquinas herramientas, NAFINSA/UNIDO Joint Capital Goods Project, March 1978, Chapter on "Tendencies Tecnologicas"; Microcomputers, Stanford Research Institute, Report 556, California, USA, 1976; "Can US Machine Tools Maintain an Edge", M. T. Rohan, Industry Week, August 21, 1978, pp. 64-72; "A Management guide to computer-integrated manufacturing", B. J. Pond, Iron Age, April 10, 1978; "The Road to CAD/CAM", B. J. Pond, Iron Age, March 28, 1977 pp. 37-44, April 25, 1977, pp. 39-44, May 30 1977, pp. 32-37, June 27 1977, pp. 31-34; "Machine Tools: A Time of Change", B. J. Pond, Iron Age, December 5, 1977

(34) "Efectos del Origen de la Ingenieria en el desarrollo de la industria de Bienes de Capital en Mexico", Istituto Mexicano del Petroleo and UNIDO, April 1978

7. Planning of Development, Science and Technology: the Case of the Mexican Agrarian Sector

ARTURO WARMAN

THE SHAPING OF A CRISIS

Around 1945, Mexico once again reached the level of production of 1908-10. The enormous social cost of resource concentration which had allowed this level of production led to a social revolution whose participants were on the whole rural dwellers. The recovery of the level of production was taking place in an economic content which was very different from that of the turn of the century. Indeed, by the end of the Second World War, Mexico had an agrarian structure shaped by a long although discontinuous process of land distribution. From then on, two clearly defined stages can be detected in the course of the agrarian-sector. The first stage goes from 1945 to 1965 and it is marked by an increase in agricultural production largely exceeding the rate of population growth which was - and still is - one of the highest in the world. This substantial increase in the primary production laid the foundations for a period of rapid economic development centered on the industrial sector and based on a program of import substitution of consumer goods.

There are differences worth emphasizing between the first and the second decade of this stage. From 1945 to 1955 agricultural and livestock production increased at an annual rate of 5·8%. The most important factor in this process was the agricultural growth which provided over half the total value of agrarian production and expanded at an exceptional annual rate of 7·5%. The main reason for this expansion was the constant increase of cultivated areas which averaged 5·6% per year. Part of the increase was due to land irrigation in the north and northwest. The irrigated land areas nearly tripled in the decade, due mainly to government investment in large public works. It is important to note that public investment in agriculture was proportionally lower than investment from 1935 to 1945, but its near exclusive concentration in hydraulic infrastructure works favoured the constant increase of irrigated land.

In the new irrigated areas, as well as in other privileged zones of the country, there flourished modern agricultural enterprises in private hands, whose aim was to obtain profits and they geared their activities to maximizing them. Several factors contributed to help this growth. In the first place, there was the change in the agrarian policy, especially from 1946, which on the one hand put a brake on the rate of land distribution while, on the other, it granted legal guarantees to medium-size and large private properties. Public action, in the form of investment and incentives, was geared to benefit this sector. Among the different kinds of support there appeared agricultural research, oriented to the development of technological packages suitable for good irrigated land with capital resources.

But the largest and most substantial effort for the opening of new farming areas was made by poor peasants in rainfed lands, mainly by the beneficiaries of the land reform program, and not by the agricultural entrepreneurs. The massive land distribution program which took place between 1935 and 1938, under President Cardenas, had granted the ejido - a form of corporate property - an important territorial reserve which was put into cultivation between 1945 and 1955, once land distribution had practically come to an end. Production in these new lands, often in more hazardous conditions than the ones previously cultivated, was carried out by the producers themselves, basically by intensifying peasant work and with hardly any official support. The newly opened areas produced corn and its associate plants which supplied the domestic market at reasonable prices and allowed for the entrepreneurial production to be mainly oriented to the export market and to the production of raw materials. The peasant activities which extended the agricultural frontier can be explained as an answer to inflation. The fall of the relative prices of their products and the lack of other productive or occupational alternatives, together with the availability of land reserves, forced the peasants to increase production to keep their standard of living unchanged. The increase in the production did not mean a bettering of their situation but probably a slight impairment compared with the previous decade.

Between 1955 and 1965 the growth of the agricultural sector slowed down to 4% per year, but even so it exceeded population growth. Again crop production was the main element accounting for the course of the sector. It grew at an annual rate of 4·3%. The decrease in the rate of agricultural growth can be partly explained because of the decrease in the rate of new lands open to cultivation. Between 1960 and 1963, it again increased by 4·7% per year, a similar rate to that of the decade of 1945 to 1955. This decline was partly balanced by an increase in the yields which for the first time were beginning to be an important growth factor. The results of the Green Revolution, in which agricultural research played a main role, reached their best between 1955 and 1965.

At the time, the growth of the agricultural sector took place in the context of a new economic policy. From 1958, one could note the effects of a relative price stability which offered a strong contrast with the inflationary tendencies of the previous years. The "growth with stability" affected the agricultural and livestock farming sector, especially agriculture, in two important aspects. The reduction of public expenditure was more than proportional in the investment assigned to this sector and meant an increase in the pattern of regional concentration and the nature of expenditure, already rather restricted. On the other hand, government policies which favoured price stability caused a downward pressure on the prices of agricultural products. Corn - the most important element in the people's diet - was especially affected and its price, controlled by imports, never again reached the 1945 level.

Under these circumstances, the trend towards polarization were reinforced with a high concentration of resources by a small number of entrepreneurs. These increased their production and productivity by controlling, for their own benefit, irrigation works, credit, capital, technology and the market. Apparently, the agricultural enterprise was the most dynamic group and it seemed to be the pivot on which the sector's growth was based. But the number of farms, small from the beginning, increased slowly and remained constant in proportion to the total agricultural properties. The rich entrepreneurs grew richer, but very few middle-size peasants were able to enter the entrepreneurial sector.

The peasants also made a contribution to this last period of growth, but it was done more slowly and with greater costs. They exhausted the agricultural frontier by putting under cultivation all the land reserves inherited from the Cardenas' land distribution era. To increase their production and reach a level which allowed them to compensate for the reduction of the relative price of corn, they had to introduce "modern" technological elements. From 1960, chemical fertilizers became widely used to keep up soil productivity. Increasing monetary costs, plus fixed prices, could be met in two ways only: by increasing efficiency or by lowering the "pay" of the peasants and their families. The technology from the "Green Revolution" could not increase the yields, considering the production methods used by the poor peasants. It required large capital investments and demanded safety conditions - frequently tied to irrigation availability - to ensure good returns. Peasants lacked capital as well as land and water resources to ensure investment returns. They had to meet a new loss in their "renumeration" that, in any case, only becomes cash income after harvesting and selling a share of the product in the market. Conditions pushed them into "irrationality" in the productive activities as their "pay" went under the average rural wage. The latter was 50% lower than the legal minimum in most of the country. The lack of occupational alternatives and the importance of corn to survive, besides many other factors, forced the peasants to increase their production under conditions inexplicable in terms of profit maximization. Peasants, by selling more labour and engaging in other complementary productive activities, survived precariously on the land during the last phase of this fast growth of agricultural production.

The spectacular growth came to be a severe crisis after 1965, although its effects did not become clear until the 1970s when the country again had to import large quantities of grain and vegetable oils. From 1965, agricultural production grew by only 2·1% per year, that is, below the rate of population growth. Crop output suffered the biggest collapse and it only grew by an annual average of 0·8%, while livestock farming and fishing grew at a higher rate than before. Again, a unique integrated process can be seed from the contradictory alternatives of farm enterprise and peasantry. Agricultural enterprises, although they received increasing support from the State, lowered their rates of growth. In aggregate terms this decline is due to a change in the products grown. The most profitable products were discarded, as a reaction to a crisis in the international market, and agricultural activities were re-directed to the growing of subsidized products for the internal market, mainly grain for cattle and oil seeds; the latter did not present any risks although they did not offer the high returns of other commercial articles. In this way, capitalist agriculture diminished its intensity as livestock farming became more and more important as a means of capital accumulation. This change was partly due to State policy, which shifted priorities by trying to keep the price of basic products low. Irrigation continued to expand but at lower rates than in past decades, and these new areas were sown with cheaper products, and machinery became more intensively used. This resulted in a lesser demand of peasant labour. The Green Revolution, attractive as it was when it provided high returns, far exceeding the national average, was vehemently slowed down.

Peasants not only could not place new lands under cultivation but gave up agricultural exploitation of nearly two million hectars of rainfed land. A good part of these lands, for example in the southeast, were taken from them and were dedicated to the enormous growth of livestock farming in private hands. Livestock farmers have occupied peasant lands by means such as rental, "association", and "enclosure" of agricultural land. This occupation has been favoured by the "irrationality" affecting some peasants and it explains the exodus from the poor and high risk lands, frequently due to the threat of drought. The cost of cultivating these lands has gone up, mainly because of the accelerated rise in the prices of fertilizers. Production remains static or has grown very slowly. But the price of the product (corn) declined further. In 1971, the real price was lower than in 1940 and hardly higher than during the years when the effects of the 1929 world crisis were at their worst. The "assumed remuneration" that peasants received for their labour in those lands fell dramatically. Their "investment" in labour became irrational. This lack of incentive for the growing of corn in marginal lands was partially balanced by a change in the structure of peasant products in less risky lands. Vegetables, flowers and other commercial products were grown there, and frequently the enterprise ended in financial disaster either because the risk was still too high or because of the nature of the market. By competing with similar products, peasants favoured the farmers' trend to withdraw from the more labour intensive and risky products. Peasants did not give up corn-growing altogether, but they did reduce the sowing area, trying to avoid the ruinous corn market. The national deficit of corn is the basic problem shaping the contemporary crises in the agrarian sector.

THE COMPONENT ELEMENTS

In the shaping of the agrarian crisis there are several interacting factors. For a better understanding they can be grouped into three categories: the structural elements, the economic policy decisions and planning and public policy in the agrarian sector. It would be presumptuous and naive to try to include all three levels and their interdependence, but it is inevitable to outline certain points that will allow us to place public action <u>vis-a-vis</u> the agrarian sector in its more general context and try to understand the complex relationship between science, technology and development planning.

Among the structural elements, it is worth mentioning that Mexico was by the mid-twentieth century a basically agrarian country. Nearly 60% of the population worked in agrarian activities. The other sectors of the economy were weakly developed and incomplete. Twenty-five years later, the country still has an agrarian character: most estimates reckon that some 40% of the economically active population work in different agrarian activities. The other sectors of the economy have grown rapidly but without fitting in with the economy as a whole: for example, excessive industrial capacity and high costs plus dependency from abroad for the technical processes and often for capital itself. That is to say, Mexico is an underdeveloped country.

A capitalist model, based on a market economy and integrated to the international capital goods and money markets, was chosen for Mexico. Given its character, it has required an economic levy from the primary sector to finance society as a whole. By different means - difficult to estimate - the agrarian sector has transferred resources and capital to other sectors of the economy. The agrarian product is valued in a complex form to carry out the abovementioned purpose and the income received by the rural population is, on the average, the lowest in society.

In spite of this global levy from the sector, a small group of farmers succeeded in reproducing and accumulating capital. This means that they must obtain profit rates equal to or higher than the national average, which are very substantial, due to the high cost of money. To succeed, they have to control, for their own benefit, the best productive resources and lower the prices for those cost factors outside the "modern" sectors, especially peasant labour. This control takes place at the expense of most rural producers who barely survive by combining their own production and selling their labour. According to statistics, approximately 70% of agricultural production is created by less than 5% of the rural producers. Concentration indexes have been increasing since 1940. Most of the rural population suffers the effects of the general levy on the sector, and particularly the one from the group of producers who monopolize the productive resources. Agrarian structure exhibits an extreme polarization. However, there is no duality between the two different groups but an integration in which there is a flow of resources: both share one and only one system. Dual analysis confuses this fact by emphasizing details underlying the differences, but both groups are constantly incorporated within a general situation embracing them all.

These conditions, present in many other countries, acquire certain peculiarities in Mexico, due to the origin and nature of the agrarian reform process which started in the second decade of this century after a bloody civil war. Agrarian reform imposed severe limits to private land accumulation. The limits, which have not always been respected, actually condition the development of agricultural and livestock farming enterprises, and even if it does not prevent such development, they give it specific features. On the other hand, land distribution withdrew from the market nearly half the land area by giving it to peasants as property that is inalienable and cannot be foreclosed, that is, "exempting" it of its marketable value. This "exemption" does not prevent the land from being monopolized and transferred to the dominant group by means of illegal but frequent and well-known mechanisms, but it implies that land in its function as capital, and considered a factor in the costs of production, operates "abnormally". For example, the hiring of peasant land by farmers at a rate below the market price, together with the low prices of peasant labour, is the core element which accounts for the high profits. It is worth noticing that as long as the standing legal norms subsist, it is impossible for the distributed lands to become privately owned but not vice versa.

Among the economic policy decisions it is worth repeating that after the Second World War, the growth of the economy was based on an industrial development aiming at replacing the imports of consumer goods. All kinds of facilities were granted to industrial development and economic policy focused on the task of reorganizing the country to serve industry. Subsidies, levies, prices, public investment, financing, foreign exchange - all were conceived and carried out for industry's benefit. It is important to point out that since the 1960s, the highest priority has been given to the automobile industry which has a particularly complex effect on the spatial organization of the land. Support of other productive activities or social services was deferred or subordinated to the industrialization program.

As mentioned above, during the first stage of the industrialization process there was an accelerated inflationary process which, given an unfavourable foreign trade, meant successive devaluations of the national currency. The so-called "growth with stability" which limited public intervention in the economy and focused it to benefit the industrial sector, reinforced the process by which the agrarian sector and social services were sacrificed, giving rise to a gradual decline in the standard of living of most rural inhabitants.

National agricultural activity became subordinated to industrial development and it performed the following functions among others for the latter's benefit:

(i) The obtaining of foreign currency by exporting farm products for the financing of foreign capital goods and raw materials for national industry.

(ii) The supplying of cheap raw materials, for industry, often at prices below the world market.

(iii) The feeding of urban population at low prices, so as to make attractive industrial investment, given the low cost of living and reproduction of the labour force.

(iv) The supplying of people, not only as labour for industry and other "modern" occupations, but to form a reserve of the unemployed, which exceeds by far the employed population in industry and "modern" services. The unemployed are a decisive factor for keeping wages low and limiting labour demands throughout the country.

The growth of the agricultural sector was a response to the above demands. However, the cumulative effects ended in the abovementioned crisis. As for industry, it grew at a more rapid rate than any other sector, yet in several aspects it did not fulfill the hopes placed on it: it was able to create employment to absorb population growth; it did not achieve enough efficiency to be able to compete in the international market; and it did not succeed in balancing the trade balance but, on the contrary, contributed to increase its deficit. By 1973, all this ended in a general economic crisis which led to a questioning of the chosen economic model, at present based on oil exports.

Planning and public action in regard to the agrarian sector can be outlined around the relation of the subject of growth and development. The subject was the large agricultural enterprise, comparable with the most efficient units of American agriculture. One has to remember that, due to the effects of war, the other models of agricultural growth were not fully functioning, and that it was impossible to find any help to carry them out. It was assumed that this type of enterprise was the most efficient and dynamic. Under Mexican conditions, this meant selecting as subjects of development private landowners who not only held larger properties, but were very receptive to market incentives. As a first measure they were granted legal guarantees: legal agrarian protection, and the concession of unaffectability, besides a selective administrative handling of agrarian legislation.

Public investment - the most effective instrument to stimulate the chosen sector for development - was a very limited resource, given its massive channelling into industrial development. For the achievment of the desired aims, its use was centered in two ways. The first was a geographical one. Public investment focused on the north and the northwest where population was scarcer, with peasant pressure on the land lower and easier to control. The northern areas are rather arid so the construction of hydraulic infrastructure was indispensable, for which there existed some favourable conditions, but in no way privileged, when compared with the rest of the country. Given its aim, public action centered on the construction of irrigation districts which absorbed 80% of the total investment. Incentives like credit, support prices, agricultural research and extension, etc., followed the patterns of geographical concentration, centered on irrigation, and they flowed mainly towards those areas.

The objective assigned to the growth of production was multiple: to increase exports, to provide the domestic industry with raw materials, and to supply the market with basic products. The results have been erratic and variable, with periodic crises of surplus or deficit of one or several products. Since 1971, there has been a crisis in the supply of basic products. Frequently there had been contradictions among the different aims because farmers reacted too quickly to market conditions. In regard to the first two objectives, given a price system outside state control, the policy centered on incentives, among which the use of subsidies was the most important. With respect to the third objective, State action was more decisive and consisted in the establishing of support - prices, official systems of distribution and State handling of imports and occasional exports. Scientific research centered on the last objective: supply of basic products.

Cotton, which illustrates the case of production for export, was the most important export commodity, representing nearly 50% of the total value, and was the supplier of domestic industries, which depended upon imported technology. Seeds, machinery, fertilizers and insecticides were purchases abroad. Agricultural expansion by means of this technology was left in the hands of sales agents of these inputs. The only native element, the one that precisely provided the comparative advantages allowing Mexican cotton to compete in the international markets, was peasant labour which offered better results in the products' quality and was cheaper than mechanical harvesting.

Wheat, which illustrates the supply of basic products by means of successive State intervention, and the notorious participation of agricultural research carried out in Mexico, has always required some direct subsidy. This subsidy was necessary not only to pay the costs of research and information, but basically, due to a guaranteed price that covered production costs based on mechanization, in which there was no comparative advantage except a profit margin equivalent to that of other competitive products. This enormous subsidy became too much of a burden when the country exceeded self-sufficiency and had to export. As long as wheat was dedicated to internal consumption, subsidies were disguised and assigned to "popular" consumers - even if wheat was a secondary element in the basic diet of Mexicans - but when it entered the international market, that subsidy had to be met directly; it meant that the State had to meet over half the buying and handling costs. This paradox, resulting from the global inadequacy of the country's agricultural development model and from specific inadequacies of agricultural research, will be the last theme of the present analysis.

It has to be mentioned, however, that most rural producers - the peasants - were not included in the project. It would seem that planning and public action, with few exceptions, have considered peasants to be non-existent as long as they do not become entrepreneurs. Even after their existence had become obvious as one of the causal factors in the agricultural crisis, the previous tendencies in public policy have been actually reinforced. The public sector's programming seemed to lack information and analysis on the position and behaviour of peasants. This paradoxical situation is serious because these producers would be the ones to respond better and more quickly to public actions.

PLANNING, SCIENCE AND TECHNOLOGY

Against the background of the above premises, the obvious question points to the role played by development planning in respect to the agricultural crisis and the social turmoil present at its point of origin.

There has been frequent recognition of the limitations of planning in countries like Mecico. Apart from the technical problems of planning derived, above all, from lack of sufficient information, hardly reliable and especially unsuited given its descriptive and analytical categories copied from other countries with very different social conditions, other factors take precedence in the way of restrictions. Strong foreign dependency, not only at the trade level but also as regards the internal productive processes themselves, introduces a set of uncontrollable but foreseeable factors which "distort" planning possibilities. The course of the national economy often consists in a set of measures to adjust to external pressures. On the other hand, the capitalist nature of the whole economy, with strong liberal features, makes the State the only agent able to carry through a limited planning. Lack of instruments to impose objectives, conditions and time-periods on the private sector - this latter has to be incorporated through incentives - transforms planning into an indicative program which defines general goals but without any scope vis-a-vis particular objectives. A more careful planning can only be carried out by means of the limited but powerful effect of public investment. In these conditions, and for the country as a whole, development derived through industrialization should be analyzed in terms of a model with general goals rather than as a development plan.

Planning possibilities of the agricultural sector are better, although they have been weakly performed. Those possibilities arise from the fact that the country's constitution allows the nation to impose on landholdings the manner of exploitation dictated by public interest among others, it has the right to limit landholding acreage in private hands. This power transforms land distribution into a powerful mechanism for the management of the economy and planning, although, as has already been mentioned, land distribution was not carried out during the period under analysis. The limits to the extension of private holdings had another effect: they restricted private investment of fixed capital in the countryside, either because of scale problems or "insecurity" of tenure. This lack of private investment made public investment the most important factor for capital formation in the agricultural sector, since it represented over half the total amount invested. This capacity to act on the sector's production behaviour was consistently used.

Although no long-term detailed plan is known - it may not have existed at all - the consistency and rigour with which all public investment coincides in its purposes, preferential areas and priority policies during the period under analysis, is quite remarkable. Consistency was well set around the large irrigation works which acted as poles of attraction for otherminor schemes in regard to investment. This consistency which up to the present has not been altered, although since 9173 new alternatives have been tried, can be analysed in terms of a rigorous plan, as a clear strategy, even if it lacks the specificity of a plan. This program not only had rigour and efficiency, given the proportionately low amount of public investments; the rate of growth of irrigated acreage is among the highest in the world.

However, the program - at least during the period examined - has been unable to fulfill its declared and implicit goals. It did not result in a constant rate of growth of output. It did not supply the internal market with enough basic foodstuffs nor steadily increase the volume of agricultural exports. The productive branches which were not included in the program based on the irrigation schemes - such as livestock farming - grew at a quicker and more constant rate. It also did not succeed in raising the welfare of the rural masses - this latter goal was paid lip-service but was actually very weakly implemented - but, on the contrary, it intensified income differentiation with a further impairment for the lower levels. The strategy amply favoured a very small group who had never been poor and not it increased its wealth and power. The group's substantial profits were not reinvested in agriculture - or if they were, it was on a very low scale - so that public investment had to replace it. This group did not grow and expand all over the country - as some had hoped it would - but rather absorbed an increasing amount of public investment in the form of subsidies. Modern commercial agriculture did not expand to other groups, nor did it spread its technology.

Part of the failure in achieving this strategic goal lies in deficiencies or impossibilities for its proper execution and performance, in contradictions among the different government agencies or eventually it could be attributed to insufficient research and information. Nevertheless it seems evident that the solving of these problems might have brought about specific effects but it would not have altered the end result. The most suggestive hypotheses agree in explaining the complex result through the inappropriateness and the contradiction existing between the strategy and the socio-economic conditions in which agrarian production takes place. Among the inadequacies one should point out the following:

(i) The stretegy was based on the development of the agricultural enterprise, defined by its goal to reproduce its capital through profit and by its productive relations: to buy inputs, including land, in a money market, and to sell production under the same conditions. The great majority of Mexican farmers, at least 80% of those who possess holdings and a similar number of the family associates, are not entrepreneurs, nor do they operate on the same economic basis of the enterprise, or have the objective possibilities to adopt it. The goal of their production lies in ensuring their own biological and sociocultural survival. As long as they lack resources to produce, in terms of quantity, quality or unequal and unfair exchange conditions, they will work on an "uneconomic" basis, that is, "profitless". It is needless to add that the present levels of biological and sociocultural subsistence are low and can be substantially improved without seeing any profit whatsoever. To survive and avoid the ruinous market competition which is very unfavourable to them, they try to limit their participation in market transactions and keep a share of their own production for family consumption. The relations of production within the productive units are not only regulated by market transactions but social relations as well, which play a key regulating role. As a rule the main factor in the "cost" of peasant production is the unpaid labour of the producer and his relatives. Peasants own the land without considering it a merchandise, but as a production, good to which one accedes through socio-political relationships, as for example, land distribution.

(ii) The efficiency model pursued by the development strategy was based on large scale units, specialization and mechanized power; this model implied land concentration of uniform areas. The country's agrarian structure showed - and still does - a clear trend towards small holdings. This trend does not reult at random nor is it a by-product of the agrarian reform's "failure", but rather a historical answer to objective conditions such as population pressure on the land, lack of employment alternatives, the need to intensify the use and crop yield of the land per unit of acreage, through the possibility of absorbing increasing amounts of labour, etc. The idea, complementary to the large scale model, that small holdings are inefficient has not been proved certain. Agricultural productivity in European countries, or in Japan and China, where farm units are small, exceeds by far that of the large scale model which has proved its suitability in countries like the United States, Canada or Australia. Conditions in Mexico are different but pushing the analogy somewhat they resemble rather the cases of the small-holding model. As for Mexico, Eckstein's statistics proved the small holding's greater efficiency in the use of production factors. It should be added that for many products the yield per acre is always higher in small holdings. This applies not only to corn but also to coffee and cotton. Furthermore, it has been shown that in many cases, the diversified production of several associated products exceeds the global yield of specialized production. Besides, the latter adds the severe risk of ecological imbalance, a fact which explains the shift from several important products in large areas of the country.

(iii) The farm's productive decisions are made so as to maximize the profit rate. The yield per acre, the required labour, the intensity of the soil's use and other basic criteria for national agricultural development are considered by the farm as dependent variables of profit maximization. Generally speaking, the model adopted by farms in the irrigated areas, since the 1965 crisis, has been to choose a medium economic intensity in products with support prices - excluding corn and, to a great extent, wheat - like sorghum, soyabeans, safflower, etc., all of them raw materials and basic products, scarcely influential on the general cost of living; this is the reason why their rural prices have not been kept down so drastically. The available technology for those products is mechanical and requires less labour force. The average yields per hectare are higher than the national average, but they compare unfavourably with those from other countries. It has been preferable to increase profits by enlarging the cropland through the hiring of peasant holdings whose owners lack capital to cultivate them. The farms favourite activity in rainfed lands is extensive livestock grazing which demands medium economic intensity and very low labour requirements.

The decline in labour demand seems to be constant, as if the farm's rationality lay in maximizing labour productivity through capital investment in machinery or livestock. This seems surprising since the cost of machinery, livestock and even capital has risen more than that paid out for wages. The explanation of these operations lies in the complex relationship between the irregular performance of the market, where labour intensive products are offered, and the safety derived from the official protection to certain foodstuffs which are more expensive within the country than in the international market.

It is not an exaggeration to state that commercial farms have adopted public subsidies to optimize the relation between investment and profit.

Peasant producers, due to their being at the subsistence level, do not see objectively the distinction between profit and the renumeration of their own and their families' labour. Their tendency is to maximize the total net product or the difference between earnings - either in money or in kind - and the necessary money expenditures. As long as there are no other occupational alternatives, peasants are in a position to increase the intensity of their production only if their output grows proportionately more than their money expenses; they barely take into account the cost of the essential family labour.

The dilemma is solved by a more intense use of the land - limited resource - with the investment of more labour - an abundant one. This tendency can be observed in a structural change in peasant products; since the crisis there is an increasing shift out of corn-growing and the adoption of more labour intensive and commercial crops. Obviously, this tendency has its limits. The most severe ones derive from the poor quality of peasant land resources, especially the lack of irrigation, controlled by the entrepreneurial sector; the product's low prices, which make the increase in yields irrelevant, compared with the risk involved and the effort to reach them; and the limitation of alternative "intermediate" or autonomous technology to introduce an increasing number of crops in those conditions.

This contradiction may be expressed in different terms if we reflect the contemporary crisis of production in the occupational field or employment, which constitutes a social expression of the same phenomenon. The entrepreneurial alternative cannot face up to the lack of employment in the countryside. The decline in the masses' standard of living can only be slowed down by a project which will turn production and employment into complementary and not contradictory categories.

(iv) The farm can take some limited risks. Its risk margin is, at the most, equal to the profits, and these represent a relatively low percentage of the value of aggregate production. If we add to this the real or fictitious limitations to fixed capital investment, the possibilities of expanding agricultural output territorially are very limited and they are conditioned by the building of a hydraulic infrastructure and communications network charged to public investment. If the investment is not carried out, entrepreneurial expansion can only be effected through livestock farming, as has actually happened. Peasants expanded the crop-land areas without government incentives as a result of land distributions. This potential for growth, which in the past meant sacrifice and injustice for the peasants, is still present, and is relevant to bear in mind since, apparently, the agricultural crisis will not be solved without the substantial expansion of the agricultural frontier. The physical possibility does exist, and it has been inaccurately estimated by about an equal amount of land as the one presently under cultivation. Future strategies must establish how, what for and for whose benefit the expanding of the agricultural frontier will be effected.

A final question remains: what sort of relation existed between science and technology, on the one hand, and the development strategy, on the other? It was an obviously very close one in the Mexican case. So much so that the inadequacies referred to were not even considered by agricultural research, and thus the new technology could only be used in the commercial farming units. Agricultural research was an important factor in the enterprise's growth. A brief and partial outline of its development can offer the elements upon which to establish the foundations of this statement.

Systematic agricultural experimentation was weakly started with government backing by the late 1930s. This group, in 1947, became the Institute of Agricultural Research and vaguely represented a tendency to place research at the service of peasant agriculture. In 1943, the Mexican government signed a technical cooperation agreement with the Rockefeller Foundation, from which sprang the Ministry of Agriculture's Special Studies Office. This program exerted a decisive influence on research, given its greater technical and financing resources. In addition, the program trained hundreds of Mexican agronomists; eventually, many of them went to American universities for postgraduate studies. Some of them reached high positions in the government bureaucracy and contributed toward establishing and managing the development strategy. In 1961, the Special Studies Office and the Institute of Agrarian Research merged, forming the National Institute of Agricultural

Research which formally was entirely independent from the Rockefeller Foundation. However, the trends established with the aid of the Foundation continued in the new Institute. As a result of this influence, it was not until after 1965 that some research programs, such as the Puebla Plan, were started to try to increase peasant production, and it was only after 1975 that the trend to experiment with new products with the producer's help in small holdings was initiated. It is not by any means an overstatement to declare that the joint program with the Foundation generated concepts, methods and objectives which have dominated Mexican agricultural research. Needless to say, the joint project had many positive effects, above all the creation of a research infrastructure with highly qualified personnel; but what is being questioned here is its interaction with the development strategy, which it helped form and implement.

The goal of the technical cooperation agreement was to increase food production. To define that goal, United States experts carried out a technical diagnosis of Mexican agriculture, comparing it with their own agriculture without questioning whether the latter's progress was transferable. Social conditions of production, landholding, and peasant population were not taken into account then or later. Underlying the whole concept was the efficiency model of the United States agricultural enterprises. The Special Studies Office worked according to this model and started the development of improved seed varieties which would respond to the kind fo capital investment. United States farms were capable of: irrigation, intensive fertilization, abundant and increasing use of pesticides, mechanization, etc. They were successful, but their findings were useful to few producers. The State assumed the task of creating the conditions for the latter's growth. It made the mistake of assuming that society could be reorganized to suit an efficient technique. The development strategists shared the same false lead.

The Special Studies Office started programs to improve several products focusing mainly on wheat and corn. Leaving aside the scientific discoveries, which apparently were plentiful, the only project with any meaningful effects on national production was the wheat program in the northwest, where millions of hectares had been put under cultivation after the irrigation schemes were completed. The corn program centered around the search for hybrid varieties suitable to the commercial farmers' exclusive use on irrigated lands. The low price of corn, together with the old prejudice that corn was barely productive, discouraged their sowing it in irrigated areas. Corn is still a rainfed and peasant product. Given these conditions, peasants get small benefits from hybrid seeds, which are expensive and must be bought yearly. The main advantage of hybrid seeds is their good yield response to intensive fertilization, which in turn raises production costs though it does not end risks nor offers, on average, sufficient returns to balance the joint effect of costs and risks.

The wheat program, centered on the attainment of highly profitable varieties resistant to <u>chahuistle</u>, had a greater impact. By 1966, Mexico had achieved self-sufficiency, and in the 1960s substantial surpluses were harvested for export; these required a costly subsidy. In the 1970s significant wheat volumes had to be imported again. Cultivation of this cereal became exclusive of agricultural enterprises in irrigated lands which could use the technological package resulting from research. But to use it they required heavy subsidies, since Mexico offered "comparative disadvantages", given the higher cost of machinery and other inputs, which were an essential part of the technological package. The most remarkable research achievement were never adapted to production conditions. Another extra cost should be added: wheat growing practically disappeared as a peasant cultivation from the country's central region.

The research and strategy or development plan shared ideas and goals: apparently, they turned out to be inadequate. It is difficult to establish who led whom in the process of adopting and making decisions; whether academic paradigms and the perception derived from them created the spaces in which alternatives were selected, or whether, on the contrary, the political pragmatic view imposed its aims on research and ordered it to create technologies which were subordinate to the strategy. The salomonic statement that both naturally agreed, or that their action was geared by their sharing a common analytical system, is unsatisfactory. The course of Mexican agricultural development in the last thirty-five years provides a favourable field in which to search for the answers to this sort of question, on still a general level, but which are by no means irrelevant.

Speaking about inadequacies and failure in a process of such scope, complexity and duration cannot be simply interpreted as the result of individual action. Looking for individual responsibilities does not make any sense. I emphasize this final statement because, very often, discussions about the Green Revolution have been swayed in this direction. Inadequacy and failure carry a value charge that I wish to avoid, by pointing that they are simply facts.

Recommendations in the present case are impossible. To ask for adequacy is a rethorical position. To hope for social conditions, development plans and scientific research and technological advancement to agree, and on top of that to wish that the decision of that agreement be for the benefit of the masses, might be the final result of a long process in which one should participate.

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PART III

Incorporation of Science and Technology in the Techniques of Development Planning

8. Information in the Service of Development

JOHN E. WOOLSTON

INTRODUCTION

Development is a question of making choices. Particularly so when resources - human, financial and material - are in short supply, and only a few of the many things that need to be done can even be attempted. Making a choice is making a decision. Some of these decisions are big ones - they involve the policy-making organs of government and, in the last analysis, are made by the central executive authority. But also there are thousands of other decisions that are taken daily at lower levels, many of them not in the capital city of the country bu by practitioners on the site of development projects.

Science and technology - and here I use these terms in the broadest sense to include economics and social aspects - can help to provide the basis for decisions; can help to ensure that the decisions are wise ones.

At the moment when a decision is taken, science and technology can be manifested, either in the brain of the decision-maker, or in the brains of others who are meeting with him, or in the documents that are before their eyes. An informed decision is more likely to be a wise decision.

So first perhaps one should re-state the thesis that scientists and technologists need to be present at the table where decisions are taken. This may seem like an appear for the establishment of technocracies - what in Canada we refer to as the power of the mandarins (the civil servants as opposed to the politicians). But by no means is it intended to exclude the political aspects from the decision-making process. Any mature scientist will readily agree that, however scientifically sound his proposals may be, they are wrong if they are incompatible with political realities: wrong, because they cannot be implemented and, therefore, cannot aid the process of development. The decision-making table is the place where an accommodation must be found among the various factors: the scientific and technical, the social and economic, the cultural, and the political.

The points I am making are not new; they are stated over and over again. Development planners are well aware of the importance of taking informed decisions. They seek information. They commission surveys, studies and research. They do much to keep consulting firms in business. Directly or indirectly, they help keep academic institutions going with sponsored research projects.

But my thesis is that there is a lot of waste and duplication in the process of acquiring the information needed for decision-making, and that many decisions are taken without the decision-makers being aware of relevant information that has already been recorded.

Obviously, a planner who commissions a particular study will receive the document in which the results of that study are recorded. The study may provide background data; it may recommend particular policies or actions; it may be a feasibility study for a particular project; or it may be an evaluation of past actions. But whatever it is, if it is any good, it could be useful to many more people than the immediate sponsor; it could be useful in many more situations than the one for which it was immediately commissioned. It is the regrettable experience of most countries, however, that such documents are often buried in the files of the sponsoring organization, and they are not available on all the occasions when they could be useful and help to inform the decision-making process: this is waste. And, since they are not available, more studies and more surveys are commissioned often repeating work that has already been done before: this is duplication.

The more developed countries have this problem, but they can afford a certain amount of waste and duplication. The developing countries cannot afford it.

In this paper I would like to cover two principle themes: 1) what can be done within a developing country to get more use out of its own information, and 2) what can be done by a developing country to get more ready access to relevant information from other countries.

THE PROBLEM OF NATIONAL INFORMATION

The most useful mass of information for a country is its own information. This information did not just come into being by accident. Each piece of information, each document, came into being because someone thought it was worth creating. The totality of the nationally produced information represents an aggregate view of what is important for the country. Quality and reliability will vary, of course. But the judgement about what is useful in his contect can best be made by the user - not by a librarian or documentalist who is processing the information.

How can a decision-maker - or the staff that serve that decision-maker - most conveniently get access to the national store of information? Obviously he cannot do so if the national store is not well-organized. Having a vast amount of information is of virtually no use at all if it is randomly distributed in different places and if finding the useful document is a matter of luck. People will not even bother to go to look for information unless they know it exists. Even if they know that relevant information might exist, they will rapidly be discouraged unless the inventory is indexed and they can quickly retrieve only that information which is relevant to their current needs.

I was recently in Morocco. That country, with a lot of help from FAO and UNESCO, has attempted to build a centralized service handling national information. It has brought into its inventory about 100,000 documents dealing with Moroccan development problems.

The content of each document is described in a short abstract. These abstracts are held in a computer system. Questions can be addressed to the computer system; for example, "What documents exist dealing with the <u>costs</u> of combatting <u>soil erosion</u> in a particular area of the country?" The computer will print out a <u>list of such documents</u>. The user can select from this list, and ask for copies of those documents that he particularly wants to read. In the Moroccan case all the documents have been microfilmed (the National Documentation Centre does not even keep the original paper copies) and the user is sent a piece of microfilm - what is called a microfiche - with the text of each document that he has requested.

The costs are not unreasonable. Leaving aside capital costs (building, computer, microfilm cameras, etc.), the National Documentation Centre finds that the cost of putting a document into the system is about $12. This includes writing the abstract, selecting the indexing terms, entering the record in the computer and preparing a master microfiche. In Morocco, the salary of a trained documentalist is about $8,000/year and, since this is the major component in the total cost, it can be used as an index to find an equivalent figure for other countries.

Capital costs (building, computer, etc.) need not be more than a million dollars. For another million, one can build an inventory of about 100,000 documents. It cannot be done immediately, of course. One documentalist adds records to the inventory at a rate of about 10/day so, even with 10 documentalists, the job could take about 3-4 years. The question is: can one afford not to do it?

Once one has the inventory, the costs of exploiting it are relatively low. Different government departments can have terminals from which they can make links by telephone to the computer as and when required: one such installation costs about $4,000. Microfiches can be ordered through the same links: duplicate microfiches cost only a few cents to produce. A perfectly adequate microfiche reader costs about $200.

One other capital cost is that of developing an indexing system: this is simply a set of words (perhaps 10,000-20,000) which identify the concepts for which computer searches may be made. OECD has already produced what is called <u>Macrothesaurus</u> which can be used as a basis. Each country would, however, want <u>to add more terms</u> to identify its own geographic localities and special interests. One full-time documentalist should be allocated to the maintenance of the set of indexing terms. (Incidentally, the current version of the <u>Macrothesaurus</u> is available in three fully equivalent language versions: <u>English, French and Spanish</u>. Since the previous edition also became available in Portuguese, Arabic and several other languages, we can expect the new version to be similarly available in a few more months).

The Moroccan experience is one based on centralization. This is efficient provided 1) you can get a really good director, and 2) you locate the activity centrally in the political power structure (the Moroccan National Documentation Centre depends directly on the Office of the Prime Minister). Other countries prefer a decentralized approach. In this, it is, say, the Ministry of Agriculture's documentation centre that has responsibility for identifying and indexing documents in the agricultural sector; other Ministries similarly look after their own sectors. But to do this still involves having a central and quite powerful office responsible for ensuring compatibility (including the vocabulary of indexing terms) and for training the documentalists in applying the national standards. If compatibility is assured, then a single investory can still be constructed in a single computer by merging the material from the several sectoral documentation centres. In practice, of course, most countries still have independent systems in different sectors, most of them far from complete. Attempts at coordination invoke the usual human reactions, and often it is those who are responsible for the weakest efforts that are the very ones who most strongly defent their professional independence.

The construction of a well-indexed inventory of nationally produced information is technologically feasible. The computer permits the index to be accessible in many different ways - by subject, by discipline, by sector, by geographic parameters, by institutional parameters, etc. The teleprocessing features now available permit the index to be interrogated from any point in the country where there is good telephone service. The advent of smaller but highly reliable computers (the so-called minicomputers) keep the capital investment down and ensure that the machine can be dedicated entirely to this particular use - thus avoiding the bureaucratic problems that often intervene when a large computer is shared by many different users in many different departments. Necessary computer programs are already written and can be obtained, essentially free-of-charge, from international organizations. The microfiche technology obviates the need for handling large quantities of paper and permits documents to be sent by first-class mail in standard envelopes.

The total investment required is within the reach of even the poorest developing countries and, however it is viewed, is a very small add-on to other investments. Compare, if you like, the $12 that it takes to put a document into the inventory with the $10,000 (or many times that figure!) that it takes to produce a document in the first place. Development aid is available for projects of this type and, in particular, for the training of the documentalists that are needed for the successful operation of the system.

So why have not more countries followed the example of Morocco and created effective national documentation programs in the service of development? Quite simply, the answer is an absence of political will. That will is the most essential of all the requirements for success.

Most of the documents that are really important for decision-making are not documents that are publicly available. That is not to say that they are officially secret. But they are documents prepared, typically within or for a state organization, with no obligation that they be published. They cannot be bought; they cannot be found in libraries. Knowledge is power, and the recipients of these documents often believe that they can enhance their personal or departmental interests by keeping the documents to themselves. This practice can be broken only if the central executive realizes that it is in the national interest to break it. A documentation service will be successful only if it is given the authority to go into the various agencies of the state and to pick up and copy the documents that have been hoarded there. In most countries, this means a Presidential Decree. The Decree can call for one copy of each new document to be sent to the national documentation service - but it will be successful only if it is enforced.

The political will is also necessary if personal and professional jealousies are to be overcome. There is an almost infinite variety of different ways in which information and documents can be described and indexed. Documentalists and libraries will argue for ever about the relative advantages of different <u>minutiae</u>. But, in reality, one method is about as good as another: I am quite <u>sure that</u> the effectiveness of an index depends far more on the intelligence of the indexers than it does on the design of the indexing system. The national documentation system must have the power to impose a national standard.

My own organization, the International Development Research Centre (IDRC), is a foundation which has funds to support the improvement of information systems and services in and for the developing countries. My colleagues and I are convinced that the priority need is for developing countries to get control over their own information. We would like to devote the major portion of our budget to the support of national documentation services - but we are most reluctant to do so unless we see evidence of the political will that I have described. Without that, we would be squandering money on the proliferation of more and more competing services within a country. And, in the end, this would be counter-productive - because it would only make it more difficult for the country to coordinate its documentation activities when it is ready to do so.

INFORMATION FROM OTHER COUNTRIES

While I earnestly believe that the most important literature for a country is the information produced within that country, there is, of course, also a need for information from abroad. In general, this need will be for information of a more technological character which tends to be more universally valid (economic and social information tends to be more country-specific).

Recognizing this need, developing countries have been expressing demands that the more industrialized countries should be prepared to make their technological information more readily available. The Declaration on a New International Economic Order makes specific reference to the need to share knowledge on a basis of equity.

At present, it is true that the more industrialized countries have the principal resources for responding to this need. Very large information systems have been constructed and, in many cases, it is inconceivable that they would be dismantled and replaced by new "more equitable" systems. The American Chemical Society, for example, produces a virtually comprehensive service identifying information in the field of chemistry. The service is made available, both in printed form (Chemical Abstracts) and on magnetic tapes for use in computers. But it cost money - it costs hard currency. The current subscription price for Chemical Abstracts in its entirety is $4,200 per year.

In North America and Europe, an "information industry" has come into being. This has many facets. An important one, however, involves private companies that acquire the indexes - e.g. from the American Chemical Society - and that then mount these indexes in big computers and sell services to those who can make telephone connections to the computers. This is becoming a big business in its own right. The information industry is naturally looking for markets. With the advent of communications satellites, it sees the whole world as its potential market. Mexico, for example, already has experience of connecting to these computers and searching the big indexes for information that is required. And, in recent times, the companies that offer these services have introduced a new component: while you are hooked in to the computer, you can place orders for copies of the documents you want to receive. The documents - and the invoices - follow.

Again it cost money, and it costs hard currency.

Is it a solution for the developing countries? In the short term, of course, it gives much more ready access to the same stores of information that the industrialized countries enjoy. But these stores are built to contain the information that the industrialized countries are interested in. They can be lacking in information that is relevant to the particular scientific and industrial interests of the developing countries. It can be argued that, in the long term, the employment of such services will tend to perpetuate the condition of dependency.

Is there an alternative - one perhaps that would respond more directly to the aspirations of the Declaration on a New International Economic Order? In fact, there is some flexibility in the world as it is today. Most of the older big systems that exist in the industrialized world were conceived to meet the needs of research scientists. They reflect the organization of science at the time they were created. They are based on disciplines: chemistry, biology, physics, electrical engineering, etc. More recently, however, there has come a realization that technological progress often involves several disciplines at the same time: development work is interdisciplinary. To reflect this, the world has begun to build information systems that correspond to missions. For example, one mission may be to promote the peaceful uses of atomic energy; such a mission involves bringing together knowledge and skills from many disciplines - physics, chemistry, metallurgy, engineering, etc. Whether a given piece of information is or is not entered in the system then depends, not on the discipline from which the information comes, but on the purpose for which it was created: it belongs in the system if it was created with the purpose of promoting the mission that the information system is designed to serve.

While a number of mission-oriented information systems have come into being, there is a lot of scope for more. This is why I maintain that the present situation is fluid and can be directed to respond to the needs of developing countries.

And we do now have considerable positive experience with mission-oriented systems that have been designed to permit all countries to participate on an equal basis. The first of these was the International Nuclear Information System (INIS), which is managed by the International Atomic Energy Agency (IAEA). Every member state of the IAEA is invited to participate in INIS. Participation involves accepting the obligation to identify all relevant new information produced on one's national territory and to report it to the system. Thus countries with large nuclear programs have a large job to do; countries with small nuclear programs have a similarly small job to do. When the reports arrive at the IAEA, they are merged, and a world index (data base, in the jargon of the profession) is created. Copies of this index are made available to all participating countries both as printed publications and as a magnetic tape for handling in computers. The service is rapid (published indexes, 24 times a year; magnetic tapes, 12 times a year); the service is complete (independent evaluations indicate that better than 90% of the relevant new publications are captured by INIS); the service is available to all participants essentially free-of-charge in exchange for their contributions.

And, for those documents that are not easily available through commercial channels, the IAEA runs a service of putting them on to microfiches. All countries can obtain these microfiches for the cost of production - and even that is payable in local currency.

The costs of the central operations of INIS are borne on the regular budget of the IAEA, and hence shared among member states on the UN assessment formula.

It is difficult to imagine a more equitable system - each country puts in what it produces, but each country is able to exploit the entire data base according to its needs. Each country shares in the management of the system, whose rules cannot be changed except by a consensus of the participants.

The Food and Agriculture Organisation (FAO) has now built a very similar cooperative information system. It, too, is mission-oriented (production of food). The system, known as AGRIS, uses essentially the same cooperative mechanisms as does INIS - in particular, it uses the same "territorial formula" for sharing the responsibility of reporting new information to the central data base. More than 100 countries have indicated their readiness to participate in AGRIS. Although it only began to operate in 1976, it is now covering about 60% of the world's new agricultural information - that is 12,000 items every month!

AGRIS serves as a good example of how an international cooperative system can capture information from the developing-countries - information that may well be neglected by the systems operated in the industrialized countries. For the general field of agriculture, there are now three major systems: AGRIS itself; AGRICOLA which is constructed by the United States National Library of Agriculture; and CAB, which is constructed by the Commonwealth Agricultural Bureaux in the United Kingdom. Recently we compared the coverage of these three systems for information respecting three crops (sorghum, cassava and coconuts) that are important in the developing countries. Our analysis covers the year 1977; in summary the results are shown in Table I.

This comparison is really unfair to AGRIS, since 1977 was only the second year that this service was in operation, whereas the other systems are based on programs that have been operating for many years. Despite this bias, it is already clear that AGRIS is the most successful system in reporting the information originating in the developing countries.

Other systems have been proposed on the same model. Some would, like INIS and AGRIS, be global systems, but others would be regional. Latin America has started DOCPAL, a system to handle information about population policy questions and population programs. Africa is following this with an entirely compatible system to cover the same areas of concern. The United Nations Population Commission recently gave its benediction to these efforts and authorized the establishment, headquartered in New York, of a program to be known as POPIN (population information network) for harmonizing the regional efforts and promoting their cooperation. It takes very little imagination to see that, eventually the separately-managed regional data bases could be merged to establish a world data base.

There are a whole range of similar proposals: SPINES (science policy); ARKISYST (architecture); HERIS (health); WISI (informatics); HABITAT (human settlements). All of these are systems that would identify particular pieces of information (documents). But there are other cooperative systems that identify research projects (e.g. CARIS in agriculture); development projects (e.g. CORE in the United Nations); sources of information (e.g. UNITERRA for environmental questions); sources of expertise (e.g. TCDC for promoting South-South linkages). These systems depend on the same formula - that the producers of information have the responsibility for reporting the information that they produce, but that all participants then have access to the total file.

If we try to get mankin's missions into some order of priority, I imagine that most of us would identify "the maintenance of peace" as the first, and "the economic and social development of the Third World" as the second. The IDRC has been actively

TABLE I

References in Three Data Bases
during Calendar Year 1977

AGRIS

Commodity	Total No. of References	References from Developing Countries	Dev. Countries as % of Total
Sorghum	485	231	48·6
Cassava	252	226	89·6
Coconuts	149	134	89·9

AGRICOLA

Commodity	Total No. of References	References from Developing Countries	Dev. Countries as % of Total
Sorghum	495	126	25·4
Cassava	79	35	42·3
Coconuts	124	41	39·0

CAB*

Commodity	Total No. of References	References from Developing Countries	Dev. Countries as % of Total
Sorghum	1.002	413	41·2
Cassava	149	96	64·4
Coconuts	180	96	53·3

*Note: the CAB data base, because of its method of construction, contains a high proportion of duplicate references. The duplicates have <u>not</u> been eliminated from these figures. The proportion of duplicates is variously estimated from 20% to 40%

working with other organizations to design and - frankly - to promote the building of an international cooperative system that would deliver the central information generated in the pursuit of the second of these missions. We call it DEVSIS (Development Sciences Information System), and what I believe is a rather thorough feasibility study was carried out in Geneva in 1975. As with all the cooperative systems, each participant would contribute descriptions of the information produced in its own territory. For developing countries, this would probably indicate that the prime participants should be Planning Ministries and Development Banks. For the industrialized countries, the prime participants should probably be the bilateral development-aid agencies. And one would look to see participation, in their own right, by the multilateral (global and regional) organizations that have economic and social development as their goal.

For a country that already has a national documentation service as described in the first part of this paper, participation in any international cooperative information system is relatively easy. The documents are already identified, and it national norms are written in the light of international norms, it is unlikely that records would require any significant re-working.

The 1975 study suggested that the world is generating about 100,000 documents per year which directly address the question of economic and social development: policy-making, planning, programming, etc. This leaves aside the material that is indirectly concerned with development (e.g. information from agricultural research which, more appropriately, belongs in the relevant sectoral system - in this case, AGRIS). Of the 100,000 documents per year, only about 40% are "published" in the usual sense of that word. The remainder - and probably the most important - are the unpublished documents whose production is in most cases "sponsored" by a development organization.

Although the DEVSIS study was sponsored by six organizations (DECD, ILD, UNESCO, UNDP, the UN Department of Economic and Social Affairs, and IDRC), the information system DEVSIS has not yet been adopted as a global program. Nevertheless, some very interesting national and regional initiatives have already resulted from it.

IDRC, acting for Canada, and the Deutsche Stiftung fur Internationale Entwicklung, acting for the Federal Republic of Germany, have produced an experimental data base. National data bases, using DEVSIS methodologies, have been started in Pakistan and the Philippines. The Netherlands has carried out a DEVSIS-like program since before 1975 (and the DEVSIS feasibility study borrowed from this Dutch experience). Several countries, including Morocco, Indonesia and the Societ Union, have indicated willingness to participate in joing experiments during 1979. A small, perhaps somewhat tentative, experiment has begun at the United Nations in New York. But the most exciting response has ceom from the Economic Commission for Latin America (CEPAL) and, more recently, from the corresponding body in Africa (ECA).

CEPAL, responding to resolutions passed at meetings of Ministers of Planning, is designing a system to permit these Ministries to exchange their information with each other and with the regional bodies concerned with economic integration. Tentatively known as INFOPLAN, this system should reach the demonstration stage before the end of 1979. It is expected that it will draw heavily on the recommendations of the DEVSIS study.

A proposal, commissioned by ECA, should be in the hands of its Executive Secretary at the time this paper is presented. It, too, will advocate a plan for a cooperative information system involving the Member States in the African region.

Can we do anything to hasten the building of cooperative mission-oriented information systems? It is right and proper that this depends on the will of governments. For it is governments - particularly in the developing countries - that cause the creation of much of the mission-oriented information. And it is governments that are the first users of such information. So, as in the case of national documentation services, this is a matter of political decision. If governments wish these systems to be built, they will make the view known in the councils of the United Nations and its specialized agencies. In general terms, governments have already expressed a will - in, for example, the Declaration on a New International Economic Order. Now it is a question of mechanisms. If governments believe that systems on the model of INIS and AGRIS can be a solution to some of their information problems, they will need to say so. The Secretariats of the international organizations can organize this type of activity - but only when their masters tell them to do so.

SPECIALIZED INFORMATION CENTRES

So far in this paper I have talked, primarily, about building inventories of available information. National inventories that cut across all sectors, and international inventories that are identified with particular missions.

But is an inventory enough? Many would-be users of information claim they do not have the time - or even the skills - to evaluate the available information on a particular topic and to select from it the key items that will help them. And they cannot leave this task to amateurs or generalists.

In the post-war world, we have seen the emergence of "specialized information-analysis centres" which, particularly in fields of high technology, serve a very useful function. Within a very tightly defined subject area, they evaluate, select, correlate and condense the available information. They issue state-of-the-art reviews, and identify gaps in knowledge that need to be filled by new research. They issue newsletters to keep clients abreast of recent developments. The operate question-and-answer services, fine-tuning the ansers to the needs - and to the level of understanding - of the questioners.

Such centres can be operated only by specialists. Indeed, I believe that they can be effectively operated only within establishments that are, themselves, centres of excellence for research into the subject matter. Then the information and advice coming out of these centres is based, not merely on the information recorded in documents, but also on the wisdom in the minds of the researchers. Fortunately it is becoming more and more accepted that research is not an ivory-tower exercise, and that researchers must be parties to a "social-contract" under which, in return for the support they receive, the researchers undertak to share their knowledge with those who can apply that knowledge for the purpose of development.

I believe that we need "specialized information analysis centres" for the rationalization and interpretation of scientific knowledge. But is this again goind to lead us back into conditions of dependency? Not if the developing countries are prepared to focus the efforts in their own centres of excellence. There are many areas in which developing countries are already in a position of pre-eminence, and it is a question of capitalizing on the resources that already exist. Let me just give a few examples.

> Soils and foundation engineering - as applied to tropical soils. On this subject, the Asian Institute of Technology (Bangkok) clearly has had more relevant research experience than any institution in the temperate zones. It has created the Asian Geotechnical Engineering Information Centre, which over a period of about five years has produced a highly respected information-analysis service.
>
> The cultivation of cassave. The Centro Internacional de Agricultura Tropical (Cali, Colombia) has built, with international financing, perhaps the largest single program of research into all aspects of cassava cultivation. It has been operating a Cassave Information Centre which has now acquired probably the world's most complete set of organized information on this crop and which offers a wide range of information services to clients throughout the world.
>
> The cultivation of coconuts and associated crops. The Coconut Research Institute (Sri Lanka) has had a research program in place for about 40 years. It has a remarkable library, and it has issued useful information services but mainly for local clients. Recently it has accepted a mandate from the Asia and Pacific Coconut Community to expand its information services and to offer them worldwide.

Other examples could be cited. But the very nature of the topics brings home the truth that some of these services can only be operated from the developing countries: no establishment in Europe or North America can be a centre-of-excellence for research into the cultivation of cassava or coconuts! And, while these examples may be rather facile, there are many areas of research which, while they may not be climate-specific, are going to be concentrated in the developing countries for economic or social reasons. Many labour-intensive technologies will fall into this group, if only because the industrialized countries have no incentive to invest in them.

CONCLUSION

To sum up, I see very important roles for developing countries in building a new world order in the handling of scientific and technical information:

> Building national documentation services to ensure that each country gets full benefit from its own investments in the generation of information.
>
> Cooperating as equal partners with the industrialized countries in the establishment of regional and international mission-oriented information systems (on the model of INIS and AGRIS).
>
> Operating information analysis centres on very specialized topics of high priority to development.

If there is any short cut to development, it is by making optimum use of man's accumulated store of knowledge and wisdom.

9. Development is a Systems Problem; Can Systems Analysis Help?

ROGER E. LEVIEN

DEVELOPMENT IS A SYSTEMS PROBLEM

The problems that face governments in trying to achieve an increase in national income, or to improve social and individual welfare, do not ordinarily fit within the boundaries of traditional academic disciplines or the responsibilities of the normal ministerial authorities. With disdain for the competence of professors or the portfolios of bureaucrats, such problems can simultaneously engage economics, technology and sociology or demand the coordinated action of, say, agriculture, transportation and education officials.

A dam designed by civil engineers and built by the Ministry of Water to control floods and produce energy may also unexpectedly spread parasitic disease that must be fought by the Ministry of Health with the aid of physicians and public health specialists; reduce crop yields through loss of fertile soil so that the Ministry of Agriculture must undertake the production or import of energy-intensive fertilizers; and encourage an increased flow of rural population to already crowded cities where they will need the services of several other ministries and specialists. But this is just one illustration, selected from a multitude, that development problems are highly ramified, spreading across fields of knowledge and responsibility in ways that conventional scientific institutions and the usual government bureaus are not well-equipped to handle. Problems of this kind are now commonly called "systems" problems. They occur in societies at every stage of development; and within societies, they arise at every level of decision.

Consider, for example, the problem of improving the availability and utilization of energy in a rural Indian village, which depends primarily on firewood and cattle dung for fuel. An engineer might immediately see the potential of a communal biogas plant, which could transform dung into both cooking gas and fertilizer. But energy production and use are tightly linked to the village social and economic structure; attempts to change the energy system may either founder due to communal resistance or set in motion unanticipated and possibly undesirable alterations in the social fabric. The poorest families in the village, for example, have generally obtained free fuel by gathering dung from the cattle and buffalo of the better-off families. But if the dung can produce value through conversion in the biogas plant, then it may no longer be available free. Will the poorest then be driven to put an even greater strain on the already overburdened firewood supply? And how can the low BTU biogas produced in a communal facility be distributed for cooking and other uses in the mud huts of the families without expensive pressurized piping or tanks? Or will they have to come together for communal cooking? Would they be be willing to do so? By what means will the gas and fertilizer produced in the plant be allocated to the village families? These aspects of the problem go beyond the usual training of the engineer; they demand the skills of social scientists familiar with the village social structure. The problem of energy supply and use in an Indian village is a systems problem, demanding a complex solution that cuts across disciplinary and bureaucratic lines.

Or consider another example: the introduction of new, more productive grain varieties into local societies attuned to traditional agriculture practices. At first, this was seen by the agricultural specialists to be a relatively simple change in what the farmer does: what he plants, how he fertilizes, how he cultivates. But in many cases it created a complex web of unexpected consequences, or demanded a series of coordinated changes to make it viable in such non-agronomical aspects of the society as land tenure, finance and money lending, fertilizer production, marketing of agricultural produce, education, and farm to market transportation. To achieve the maximum net benefit from the agricultural innovation, a linked series of complementary changes in the economic and social relationships and the physical infrastructure has to be made. That is, the problem is one of redesigning major segments of an agriculturally-based community; it is a systems problem.

Because the problems of development are not packaged neatly to fit man's cubbyholes of thought and organization, but are lumpy, sprawling, and tangled, they demand the application of new modes of thought that cross conventional boundaries and are equipped to deal with complexity.

SYSTEMS ANALYSIS IS A DEVELOPING CRAFT

In response to similar needs within countries already at a high level of development, there has evolved the activity called "systems analysis".

History of systems analysis

The phrase "systems analysis" was first used about thirty years ago to describe an activity that arose to help defense officials plan development of their military systems in the face of a technologically and politically uncertain future. The experience of World War II had convinced the military planners that advances in science and technology beyond their own fields of competence would significantly affect the opportunities and the threats with which they would have to deal. They therefore enlisted the aid of scientists and technologists in anticipating the future. They established organizations inside and outside the government that could mobilize teams of specialists to help foresee and exploit scientific and technological advances in the service of national security.

The best of these groups soon recognized the need to link the insights of physical science and engineering with the knowledge and approach of social scientists, particularly economists and international relations specialists. They adopted the phrase "systems analysis" (SA) to describe their work, to distinguish it from the activity of operations research (OR), which had grown up in World War II. Whereas OR dealt with the most effective use of an existing military system, SA was concerned with the design and selection of prospective military systems. SA therefore faced a greater amount of uncertainty and a wider variety of options, and demanded, as a consequence, a broader base of knowledge and repertoire of techniques. The interdisciplinary team of physical and social scientists and engineers became the hallmark of true systems analytical studies.

Systems analysis was brought to wide public attention when Robert McNamara became US Secretary of Defense and created a high level office of systems analysis in the Pentagon. His initiative was followed by similar actions through the US Federal government. The enthusiasm for systems analysis was not always matched by competence in its application, and the high-tide of reform receded, leaving pools of activity unevenly distributed within the government.

This first phase in the evolution of systems analysis lasted into the second half of the 1960s. It was marked by a number of dramatic successes, some failures, and many mundane, but useful, results. A certain amount of codification of practice and development of a community of systems analysts occurred, but the activity achieved the status neither of a discipline nor of a profession.

In the second half of the 1960s, systems analysis was turned to other subjects outside the military sphere. First, space exploration and exploitation and then transportation, communication, urban planning and management, health care, education, and environmental protection became fields for systems analytical study. Here the record was even more mixed, with some significant successes and some embarrassing failures. The tools developed in military studies did not all transfer readily to the social arena, where the problems were far more complex and the impact of human and societal behaviour was far greater. And at first the physical scientists and engineers, who formed the majority of the systems analytical community, did not have the knowledge of individual and group behaviour they they needed to support effective modelling and prediction of the results of alternative social system designs. The result was some misguided attempts simplistically to apply aerospace techniques to urban and societal problems. These naturally turned out be unsuccessful and were the subject of considerable criticism. But the letter analytical organizations adapted their approach to the new subjects of concern. New specialists (sociologists, lawyers, physicians, statisticians), were added to the teams, while the participation of some specialists (physicists, aerospace engineers) was reduced. The reliance on complex mathematical models and theories was decreased in favour of analysis of empirical evidence and the design and evaluation of experiments.

As the 1960s passed into the 1970s, the analytical community found itself more and more engaged with new classes of problems outside the military sphere: evaluation of public programs, assessment of environmental impacts, and design and testing of social programs among others. In most of these cases, the topic of concern was not the design and selection of a system (such as a military weapon system), but rather the formulation and implementation of policy (such as an income maintenance or environmental protection policy). Many practitioners of this activity, therefore, felt it more appropriate to call themselves "policy analysts" than "systems analysts". And offices of policy analysis began to appear in many agencies, sometimes simply as the result of renaming offices of systems analysis. At the same time, an educational base for the community began to be established in the universities with the creation of schools of public policy, policy analysis, or policy sciences; and several journals with those phrases in their titles began publication. Nevertheless, the activity could not yet be said to be either a discipline or a profession.

In the first half of the 1970s, systems analysis (and its twin "policy analysis") stepped onto the international stage. This was symbolized by the establishment in late 1972 of the International Institute for Applied Systems Analysis (IIASA) by scientific organizations from 12 nations. Through its creation, systems analysis, which was born in the United States and present to a small degree in Canada, the United Kingdom, and a few Western European countries, was adopted as a theme for joint effort by the scientific and governmental communities in 12 - eventually growing to 17 - developed nations, spanning the range from Western market and mixed economies to Eastern centrally-planned economies. Those who established IIASA felt that the problems faced by mankind are systems problems that not only cross disciplinary and ministerial jurisdictions, but national boundaries as well. Therefore, to analyze them effectively requires the establishment of international teams.

The Institute recognized that it could address two categories of international problems: "global" and "universal". Global problems cut across national boundaries and cannot be solved without the joint action of groups of nations; they are inherently international. Protection of the climate, exploitation and preservation of ocean resources, and meeting the basic needs of an expanding global population are global problems. They are also, self-evidently, systems problems and demand the attention of international systems analytical teams. Universal problems lie within national boundaries and are subject to the actions of national decision-makers; but many nations share them. Planning a health care system, protecting water quality, improving a communication network, or advancing agricultural practice are universal problems. They too, however are systems problems and can benefit from the exchange of experience among national teams studying them in different nations, and from the work of international teams of specialists bringing together the best knowledge and methods available throughout the world. Although the founding members of IIASA were from developed countries, it was evident that both global and universal problems were equally of concern to the developing countries and that their participation in the analyses would be extremely desirable.

In addition to the extension of systems analysis to consideration of international problems, IIASA's creation also served to disseminate the idea of systems analysis to nations where it had not been used previously, and to initiate the formation of an international community of systems analysts. This was an important step, because unlike the established scientific disciplines (physics, chemistry, geology) there has been no internationally shared conception of what systems analysis is, how it should be taught, or what comprises its core knowledge and methods. There has been no international mechanism for the exchange, criticism, and cumulation of information and techniques in systems analysis. And there has been no meeting ground for persons conducting systems analyses in various countries. Through its publications (including a planned Handbook of Applied Systems Analysis), meetings, and international studies, IIASA is stimulating the formation of an international community of systems analysts.

Current state of systems analysis

Perhaps the most satisfactory description of systems analysis at present is neither as a discipline, nor as a profession, but as a "craft". For like a potter, a systems analyst tries to create a unique object of use by the skillful blending of diverse materials, employing knowledge from a variety of sciences, and methods that are only partially formalized and teachable. This conception rightly emphasizes the importance of individual skill in the conduct of a systems analysis and the goal of creating something of value to the eventual user - a decision-maker. It also suggests that the best way to learn systems analysis is by apprenticeship to a master.

Systems analysis may be characterized as a craft:

(i) whose purpose is to provide information to help decision-makers make better decisions concerning important problems;

(ii) which tries to investigate each decision problem in its true complexity by drawing boundaries that incorporate the major factors affecting the decision, while excluding irrelevant or unimportant factors;

(iii) which draws on knowledge and methodology from many different disciplines and fields;

(iv) which makes use of a wide range of mathematical and computational methods to organize and explore complexity; and

(v) which treats uncertainty and ignorance explicity in its investigations and conclusions.

These characteristics are not yet all present in actual system analyses; the second and last are particularly likely to be absent. Nevertheless, they do describe the qualities toward which systems analysts aspire.

In its present stage, then, systems analysis can be said to be an evolving craft, which is based on 30 years of experience in a few countries, initially in conjunction with national security decision making, but for the past decade or so undergoing a broadening to cover a full spectrum of important public issues, both national and international in extent.

How can this craft, which originated and is still evolving in the developed countries, help the developing countries?

SYSTEMS ANALYSIS CAN CONTRIBUTE TO DEVELOPMENT

Properly conceived and excuted systems analyses can help decision-makers in developing countries in many ways, among them the following:

(i) Clarifying the nature of the problem and the character of the system with which the decision-maker is concerned. A good systems analysis treats the problems posed by the decision-maker as symptons, not necessarily coincident with the real or underlying problem from which they derive. A major goal of the analysis then is to understand what the basic problem is. By characterizing the system and its complex interrelationships without disciplinary or bureaucratic bias, the analyst may be able to reveal that, for example, the perceived population or food supply problem is really one of land tenure. The analyst may also play a role in sharpening the decision-maker's awareness of the multiple, conflicting goals that their actions influence and of the longer run effects of their immediate decisions.

(ii) Helping to anticipate the consequences of alternative courses of action before they are taken. The goal of most systems analyses is to estimate the consequences of the alternative courses of action open to the decision-maker. A variety of means may be used to this end. Sometimes a mathematical or computational model of the affected system can be constructed and used to test the effects of the possible policies. Thus, for example, a model of a river basin can be used to explore the results of different designs and locations of dams, canals, and other constructions on the supply and distribution of water. But often a variety of different models will be needed to trace through the behaviour of a complex system. To choose among water control investments, it may be necessary to have models of population, economic growth, and industrial location so that the amount and distribution of water needs can be estimated. And sometimes models will be unfeasible or unreliable, because understanding of the corresponding phenomena is inadequate. Then, analogous experience from elsewhere must be examined, or small experiments run, or the judgment of experts gathered. In the most fortunate of circumstances, a model accurate enough to be used to find an "optimal" solution can be constructed; but this is usually only possible when the modelled phenomena are neither behavioural nor social. A good model-based systems analysis will frequently result in estimates of the consequences of decision alternatives that can be explained in general terms without reference to the models that produced them. The models' purpose is help produce understanding of the system's behaviour that can then be explained in simpler terms.

(iii) Working out the complex steps needed to implement a favoured course of action. Analysis should not stop once the decision-maker selects a course of action, for the implementation of that decision is generally also a systems problem, which requires careful analysis to identify and sequence the steps to be taken. The decision to turn oil revenues to industrial development, for instance, is only the prelude to scores of other decisions that must be made to achieve that goal. And most of the subsidiary problems will themselves generate further decisions, and so on.

(iv) Monitoring and evaluating the success of an implemented course of action in achieving its goals. Analysis has an important role to play even after a selected course of action has been implemented, for it may easily be that the anticipated benefits are not obtained or the estimated costs are exceeded. Thus, a system for continuously or regularly measuring the performance of the system and comparing it with the desirable or acceptable behaviour should be established to alert the decision-maker to the need for modification or complete revision of previous decisions. For example, to ensure that health care policies are having their desired effects, measures of the use of health services and of population health status should be continually taken and used to trigger changes in policy when they diverge from those anticipated or desired.

Common to each of these specific contributions of systems analysis to decision-makers in developing countries are two, more general benefits. First systems analysis gathers knowledge and technique from many specific sciences and technologies and directs them to actual problems. Thus, it is a means for mobilizing science and technology in the service of development. Second, systems analysis creates a conceptual framework within which decisions requiring the concerted actions of multiple bureaus and organizations can be taken. Thus, it is a means of facilitating coordination among autonomous agencies in the cause of development.

APPLYING SYSTEMS ANALYSIS TO DEVELOPMENT IS NECESSARY, BUT DIFFICULT

How can "properly conceived and executed systems analyses" be brought to the service of decision-makers in developing countries? The task is not an easy one. At the current stage of development of the systems analysis craft, forming a competent team and formulating its analytical agenda are not routine activities. Even in the best of circumstances not many such teams could be brought together at present. And relatively few decision-makers and government agencies can be expected to be willing to give analysts the broad charter and freedom of investigation that true systems analysis requires. A goal of widely applying systems analysis in developing countries, while certaiyl desirable, is clearly not feasible in the short run. Instead, a reasonable objective might be to initiate a process that over time would steadily build the capacity and enthusiasm for widespread use of systems analysis in making development decisions. Some suggestions for achieving this objective are presented below.

The process of building capacity and enthusiasm should comprise three inter-related activities: the conduct of analyses, the training of systems analysts, and the exchange of experience and joint work among groups in different countries.

Conduct of analyses

There has already been some successful experience in a number of developing countries with the use of systems analysis in addressing important policy problems. The following three examples illustrate the nature of this experience:

(i) Agricultural policy in Mexico

The Mexican Government and the World Bank collaborated from 1970-1974 in the formulation and use of agricultural policy analysis models. Their development was stimulated by the government's recognition that it faced difficult and complex agricultural policy issues: could agriculture continue to meet domestic consumption needs and generate the majority of export earnings, given population growth and the increasing costs of land and water? Could the agricultural sector continue to absorb a large portion of new labour force entrants? To answer these questions, the government needed to know how fast the sector could grow and how much employment it could generate, and how the answers to those questions depended on government price policies and associated changes in crops and production technologies. The model (called CHAC after the Mayan rain god) was developed to address those questions. It incorporates information about agricultural production possibilities and domestic and international markets provided by agronomists, engineers, economists, water specialists, and so on. The use of the models was managed by the Ministry of the Presidency and, later the Agricultural Sector Coordinating Commission. Studies were made of overall sectoral strategies, pricing policies for crops and production factors, export strategies, and investment decisions. The model has led to the identification of improved policy choices and helped to provide a focus for continuing policy discussions and explorations of trade-offs and interdependencies.

(ii) Water and power development in the Indus Basin

With World Bank support again, a study was carried out to assist the Government of Pakistan to formulate a sound program for the systematic exploitation of water and power resources in the Indus Basis. This was a systems problem because of the many points of interaction both within and among irrigation, hydroelectric power production, natural gas power production, fertilizer production, agricultural production technologies, fuel imports, and foreign-exchange balances. In view of this complexity, it was necessary for the study to treat the economy of Pakistan as a whole, with the agricultural and irrigation subsystems and the energy-use subsystem singled out. An interrelated series of models was developed of the economy, the power system, the water system, and of the agricultural sector. These were used to test a large number of candidate projects in a comprehensive framework. The most promising of these were then entered in a program that generated an optimum, internally consistent water development program for the entire basin. By 1976, investment related to the work of the study had amounted to more than $2 billion. This study was a significant improvement over the conventional approach to regional development which evaluates and develops projects in isolation from each other.

(iii) Satellite instructional television experiment in India

For a year in 1975-76 NASA made available to India use of the ATS-F satellite to experiment with direct broadcast of television to Indian villages. The Space Applications Centre (SAC) of the Indian Space Research Organization viewed this experiment as one of conceiving and testing an entire system of communication from producers of information (educators) to consumers of information (villagers, school children), and not just one of testing advanced space hardware. They, therefore, formed a team of space and communication engineers, TV production specialists, educators and program specialists, and social scientists concerned with program evaluation and audience response to design, test and modify, and evaluate the entire system from reception antennas and village TV sets, through TV production equipment, to the programs themselves. The result was a dramatically successful demonstration of how education could be brought to 2400 widely scattered villages at reasonable cost and high effectiveness.

These three successful applications of systems analysis shared two essential features: a government administrator actively interested in using analysis to get better solutions to his problems and a leader and team of analysts interested and competent to address those problems. In some cases, the interest was stimulated or the competence was provided in part through external agencies (the World Bank, foreign specialists or advisors), but in each case the enthusiasm had to be sustained and the competence acquired by national administrators and analysts.

The need now is to stimulate further applications of systems analysis in developing countries. Here, external funding agencies can help by providing the encouragement and financial support. It would also be desirable to establish mechanisms through which experience in the use of systems analysis in development can be shared. This could take the form of publications for decision-makers that describe successful examples and how they were accomplished. Seminars and courses for decision-makers and prospective analysts are also desirable ways to demonstrate to them what has been and can be done. It may also be appropriate to find institutional mechanisms (like IIASA) through which scientists from developing and developed countries can work together on the "universal" problems faced by developing countries. Through such sharing of ideas, methods, and effort, a more efficient use of the scarce systems analytical resources could be achieved. (More is said about this below).

As noted earlier, developing countries have a strong stake in improved understanding and resolution of "global" problems as well. Every effort should be made to encourage and support their participation in international systems analyses (such as those of energy and food at IIASA) of such issues.

Training of systems analysts

A systems analysis study is generally carried out by a team comprising a wide range of specialists: engineers, economists, social scientists, statisticians, and so on. They will have received their training in the conventional manner of their disciplines. But if their work is to be fused and focused into a trus systems analysis, the team must be led by someone who is a systems analyst. His or her training is more problematic. For, as noted above, the primary means of developing systems analytical craftsmen has been through apprenticeship. Ordinarily, analysts have been educated in one of the traditional disciplines and then, through work on systems analytical teams, have gained the knowledge, skills, and interests to become leaders. This is a slow and unpredictable process, which must be replaced by a more highly organized and structured activity if systems analysis is to become a widely useful activity. It also evidently poses great difficulties for the application of systems analysis in developing countries, where the initial cadre of systems analysts needed to get the activity underway may not exist.

Thus, a central issue is how to train the first systems analysts to work on problems of development in a developing country. Three different, but complementary, rpproaches may be used:

(i) Potential analysts may be sent to work on systems analytical teams in developed countries or in international institutions. Experience at IIASA, for example, could help to prepare specialists from developing countries to work on problems at home.

(ii) Experiences analysts from elsewhere can be brought in to lead the first studies in a developing country, with the understanding that an important function of the study will be to train national participants in systems analysis.

(iii) Potential analysts may be sent to study in the few existing programs of education for systems or policy analysts, such as those in some American universities or the unique doctoral program established at the Rand Corporation, the Rand Graduate Institute. The International Centre for Theoretical Physics is also beginning to hold short seminars in systems analysis, for specialists from developing countries, with emphasis however on mathematical methods, rather than the craft aspects.

It is clear, therefore, that developing a pool of experienced systems analysts for work in developing countries will be a slow and difficult process, which will required cooperation between the developed and developing nations, both through national and international institutions.

Exchange of experience and joint work

With a surfeit of systems problems in developing countries and a shortage of systems analysts, there is an evident need to find ways in which the available resources can most efficiently be used. Since most development problems have the saem general character in different countries, even if they differ in detail, one obvious and attractive approach is to establish mechanisms through which experience can be exchanged among groups working in different countries and joint work can be conducted.

Exchange of experience can relatively easily be carried out through visits, reports, meetings, and courses, once the need for it is recognized, the modest financial requirements are met, and the proper arrangements are made. The closeness of good systems analysis is to policy may cause difficultues in exchange, however, as a result of the possible political sensitivity of data or results and the time pressures on analysts who work in tandem with decision-makers. These potential problems can be alleviated by focusing on the exchange of procedures and methodologies, rather than data or results, and by seeking to assure that all exchanges will indeed be mutual, and thus of value even to busy analysts. Among the mechanisms that might be set up to encourage mutual exchange are: regular international conferences on the analysis of specific problems of special concern to developing countries (e.g. energy policy, agricultural policy, housing, health care, educational planning, water resources); short courses on the analysis of these problems at which case studies of work done in developing countries would be featured; and publications (books or journals) addressed to these problems and reporting on work done in developing countries. The funding and sponsorship of these activities might come from UN agencies, other international bodies (World Bank), national development aid agencies (IDRC, AID, etc.), or foundations.

To achieve true joint work will be more difficult, but perhaps more rewarding, than th bring about the exchange of experience. There are essentially two types of joint work: collaborative or conjunctive. In a collaborative study, groups in two or more countries work together on the same class of problems while retaining their geographical and institutional distinctness. Coordination of the work may occur through occasional or regular meetings. In the absence of strong leadership, however, there is a natural tendency for the collaborators to move apart, as each follows its own interests and talents. In a conjunctive study, however, the supporters each contribute one or more participants to a geographically and institutionally separate study group with its own leadership. This group then establishes its agenda with reference to the shared need of its supporters and conducts a single commonly-useful study. A hybrid arrangement is also possible, in which a central conjunctive study provides the leadership for a distributed collaborative study. IIASA has had successful experience with all three modes: conjunctive studies are its principal activity, but increasingly these are attracting networks of collaborators and being transformed into the hybrid conjunctive-collaborative form. Both collaborative and conjunctive studies, as well as hybrid ones, should prove useful for developing countries too. Among the topics that might be treated are: energy strategies for oil-importing developing countries; policies for improving rural health status; planning water resources development; and agricultural strategies for tropical countries.

Some institutional framework will be required to organize these joint studies. It can be provided, in the case of collaborative studies, through multilateral agreements, either among governments or research institutions. For conjunctive studies, however, a separate, "neutral" organizational basis will probably be required in order to avoid dominance (or the impression of it) by one of the sponsors, to the detriment of the others. Here, IIASA as an international, but non-governmental, body can serve as model and as a means. That is, IIASA-like institutes might be established to work especially on problems of development. But, at the same time, IIASA itself is already conducting studies on many topics of interest to developing nations - regional development, water resources management, rural-urban migration, energy and food policy, and health care system planning among others; thus, there is an opportunity to use the Institute as a means to organize conjunctive and collaborative studies of issues of unversal importance to all nations, no matter what their stage of general development. Indeed, IIASA studies are already specifically addressing problems of development in Mexico, Kenya, and India together with scientists and scientific institutions of those countries.

The sources mentioned earlier (UN agencies, World Bank, IDRC, AID, foundations) should also consider funding the planning and conduct of joint studies of issues of fundamental importanct to the developing countries.

CONCLUSION

The problems of development are systems problems and demand systems analysis. However, the "craft" of analysis is not well-enough developed to support its immediate and widespread adoption. Rather, the emphasis must be on setting in motion a process through which the use of systems analysis will begin, evolve, and spread as expeditiously as possible. This will require stimulation and support of the conduct of systems analyses where the proper conjunction of analytical talent and a receptive decision-making audience can be found. These analyses must also be used as training grounds for younger analysts who will go on to lead subsequent analyses. (Training may also be achieved by sending students abroad to work on analytical teams in other nations or at international organizations, or to study in the few educational programs in the systems or policy analysis). To enhance the effectiveness of the limited analytical talent, exchange of experience among nations and, particularly, joint work should be encouraged. In principle, both collaborative and conjunctive studies of "universal" problems of development can lead to better and more influential results than studies done within national boundaries by local teams. Careful design of the institutional arrangements will, however, be needed to realize the potential benefits.

10. Technology Assessment in Planning for Development

K.-H. STANDKE and A. KORN

INTRODUCTION

Science and Technology are accepted as powerful agents of change, which affect the social fabric of a nation in profound ways as industrialization systems take root and spread throughout its productive sectors. But since there is not any <u>one</u> model in which to observe the workings of this process, an assessment of technology provides a procedure for national authorities to evaluate the relative effects of alternative technologies in a variety of national conditions and environments. From this point of view alone, so far as developing countries are concerned, technology assessment would become an important instrument for national planning.

Technology assessment could be applied both as a tool for protecting existing social and economic patterns from undesired effects, and as a tool for furthering innovative national socio-economic objectives, including choice of technologies. In any case, technology assessment has an important contribution to make to the national planning and decision-making process.

NEEDS FOR TECHNOLOGY ASSESSMENT

If a country of society is to control its own destiny, there must be a clear vision and understanding of at least the major development objectives which are to govern and shape the evolution of the society. There must also be an understanding of the value which should be attached to such questions as the standards of living, the quality of life, and the degree to which changes of the environment and in patterns of human settlement, as well as in agricultural and industrial development can be accepted. In other words, what is needed is a clear understanding of the development objectives of a given society and knowledge of the trade-offs which the society is prepared to accept, both in changes of their current status and in changes over time.

Given the increasing awareness of the interaction between technology and society during the recent decades, the role of technology and its impact on society is now being more seriously questioned in both highly industrialized and developing countries, though for different reasons and with different perspectives. More basically, during recent years, there has been a body of criticism in developing countries about the basic planning approach and development objectives identified mostly with the highly industrialized countries, an approach which emphasized quantitative economic growth as an end in itself, rather than as a means to improve the standard and quality of life. There is therefore a "search" in many developing countries for alternative planning and development approaches which place more emphasis on meeting the needs of the entire population as rapidly as possible. Such searching constitutes an important component of the present concerns of the developing countries and possibly as well of industrialized countries at the present time. (1) However, whatever model and style of development is adopted, whatever political options are taken, it is indispensable to have the required technical capacity to study and analyze, to plan and to decide, to negotiate, and to set in motion the technological components of the development complex of the country.

RELATIONSHIP TO PLANNING

Planning requires assumptions about the future that must be based on a degree of predictability and understanding of the elements which are likely to have a bearing on that future, however uncertain it may be. Technology assessment is a discipline which deals with these elements and is therefore an essential part of development planning. The area of value judgments, of assumptions and variables relating to the future and the growing range of technological options require active relationship between technologists and decision-makers. Technology assessment, therefore, can provide a valuable part of the framework for planning, for design and innovation, for negotiation, as well as for policy analysis and for decision-making.

INTEREST FOR THE UNITED NATIONS' SYSTEM

The United Nations is arriving at the threshold of the 1980s with a body of decisions, proposals and commitments to development, unprecedented in their scope and, more important, in their consistent emphasis on the vital need of developing countries to increase their own capability to chart their development, to reduce their dependence for their economic and technological growth, and to acquire effective negotiating abilities.

Resolutions, plans of action, and specific proposals arising from the General Assembly and the ECOSOC and their subsidiary bodies, from the governing bodies of the specialized agencies and from the series of world conferences in the last few years, are numerous, and they are as diverse as the sectors and disciplines bearing on developing planning. But their persistent theme, which is drawn up with increasing clarity is that developing countries must have an indigenous capability for development planning and for implementation and management.

> "Development means more than a quantitative increase in production. An increase in production would in fact be more a consequence of development than its essence. In other words, development is more than growth. In his proposals for the First United Nations Development Decade, the Secretary-General expressed this by saying that the real problem of development was not to increase production but to increase the capacity to produce. This capacity ultimately is inherent in people. It depends on people with the outlook, knowledge, training and equipment to solve the problems posed by their own environment, and thus control their environment rather than be controlled by it. This capacity has grown in the new richer industrialized countries by a historical process, sometimes natural and slow, sometimes planned and even forced, often aided from abroad, but always also indigenous." (2)

The process of acquiring this capability is itself varied and depends strictly on the particular approach and requirements of a country, but it is generally conceived as including a certain interaction with the industrialized countries, a process which contains the important question of the "access to technologies", which in turn requires a fuller understanding of the range of issues that arise - politico-economic, fiscal, legal, etc. and an adequate knowledge, or capacity for possible innovation, of the forms and modalities to deal with them. It equally suggests a clear, important role for the United Nations and the UN specialized agencies, as well as of other relevant international and regional organizations, in promoting, assisting and helping establish the machinery for setting and maintaining in motion this process.

For its part, the United Nations needs to examine the discipline of technology assessment in all its dimensions because of the concentration of efforts the organisation is called upon to mount in the areas of development as they arise from the Development Decades, the International Development Strategy and from the New International Economic Order. These documents are unambiguous in their priorities in respect of the establishment of a technological capability as an indispensable part of the processes of national development planning.

The General Assembly, at its Seventh Special Session in 1975, in calling for a World Conference on Science and Technology, gave it the following objectives:

> "7. A United Nations Conference on Science and Technology for Development should be held in 1978 or 1979 with the main objectives of strengthening the technological capacity of developing countries to enable them to apply science and technology to their own development; adopting effective means for the utilization of scientific and technological potentials in the solution of development problems of regional and global significance, especially for the benefit of developing countries; and providing instruments of co-operation to developing countries in the utilization of science and technology for solving socio-economic problems that cannot be solved by individual action, in accordance with national priorities."

Similarly, the UN resolution on the Establishment of a New International Economic Order includes the following provisions in respect of technological development:

from the

> Declaration of the New International Economic Order
>
> "(p) Giving to the developing countries access to the achievements of modern science and technology, and promoting the transfer of technology and the creation of indigenous technology for the benefit of the developing countries in forms and in accordance with procedures which are suited to their economies;"

from the

> Programme of Action for the Establishment of a New International Economic Order
>
> "All efforts should be made:
>
> (b) To give access on improved terms to modern technology and to adapt that technology, as appropriate, to specific economic, social and econological conditions and varying stages of development in developing countries;
>
> (c) To expand significantly the assistance from developed to developing countries in research and development programmes and in the creation of suitable indigenous technology;"

RELATIONSHIP TO TECHNOLOGICAL CHOICES

In developing countries, and indeed for the United Nations and its specialised agencies, in their efforts to mount effective development programmes for self-sustaining growth of developing countries, problems arise not only in securing the necessary financial support for their development operations, but also in choosing the particular technological approach which must constitute an integral part of their development planning process. Just as developing countries need to decide themselves what aspects of the technological spectrum should receive priority attention in order to promote the development process, so, too, it is necessary for them to establish the national capacity reffered to above to enable them to analyse the alternatives and make the choices in terms of their own economic and social circumstances, their resource endowments and their needs. And for this it is equally necessary to allocate financial and human resources in various proportions to such different activities as the education and training of research workers and technicians, the study of specific research problems for innovation, the application of existing knowledge to particular problems of development, the international exchange of technological information, etc.

In the technological sector, as in the other sectors of development planning, decision-making involves the balancing of costs and benefits of proposed undertakings, that is, a technology assessment that represents an accounting of all the known values with their corresponding weight that have a bearing on the particular technology, and an evaluation of its anticipated effects on the development scheme. As simply states as this is and as fairly applicable as it seems, very little has been accomplished so far to develop techniques of technology assessment applicable to development planning and to decision-making for investment in science and technology for development. The problem is real in pragmatic terms, since the effective allocation of usually scarce resources requires a greatly improved understanding of technological alternatives, of the nature and extent of their economic impacts, and the problem is equally real in its politico-social dimensions if technology is the powerful agent of change as it was presented in the opening part of this paper.

A POINT OF VIEW

The fact is that technology assessment, for all its possibilities and promise as a tool of planning, cannot be treated, for the time being at least, an an operational methodology or discipline such as one with well delineated parameters, with an accumulated body of experience and practice, and with accepted guidelines for its use in any number of combinations of circumstances.

> "Technology assessment is a study form that informs the decision process. It deals with the development, implementation, and consequences of technology in a given social and cultural setting. It assumes that responsible authority can accept or reject and modify or condition the implementation of technology. If that should prove infeasible or undesirable, technology assessment assumes that the consequences resulting from tech-

nology can be mitigated, transformed, or compensated. Technology assessment does not embody action, nor does it substitute for the normal political and economic process by which decisions are made and action is taken. It is information only and assumes that informed choices are better than uninformed ones, even if the information is flawed or incomplete." (3)

In the United States, where the concept of technology assessment was pioneered, the actual applications of technology assessments do not reflect the broad concerns which are attached to the concept in terms of its interest to developing countries. It may be that in recent years, the studies preceding the introduction of new technologies or new industrial processes have gradually placed more weight on the aspects of community interests, environmental impacts, effect on the labour force, sources of energy, impacts on the economy beyond that of the particular interests of the undertaking. But these extensions into affected areas cannot reach too far before they impinge on other interests which may not be able to accept judgments which do not correspond to their own concerns.

The problem is not limited to the highly industrialized, highly diversified countries. It must apply in various forms in many developing countries, although to a lesser extent, since there usually is an element of central decision-making which could deal more directly with some conflicting situations at the planning stage. This would appear a suitable context for the notion of technology assessment which itself implies a certain requirement of central decision-making, although this cannot be strictly assumed to operate everywhere. But even on the assumption that there is a central authority, which can regulate the development process, a reasonably effective technology assessment would have to operate on a basis of fairly current and accurate scientific and technical information, in addition to other relevant information, which the planning authority would presumably obtain for the technology assessors. But this process is still itself one of the larger problems with which countries are faced. The problem of obtaining, as well as of application of information and use of information processes in their development planning.

THE CONCEPTUAL VALUE

What then can be said for technology assessment at this point? There will certainly be serious attempts by planners of developing countries to introduce a process of technology assessment as a result of the considerable movement of ideas that is taking place and of the considerable interest it attracts from international and national organisations and from many professionals concerned with development planning. If that were the case, then there is already some vindication for this movement and for all the work it generated.

This could be meant as an achievement of sorts, not in the sense that technology assessment is now ready to be adopted by government agencies as an aid for preparation and analysis of national development plans. What is likely to happen is that organs charged with the responsibilities for planning may look deeper in their examination of data and formulation of development parameters, and bring to bear such information as may reflect on the values and the anticipated effects of those development and societal objectives which have been formulated rather consistently in most of the ongoing discussions of technology assessment.

But given time, will technology assessment become the practical instrument which so many proponents foresee? Will it develop into a discipline with its cadre of practitioners and become a subject of study and specialisation? So far, the effects of the initial stirrings of technology assessment and the more basic issues that have arisen from its examination, suggest that the answer is probably 'no'. Moreover, basic specific elements that are required for technology assessment are themselves mostly matters of value judgment and as such remain ambiguous and unlikely to lend themselves to precise measurement and definition. In this sense, technology assessment is very similar to "appropriate technology" and "technology forecasting" in that it is in their conceptual stage, where they are now, and where they seem to attract such attention that one could attribute to them a very tangible value to their impact on planning.

"Technology assessment presents many problems of methodology. These include achieving comprehensiveness, interdisciplinarity, objectivity, accuracy, and evenhandedness; considering multiple and conflicting values, interests, and perspectives; tracking, measuring, and attaching values to consequences and impacts; making projections and forecasts; developing and ranking policy alternatives; reaching the proper audiences; developing an integrated picture; and remaining apolitical. As a result, some critics are pessimistic about the concept being intellectually viable and politically desirable. Assessments that have been done have been examined and found wanting from various viewpoints including that of scholarly research. Other researchers have looked for results and have become discouraged when they find that rational arguments have not been

> sufficiently persuasive to force the political decision. Still others have attempted to develop a paradigm of mega-methodology for the study concept and have been unable to capture in a model the complexities and subtleties of human society... (4)

The point of view offered in this paper, that technology assessment is unlikely to become a systems discipline, obviously could not be seen as an isolated notion but rather as a proposition, which, like the other more orthodox propositions, inevitably will result once a subject is opened for scrutiny, as technology assessment has been over the last few years.

The point made cannot be substantiated but neither can the other propositions be sufficiently substantiated and, therefore, let this view serve to question some of the assertions that are made in the course of the widespread examination of technology assessment which is taking place.

ACTIVITIES OF THE UNITED NATIONS

In our work on technology assessment in the Office for Science and Technology we have not always understood the process this way. We, too, have been pursuing the idead that we may help develop a certain methodology and that we may be able to draw up guidelines for the use of planners of developing countries. Although we do not know what the next months and years will do for technology assessment, there is importance in the promotion of the idea, and in the movement that it has generated, and even if the rather limiting point of view offered above holds true there is considerable accomplishment to report.

The Office for Science and Technology itself began to look at technology assessment in 1975 when it convened a small group of experts in areas relevant to technology assessment to try to give a first look at the subject from the United Nations' point of view. The group put the main emphasis on the societal aspects of technology and referred to it througbout its discussions as an essential aid to decision-making. Technology assessment was seen as the systematic study of the range of consequences that result from technology-related activites. The group made the important distinction that the highly industrialized countries and interested in identifying, evaluating and correcting the "negative effects" of the use of technologies, while the developing countries would like to assess technology primarily to determine and maximize the "positive effects" of using the technologies to accelerate their development process. More generally, the group felt that technology assessment in terms of society would invariably benefit the user far more than by decisions taken in the narrower context of cost-benefit choices.

The United Nations has a special responsibility in helping to articulate and define guidelines and standards for the applications of science and technology as part of its fundamental concern with economic and social development and particularly with development planning of developing countries. Further to the 1975 expert group meeting and in response to the growing interest of the member states on the subject of technology assessment, the Office for Science and Technology organised a seminar on technology assessment for development which was held in Bangalore, India, from 30 October-10 November 1978. The seminar, which brought together active professionals and decision-makers from developed and developing countries, may be viewed as an important stage in the serious examination of technology assessment which has been taken up in many forms around the world. It made a considerable number of recommendations, addressed to developing countries, to developed countries and to the United Nations System; recommendations which on the one hand see technology assessment as becoming a specialised discipline, as in the more current orthodox view, but on the other hand touched but left unanswered questions raised in this paper in respect of the practical application of technology assessment in the development process.

That technology assessment could be an important aid for decision-makers was quickly recognized in the development debates in the United Nations and elsewhere and the subject quickly drew the attention of governments and of the United Nations' interested organs. In the industrialized countries, technology assessment was perceived as a process to help account for the environmental concern and in the best of cases to help discern long-range socio-economic effects of a given technological development, a process which might often favour limitations on technology. The Bangalore seminar, by contrast, placed the emphasis on the need for <u>more</u> technology for developing countries and to that end technology assessment was a new and powerful tool to assist in the choice of technologies in a deliberate assessment of alternatives in an overall socio-economic context.

Interestingly, this view of technology assessment was recognized by all the participants from developing, as well as developed, countries and in this respect the understanding of the role of technology assessment represented a departure from the view prevalent in the highly-industrialized countries in that it required an articulation of all the known factors concerning the processes and interactions of the scientific and technological activities, as well as politico-socio-cultural elements with which development planning must deal.

TECHNOLOGY ASSESSMENT DEFINED

The debate, brought on by the contrasting views on whether technology assessment was mainly a prophylactic of high technology societies or a tool of development, produced the following definition:

> "Technology assessment is a process for the systematic analysis, forecasting, and evaluation of a broad range of impacts on society pertaining to technological change and choice in order to identify public policy options. It helps to match technological development to national goals."

The programme for the seminar included discussions on user requirements and development needs in a changing world; the concept of technology assessment, and a critical analysis of practices and experiences in selected sectors. The physical, environmental, economic, social, cultural and policy consequences of the various alternative technologies were considered within a framework of national goals for economic development and social progress.

Two central themes emerged from the seminar in support of technology assessment for development: expanded choice, and expanded decision variables, for the decision-makers at all levels and stages of the development processes. Bangalore participants believe that expanded policy options are critically important to developing nations who are often faced with a very limited range of choice or only a choice between unacceptable alternatives.

Participants also strongly emphasized that developing nations should give precedence to the assessment of those technologies which strongly relate to basic needs and national goals. In the initial stages of TA, assessment in developing countries was said to help in early identification of, and acceleration of the exploitation of, optimal technologies which may otherwise not receive due attention. Participants thought that in the developing world TA may initially have great impact in controlling the exploitation of certain technologies which may have undesirable side effects.

TECHNOLOGY ASSESSMENT AND APPROPRIATE TECHNOLOGY

Another major benefit of TA emphasised in Bangalore arises from its broad examination of impacts which determine decision variables. Technology assessment represented for the participants a method of identifying the impacts of both imported and domestically generated technologies on the society, culture, economy and environment of developing countries. It was claimed to provide a means of choosing appropriate forms of technology in accordance with the three elements of the concept of 'ecodevelopment' promoted by the United Nations Environmental Programme (UNEP). The seminar stressed that a technology can be assessed for the extent to which it contributes to satisfying human needs: it can be evaluated with an eye to its promotion of the concept of self-reliance through the use of local human and natural resources and it can be assessed with respect to its environmental impacts, as well as social and cultural effects.

Bangalore participants found the relationship between technology assessment and appropriate technology to be strong, even though this relationship has so far only been cursorily explored previously. The former is more the process; the latter should be the product. Both place primary emphasis on impacts - the formal evaluation of which can only lead to an improved decision. Although it appears to be an obvious truism, advocates of appropriate and alternate technology would do well to bear in mind the statement of the Bangalore seminar: "The appropriateness of technological application can only be determined by technology assessment". Consequently, there need be no dichotomy between technology transfer and technology assessment either at the conceptual or at the operational levels.

For many participants, the technology transfer process also offers the following additional benefits: Enhancing national and regional bargaining strength. TA was reckoned to be indispensable in the search for relevant methods to satisfy national goals and properties. TA can provide the most convenient way of evaluating technologies and this in turn will provide the potential recipient with stronger arguments and facts when bargaining with vendors of technology. TA will consequently serve to remove much vagueness which may be due to superficial notions and place negotiations on much firmer ground and with better mutual comprehension. TA conducted on a regional basis provides some insurance against unscrupulous vendors of technology playing off one host country against another.

PROMOTING PUBLIC PARTICIPATION

The seminar acknowledged that TA does not specify a methodology for public participation. However, participants (including a distinguished philosopher and an anthropologist) stressed that public perceptions and values are an important part of most approaches to TA and knowledge of the public's receptivity to a proposed technology or policy is an obvious requirement. Because final TA reports are generally made available for public review and reaction, the process of public participation can only be enhanced. For many seminar participants this is an important benefit to be derived from the TA process and can lead to the representation in the policy process of those minorities and individuals who are not normally heard unless total impacts are discussed.

ENSURING ACCOUNTABILITY

In the opinion of the Bangalore seminar, the present lack of structured methodology too often forces planners to resort to intuition or superficial economic benefit/cost calculations. But the final report of a TA provides a written record of the policy options avilable to the decision-makers. This can powerfully help to protect the developing countries from decisions serving only narrow interests. Furthermore, by identifying impacts requiring continued monitoring, administrators are provided with a set of goals against which to measure performance.

MULTIPLYING RESOURCES

An important side benefit of the TA process outlined by the seminar is the increased possibility for developing countries to extend the resources available to their policy planners. Given an open TA process analytical resources in both the public and private sectors, albeit from different sectorial interests, can be mutually buttrassing if the TA methodology is understood by all contributors. Disagreements can then centre on facts or value preferences rather than only on conclusions; conflict can be creatively managed and efforts which are presently regarded as exploitative may be rendered constructive. Moreover, by allowing all analytical resources into the assessment, developing countries can conduct joint assessments in areas of mutual interest. Even if done separately, the final report of one nation can greatly expedite the assessment in another.

Naturally, in the light of U.S. experience with institutionalized TA brought to light at the seminar, the participants did outline some qualifications and limitations. Indispensable though TA was thought to be for the progress of the developing world, TA was also recognized by the participants as not holding unlimited promise nor was it regarded as a universal panacea. Nevertheless, seminar participants while being fully cognizant of the new pressures on decision-makers, which TA brings, still strongly endorsed the TA concept. Because the concept increases challenges and the accountability of decision-makers whilst providing potential for wiser development decisions. (5)

CONCLUSION

Technological choices need to be made within the framework of national goals for economic development and social progress. To this end, it is indispensable for a country to establish a capability to forecast the directions that technologies may take in their particular circumstances and to understand as realistically as possible their probable effects. This is a dynamic process and it must be kept current.

Prior to the current perception of technology assessment as a tool of development, technological forecasts and analyses dealt with the need to determine whether a new technology would do what it was designed to do and preferably in a more efficient way than its predecessor technology. This is a practice that prevails in the industrialized countries, although it is not confined to them, since developing countries with a technological capability assess technological innovations and acquisitions by similar standards. Technology often has impacts beyond those directly intended by its designers. Technology assessment, even if in a conceptual framework, should therefore be a deliberate search for the consequences of a given technology to help determine whether the benefits will offset the created costs.

The point of view offered in this paper introduces a measure of doubt that technology assessment can be advanced to a stage where it can perform as a method with specific outputs, given the specific inputs. What is not in doubt is that having become the object of serious study technology assessment is bound to become an important element in the thinking of planners and decision-makers. It must necessarily colour their assumptions in respect to the future with which they are dealing. From this point of view, even if the point of view offered in this paper holds out, it may be said that a new important dimension has been added to the dynamics of planning for development. Moreover, as the thought emerged from the Bangalore seminar, technology assessment can qualify planning by the further condition that if development is to be authentic it must establish as its first goal the elimination of absolute poverty among masses still living in inhuman conditions. If the force of technology holds out any hope for development it should be as a resource to be harnessed to the meeting of the needs of all. And, in assessing that technology, whether systematically or conceptually, it is its impact on the overall human condition which must be the foremost consideration of the applicability of technology assessment to development.

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PART IV

The Planning of Science and Technology in the Development Process

11. Science and Technology Planning in LDCs: Major Policy Issues

MIGUEL S. WIONCZEK

I

There is the increasing evidence that the expansion of the science and technology (S & T) systems+ and the general scientific and technological advancement face many formidable internal obstacles in the more advanced underdeveloped countries such as Argentina, Brazil, Egypt, India or Mexico. In the preparatory stages of the U.N. Conference on Science and Technology for Development (UNCSTD), to be held in August 1979 in Vienna, these obstacles were identified as related to, among others, policies and priorities for science and technology, S & T infrastructure, educational and training systems, availability of entrepreneurs and managerial skills, S & T information systems, technological extension services, etc. Despite increased financial support from the state for science and technology, assistance from international organizations and local and regional S & T planning attempts, all these obstacles persist in such countries. This strongly suggests that the task of building up domestic S & T capacity in LDCs is more difficult and complicated than was earlier assumed in many quarters, both within the United Nations and at national level.

Practically all major LDCs continue to depend to an overwhelming degree on the scientific knowledge and the technical know-how produced in the advanced countries. In most cases domestic R & D activities in the LDCs consist of imitative quasi-research in the pure and applied sciences, with very little progress in technological innovation, and this includes those fields in which relevant and competent indigenous R & D has been badly needed for some time. A major reason for this is that many of the economic and social problems that arise in the context of overall underdevelopment are quite different from those currently facing the high-income countries, whether endowed with market-oriented or centrally-planned economies. Other reasons include the working of the international economy and the socio-cultural characteristics of many LDCs.

Consequently, whatever R & D efforts are made in the LDCs locally, sometimes at considerable financial and social cost, they are often largely wasted due to the absence of permanent links between S & T activities and local educational and productive systems. The weakness of these links leads to an imbalance between the demand for, and the supply of, internally-produced knowledge and technical know-how. Let us look closer at this situation.

First, LDC scientists and technologists only marginally participate in higher education activities, even when the few existing R & D centres are located at the universities. The unsatisfactory conditions of general and, in particular, technical education result in turn in great shortages of the kind of technical staff needed to support R & D. These shortages, together with the bureaucracy of the public sector and the inadequacy of the higher education institutions, further depress the generally low productivity of local small and fragmented scientific and technological communities. Moreover, the absence or the weakness of S & T diffusion mechanisms at all educational levels perpetuates the isolation of S & T from society, and impedes the extension of the scientific and technological culture outside of the small elites directly engaged in research.

Second, the demand of the productive system for technical know-how and innovations is satisfied mainly from abroad, even in the most advanced LDCs. On the one hand productive units, whether private or public and whether national or foreign-owned, clearly prefer foreign-originated technology because its use involves less risks at the enterprise level than experimenting with new locally produced techniques. On the other hand, the productive system assumes that local scientists and technologists are unable to produce useful knowledge or the process and product technology which could progressively supplant S & T imports. Thus, for the entrepreneur, technology imports seem more convenient and profitable than unproved local know-how.

Third, not only are the S & T systems in the LDCs devoid of the quantity and quality of human resources that are needed, but the financial and managerial resources available domestically for R & D continue to be largely inadequate, both in absolute and in relative terms, when the per capita income differences between the LDCs and the developed countries and the LDC needs are considered.

Fourth, the deficient functional distribution of expenditure in R & D by LDCs inhibits the S & T expansion. While up to three-quarters of financial resources, available mainly from the state, is spent as a rule on salaries and wages, funds for both 'hardware' and 'software', indispensable for serious and relevant S & T efforts, are either scarce or misused because scientists and technologists tend to follow the "overequipment" trends fashionable in some advanced countries.

Fifth, while most R & D institutions - whether located at the universities or in the public sector - are critically short of researchers, the institutional proliferation is the order of the day because of the false self-prestige of their directors. Consequently, very few scientists and technologists can dedicate their full time to R & D. Even worse, in the face of the general absence of R & D managerial skills, the best brains are rapidly absorbed in S & T administrative tasks, and readily more into other political or bureaucratic activities.

Sixth, S & T development is highly unbalanced both sectorially and by disciplines which results in a neglect of very important R & D areas. This reflects two facts: first, the S & T centres and the institutional network in the LDCs is the result of haphazard and uncoordinated individual initiatives and, second, most decisions concerning research areas and priorities are taken by the foreign-trained S & T personnel, whose preferences, despite their operative competence, lead them to engage in research which is in vogue in more advanced countries.

Seventh, while in most LDCs the supply of so-called pure researchers is larger, for historical reasons, than that of staff interested in applied research and technological innovation, financial resources for basic research are extremely scarce. Because of lack of interest on the part of the private sector in R & D, there are insufficient funds for applied research and for technological development. These activities are concentrated in only a few sectors of the more advanced LDCs, in which the presence of the state and the public sector as the producer of strategic industrial goods and social services is particularly strong. Thus in Mexico, for example, petroleum and energy, commercial agriculture and medicine and health, were in the past 10 years absorbing about one half of the total financial resources available for S & T. On the other hand, all LDCs - including Mexico - have neglected R & D in the key areas of importance for the balanced and equitable socio-economic development such as subsistence agriculture, non-renewable (except petroleum) and renewable resources, manufacturing of capital goods, transport and communications, urban development and housing, etc.

The expansion of S & T in the LDCs is also hampered by a host of other factors, arising because whatever weak and sporadic attempts are made to allocate more financial and human resources for S & T, these allocations are neither linked with overall socio-economic planning nor supported by a longer term S & T strategy and incorporated into medium-term research programmes. Both the LDC political elites and the scientific communities do not relate, as a rule, S & T activities with the scoio-economic development needs. A further difficulty is that ignorance of this relationship is even greater among domestic entrepreneurial groups.

Contrary to common sense and the experience of advanced countries, science and technology is looked upon in most LDCs as just a "new" sector which, it is thought, should receive more support than in the past merely because of the world-wide technological revolution whose nature and importance are only dimly perceived in the LDCs. This primitive perception of the importance of S & T translates itself into the occasional appearance of S & T "crash programs" which are supposed to close that particular gap between the LDCs and the DCs. While the understanding of the long-term nature of the S & T advancement is badly missing in the LDCs, these programs amount to little more than sending potential researchers abroad for training and/or to small increases in the budgets for existing R & D institutions.

As a rule, however, foreign training is not coordinated with an increased allocation of funds for R & D. Neither are efforts made to integrate these "crash programs" into the overall S & T priorities and objectives. Results are therefore disappointing, particularly to the LDC politicians who want to see rapid scientific and technological results. In their absence, the brief periods of official support for S & T followed by abandonment of crash programs in that field, and by anti-intellectual recriminations against local S & T elites for their alleged betrayal of the country's interests.

Moreover, few prople in the LDCs yet realize that science and technology consists of a broad spectrum of activities which affect all spheres of national life and that, in turn, S & T advancement is affected by all sorts of policies in force. Consequently isolated actions, such as the allocation of funds for improving the quality of those engaged in R & D and the expansion of R & D facilities, may be nullified by non-S & T policies which continue directing the weak domestic demand for knowledge and technical know-how toward external sources.

If this happens, even in those more advanced LDCs where attempts have lately been made at S & T planning, it is because most of their non-S & T policies in force had been designed long before the recent half-hearted recognition of the role of S & T in the LDC socio-economic development had emerged. As no attempts have been made in any LDC to integrate S & T policy with economic and social policies, and given that many traditional, particularly economic, policy instruments have a perverse impact upon the objective of building up an indigenous S & T capacity, the results of the uncoordinated S & T policy actions in the LDCs are highly disappointing. The conflict between science and technology policy and other policies is particularly visible in the field of LDC industrialization, and it can also be discerned in other important sectors such as agriculture, health services and urban development.

II

This brief survey of the major internal obstacles facing the advancement of S & T in the LDCs defines an overall framework for S & T planning, a framework which represents the necessary, but not sufficient, condition to create in the longer term some sort of autonomous domestic scientific and technological capacity:

(a) S & T planning should be incorporated, whenever possible, into general long-term socio-economic planning or in its absence of weakness should reflect a national development strategy;

(b) its main purpose should be to expand the size and to improve the quality of the S & T system so that it may pursue R & D of relevance to domestic socio-economic needs;

(c) its additional major objective must be the establishment of links between domestic production of knowledge and of technological know-how on the one hand, and the economic, productive and political systems on the other;

(d) it must give high priority to the task of diffusing scientific and technological culture throughout the society or, using economic terms, to the objective of creating some degree of preference by local S & T consumers for domestically-produced knowledge and technical know-how;

(e) it must go beyond the sphere of R & D activities, as defined in advanced countries where the S & T infrastructure is strong and diversified, and build up the S & T infrastructure in the broadest sense, consisting not only of human resources (for managerial, R & D and research-support activities) and the network of R & D centres, but also of such R & D support services as diffusion and information gathering mechanisms, recollection and processing of statistics, data computation, engineering and consulting firms, production and maintenance of R & D equipment and instruments, and technical standards;

(f) it must establish some priorities for very broad R & D areas, taking into consideration not only the long-term socio-economic development objectives, but the present and potential availability of human resources; S & T planning will be meaningless if it limits itself to an elaboration of a consolidated list of possible R & D projects which might be undertaken if additional financial resources were available.

(g) it should never be led by the mirage of autarchic production of knowledge and technical know-how, despite the political appeal of such an objective in some LDCs; it should be based on the premise that externally available knowledge and technology can in the medium term, only be supplemented with local R & D production, and that the major role of local R & D is to gradually increase the degree of national self-reliance with respect to the decisions of the application of knowledge and technical know-how, whatever its origin may be;

(h) except when the externally-produced knowledge and technology is unavailable or, albeit available, its application conflicts with the major national socio-economic development objectives, S & T planning must give the highest priority to the building of domestic capacity to absorb and adapt S & T produced externally, as a precondition to indigenous production of knowledge and technical know-how;

(i) because the building up of the indigenous capacity to absorb, to adapt and eventually to produce knowledge and technical know-how can be successful only if accompanied by the emergence of a domestic demand for it, S & T planning must provide for instruments regulating technology imports, instruments that would be applied not only to technology transfer transactions but to industrial property and direct foreign investment as well;

(j) provisions must be made to establish permanent planning mechanisms with the full participation of S & T community and the domestic users of technology, mechanisms that would be able to defend themselves against the dangers of bureaucracy; such mechanisms would periodically review the longer-term strategy of S & T; of designing the framework and the guidelines for the medium-term S & T plans, and of contributing to the task of the elaboration of the R & D programmes for the druation of a S & T plan;

(k) finally, S & T planning must take a distinction between science planning and technology planning, even though it is almost impossible to establish clear limits between scientific and technological activities.

III

The contemporary literature on S & T is full of rather idle speculation about the relationship between science and technology. The little that is known is that this relationship is not linear and that moder S & T systems started, historically, from many different points. In the early XIX century there were countries which excelled in science (France and the tsarist Russia) and those which had relatively little science but a lot of technological progress (Great Britain). There were also countries which lack both (USA) and where S & T started through technological experimentation. 150 years later all these countries are major S & T powers.

It is often maintained in the LDCs that science advancement is a luxury which they do not need, or can hardly afford. Concomitantly voices are also heard in the LDCs to the effect that the only science which should be promoted is that which will result in very rapid technological applications of its findings and discoveries. Both attitudes, which are not only incorrect but socially damaging, originate from pragmatic ignorance. The LDCs need good science <u>together</u> with relevant technical know-how for reasons that go beyond the common sense proposition that good science is helpful to the production of technology. Science has other important functions besides supporting the expansion of technical know-how. The most important function, perhaps, is that of providing a base for a general scientific culture, badly needed for an increased degree of overall rationality in LDC societies faced with the most complicated and pressing social and economic development problems. While scientific attitudes are not expected to substitute for iedologies, the use of ideologies in the absence of control mechanisms provided by science and rationality has led in the past, and will lead in the future, to major political and social disasters.

The LDCs must promote science for other reasons as well. Scientific advancement is an important source of national satisfaction and prestige, offers permanent links to the outside world and provides socially useful occupations to clusters of scientists which, however tiny, represent the kernel of S & T elites in the LDCs. Disregard or abandonment of science by the LDCs would clearly result in the permanent emigration of first class scientists, which would represent a very considerable loss to the society. Such emigration would take place even if an LDC gave the highest priority to technological advancement because the psychological characteristics of researchers, social determinants, and the values involved in the production of knowledge are quite different from those involved in the production of technical know-how. These differences explain why first-class scientists are rarely first-class technologists, and vice versa. Together with the differing nature of scientific and technological endeavors, and functional differences between science and technology, social and psychological aspects of S & T explain why scientific planning offers a different challenge and calls for approaches and methodologies different from those involved in technological planning.

It is sometimes maintained that because of the unpredictability of scientific discovery science does not lend itself to any planning. The statement is true only in cases where planning attempts to impose upon science short-term criteria aimed at "assuring" practical and direct application of scientific progress. Since such criteria for science contradict the very nature of scientific discovery and advancement, the planning of science should not even attempt to elaborate them.

The impossibility of establishing 'pragmatic' criteria for science does not invalidate, however, the need for and possibility of planning for science in the LDCs. Science can be planned and should be planned, first, because of the scarcity of human resources for S & T and, second, because of the infinite choices facing scientific endeavour and speculation. The major objectives of science planning are broadly fourfold; (1) to increase scientific productivity and assure excellence, i.e. to produce good and relevant science at the lowest social cost; (2) to create conditions for an interdisciplinary approach to scientific problems; (3) to advance the frontiers of science in such a way that scientific advancement may assist, directly or indirectly, specific applied research and technological development, neglected by S & T effort in the advanced societies, and (4) to support the national educational system at all levels.

Both S & T planners and scientists in the LDCs must be aware, however, that the presence of the absence of possible linkages between pure research and its subsequent application to other segments of the S & T continuum, or to other ends, cannot be determined _ex ante_ and that, furthermore, the application of science to the solution of non-scientific problems cannot become the sole criterion for scientific support. History abounds in the examples of scientific discoveries that were followed by their non-scientific application only after the delay of many generations. Other great scientific discoveries have never been translated directly into technological progress.

Contrary to some misconceptions, judicious and intelligent science planning does not involve the abdication of scientific freedom by researchers. The task of S & T planners, all of whom must have some experience with the nature of scientific advancement, is limited to defining, in general terms, those wide areas or categories of disciplines in which scientific progress seems more likely than in others, in view of the availability of highly competent human resources and infrastructure on the one hand, and some sort of balance between the accumulated knowledge and the perceived scope of the nature of the unresolved scientific problems on the other. These elements must be carefully weight, again in broad terms, against alternative needs for scientific progress in an underdeveloped society. The complicated process of arriving at general priorities for the support of scientific activities - in the LDCs and elsewhere - should never fall into the trap of absolute rigidity. Neither should it degenerate into unilateral decisions about the social relevance or irrelevance of specific research projects.

While it seems easy to arrive at an abstract conclusion that research in biology may be more relevant for an LDC than the pursuit of astronomy or topology, translation of such "priorities" into either support, or the withdrawal of support, for specific discipoines or, even worse, for specific research projects, clearly courts a disaster. The most S & T planners in the LDCs can expect and hope for is that the combination of human resources available for, and willing to engage in, scientific activities and financial and managerial resources will produce good science, and that the support of science by the state will increase the socialization of scientific elites, i.e., improve their grasp of the social function of science.

The achievement of an increased degree of social consciousness by participants in local science efforts in the LDCs should be considered a great feat by itself. Scientists in the LDCs are more 'asocial' than their counterparts from the advanced societies, not only because they share certain non-social values, and are the product, as anyone else of the faulty LDC educational systems, and victims of the over-specialization which characterizes much modern science, but also because these scientists are often rejected by their own underdeveloped societies.

Armed with broad guidelines for the preferred areas of scientific endeavour, established within a flexible framework, and engaged in consistent long-term support for a scientific infrastructure, and in sustained efforts to diffuse science and a scientific culture, the S & T planners in the LDCs can expect positive responses from local scientific communities. Good scientists anywhere are clearly able to distinguish between outside interference with scientific freedom, in the name of real or ill-conceived social needs, and the genuine support of science, viewed as an important segment of the S & T continuum as related to development.

While science planning cannot be left to scientific communities alone, neither can it be done without their direct participation; planning and programming of research programmes and projects must be left to the responsibility of scientists and their institutions. The role of the overall S & T planners as advisers at these levels is still considerable. First, they can help in designing longer-term research programmes. Second, they can act as innovators in the institutional field. Their third task would be to devise and implement long-term science support mechanisms, both with respect to the supply of the research 'hardwarep and 'software', and to propose measures that would make the daily operation of scientific institutes and individual researchers more secure, financially and otherwise. The reasonable working of such mechanisms and measures does not depend on the provision of funds alone, but also on the elimination or alleviation of manifold bureaucratic obstacles present in abundance in any underdeveloped society and also due, in the case of science activities, to general ignorance about the importance of S & T vis-a-vis other activities.

In brief, science in the LDCs should be underplanned rather than overplanned. Furthermore, the planning should be directed to the other fringes of the scientific endeavour and to its infrastructure and not to the substance of scientific research itself. Clearly, planners should avoid falling into the other extreme of catering indiscriminately to those segments of LDC scientific communities which just demand more money from the state, but are unwilling to accept any social compromise, claiming to be citizens of the alleged 'free republic of science'.

IV

Planning of applied research and technological development in the LDC is another story. It just cannot be done without entering into the substantive problems of applied research and technological development. This exercise, in turn, is practically impossible in the absence of a detailed diagnosis of the "state of art" in respect to the technical know-how available from different sources, foreign and local; of the degree, if any, of the indigenous technological innovation; of the channels for technology transmission and of policy instruments of all sorts which affect, in any important degree, imports and the local production of technical know-how as well as the global and sectoral demand for technology. Even when all such information is collected and analyzed, planners will still be unable to establish criteria and fix priorities for technology imports, their local adaptation and the production of technical know-how, unless they can related these criteria and priorities to a longer-run socio-economic development strategy. In other words, unless national policy-makers at the highest level have a clear idea about what kind of society they want to construct, no coherent technological policy is possible. In the absence of the national development strategy the future shape of the society will be decided by technology imported largely on grounds of its private profitability.

Ideally, technological plakning in the LDCs should be incorporated into overall socio-economic long-term planning. In most LDCs, however, formal socio-economic planning more resembles science-fiction, or ritual rhetorics than a real national exercise. In such a case, relating technology planning to what some social and political writers call a "national project" of the future society may represent the second-best but realistic solution because it will perhaps be the only way to permit a first approximation of the overall long-term technological needs of that society.

The next task of the planners would be to define and delineate those economic and social sectors whose different functional characteristics decide the specific technologies needed. In the case of S & T planning in Mexico, for example, long debates in the mid-1970s involved public policy makers and the private sector producers and users of the technical know-how, and leading educators. The decision arrived at by negotiation was originally that there was a need to make distinctions among technological policies and priorities for: agriculture and forestry, fisheries, manufacturing industry, mining, energy, transport and communication, urban development (including the construction industry and housing), medicine and health, and education. This division of technology by sectors was found later to be in need of refinement because, first, it did not take into account certain strategic economic activities that could only fall into the category of a sector with difficulty; second, it overlooked the important intrasector differences present in some sectors; and, third, it forgot some 'sectors' which were not productive in the limited economic or social sense. Consequently, the list of technological sectors was amplified by (a) adding food production which covers the whole range of activities from agriculture to distribution of processed foodstuffs; (b) subdividing the manufacturing activities into consumer non-durables, intermediate goods and consumer durables, considered jointly with capital goods; (c) subdividing agriculture into commercial and subsistence agriculture, and (d) establishing a new broad category of activities for which there is a need for both applied research as well as the technical know-how to take care of such problems as ecology, renewable resources and natural phenomena.

The elaboration of a similar "technological map" of the economy and the society is a prerequisite for the following planning stage that using the systems analysis approach involves the sectoral diagnosis of the technological demand and the sources of supply. Such an exercise, for which the best national experts, including scientists, must be mobilized, implies the availability of a considerable body of knowledge on the general state and direction of the world-wide technological advancement in individual sectors or subsectors, and the collection of detailed information about technical imports (also by sectors), and about the sectoral 'state of art' in local R & D. As no single national public agency, and no single local R & D institution has the information needed at that planning stage, it can be successful only with the broadest participation by national experts in each field, preferably on an individual basis.

This stage of technological planning also involves establishing a permanent S & T statistical office able to process detailed information about the national S & T system in terms of its institutional structure, human resources, and R & D programmes and projects that are underway or planned. Such a statistical S & T office must work in close cooperation with the national agencies that regulate technology imports, industrial property (patents and trademarks) policy, and control direct foreign investment, the latter a major channel for transmission of foreign-originated technical know-how.

The following stage corresponds to the translation of the sectoral diagnosis of the supply and demand of technology into general R & D guidelines, for a periof of at least 10 years, to be revised periodically in the light of technological advancements both within and without the country, and in the light of possible changes or adjustments of domestic socio-economic policies. The elaboration of such guidelines would involve the full presence of representativies of all major local R & D institutes, and of major technology consumers in both the public and private sectors. Eventually, the ensuing substantive guidelines - which cannot be considered, however, iron-clad priorities - will indicate the possible R & D areas of broad subjects. Such guidelines will have to be treated flexibly and with the understanding that the reasons for the exclusion of some areas or subjects from such sectoral lists are threefold: either these R & D areas can be taken care of by technology imports, or they are not highly relevant to the economy and the society in question, or no human resources are available domestically for their meaningful pursuit. The broad scope of substantive guidelines, which must be indicative and not mandatory, offers a great advantage for the planning implementation stage: it will permit R & D institutes to work out programmes and projects tailored to both their human resources endowment and their financial and managerial possibilities. It will also permit them to adopt some general criteria with respect to the training of new researchers, and the creation of an institutional infrastructure for the more distant future. It is at this point when the possibilities of international S & T cooperation should be explored in detail.

V

The final task of S & T planners, common to both science and technology, is that of estimating the domestic S & T system capacity to absorb additional financial resources in the light of (a) the possible supply of new human resources and (b) the expenditure planned for the expansion of S & T physical and institutional infrastructure. Such exercise, which will make the use of all information - both quantitative and qualitative - collected during the process of planning, belong to the planners themselves. This exercise, which will make it possible to set long-term financial targets for S & T support, must be done simultaneously from two ends: it must consider at the same time the potential availability of total financial resources for S & T, and also the probable costs of (a) maintaining the existing S & T system, (b) training and employing new S & T personnel, and (c) improving and expanding the S & T infrastructure over the planning period. Attempts to set the broad overall national targets for S & T expenditures - in terms of the proportion of the GNP or the per capita income - that do not consider the S & T system's financial and human resources absorption capacity are useless.

At this point the S & T planning, in a formal sense, will be accomplished. It will clearly be of little use however unless it is followed by an implementation stage, whose description and analysis lies beyond the scope of this brief paper. It is worth mentioning, however, that the implementation cannot be limited to the mere elaboration of a sequence of S & T sectoral and institutional research programmes and projects for the duration of the plan. It will have to involve many very important political and substantive decisions concerning such issues as the shape, and the power, of the permanent S & T plan implementation agency, and its position within the executive branch; legal and institutional changes needed to eliminate possible conflicts between the S & T policy instruments and non-S & T policies, and concrete measures aimed at expanding and strengthening S & T infrastructure. The scope and the importance of the implementation of the S & T planning strongly suggest that institutional arrangements originally created for planning purposes should not be dismantled after the elaboration of a plan. These arrangements will have to be redesigned, however, in the light of the experiences acquired during the planning process.

Considering the increasing global interest in S & T planning and advancement in the LDCs, it is suggested that the relationship between science planning and technology planning be studied further at international and national levels after the UNCSTD. It seems advisable to mention that such studies should abstain from advocating _ex-ante_ the divorce of scientific planning from technology planning in the LDCs. Whereas the current division of labour in international agencies would make such a proposal attractive on the grounds that science and technology deal with "different things", such a divorce, if implemented, would be very harmful for the LDCs. What is needed is the global recognition that while, for example, the UNESCO approach to S & T problems, putting most of the stress on science _cum_ culture, is not correct, neither would it be correct to put all the bets on the LDC technological advancement and foreg their science.

Footnotes

+ Defined as the total of scientific, technological and industrial development research centres and the tangible and intangible scientific and technological infrastructure.

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12. Notes on Science, Technology and Development Planning

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INTRODUCTION

These notes present an overview of current science and technology (S & T) planning and its relation with development planning, a brief survey of some changes in the conceptualization of the relations between science, technology and development, and an exploration of possible new directions for S & T planning in the light of these conceptual changes.

The first part of the paper draws extensively on the work of the Science and Technology Policy Instruments (STPI) project, in which S & T planning was paid particular attention. (1) However, most of the work of the STPI project was carried out during the early 1970s, and this prompted a critical examination of findings in the light of some recent ideas on the relation between science, technology and development. The second part of the paper therefore draws on some hypothesis that have evolved during the last three years, as part of a larger research effort in which I am involved, while the third contains only tentative suggestions and appreciations that need further development.

A REVIEW OF THE STATE OF THE ART IN S & T PLANNING

The context of science and technology planning

In the broadest sense, planning is anticipatory decision making. The anticipatory decisions that constitute the planning process are concerned with the generation, identification and evaluation of alternatives. Policy making can be distinguished from planning because it involves establishing the criteria for generating, identifying and choosing among these alternatives. A planning methodology refers to the procedures followed in arriving at the commitments made in advance by the planners, and to the way in which they are translated into decisions. A plan consists of statements spelling out the anticipatory decisions taken, their interrelations and the criteria employed in making them.

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

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

When development planning in general is not given great importance by the government, it is obvious that science and technology planning will be paid little attention. This may be either because planning is marginal to the socio-economic life of the country or because the planning establishment - when it commands attention and power - may not be inclined to consider S & T as a significant component of development planning. But even when S & T are considered important, they usually are not awarded the same priority as other social and economic activities. This may lead to few resources being allocated to science and technology when budgets are negotiated, particularly in times of economic crisis.

S & T planning requires the active participation of the scientific and technological communit, and this usually takes place under the stimulus of vague political commitments at the highest levels of government. However, when other pressing issues take precedence over science and technology, the scientific and technological community becomes disenchanted with the S & T planners, whom they see as failing to deliver their promises. This may in the future jeopardize the chances of engaging in a meaningful participatory process of plannint S & T. Furthermore, there is often a diversity of opinion between the scientists of the "establishment" who obtain resources and funds through their influence on particular ministries, government agencies, foundations or foreign organizations, and who frequently resist planning efforts, and the younger scientists and engineers who see planning as a way of redistributing resources and developing the S & T system in a more organized fashion with links to development objectives.

These remarks are intended to place S & T planning within the constraints it operates in most underdeveloped countries so that the discussions that follow will not be interpreted as giving S & T planning more importance than it really has. In the final analysis only the political will of government, if and when it can influence the behaviour of the socio-economic system, can give S & T planning its rightful place. The test for this is whether, in the face of resource constraints and adverse political pressures, S & T planners are given enough political support and resources to manoeuvre the development of S & T along directions that may contribute effectively to development.

Economic planning and S & T planning

It is necessary to establish a difference between planning scientific and technological activities and the integration of technology considerations into economic development planning. There is a body of what can be called "scientific and technological activities", comprising basic research, adaptive research, development, engineering design, support activities such as information systems and special training courses, and so on. The anticipatory decisions involved in S & T planning are directed at these. Broadly speaking they refer to the generation, importation, diffusion and absorption of technical knowledge.

Economic planning aims at orienting and regulating the activities of the productive system and the services related to it. From a particular structure of productive activities postulated by economic planners it is possible to derive its technological implications and from these examine the types of scientific and technological activity needed. The insertion of technological considerations in economic development planning involves both the explicit introduction of the technology issue at all phases of the planning process and the identification of implicit technology policies derived from the economic plans. These explicit and implicit aspects of technology in development planning shape, to the extent that plans are implemented, the patterns of demand for technology.

Assuming that planning is taken seriously by the government it will not suffice to devote attention to S & T planning alone, for doing so would miss the essential component of the pattern of demand for S & T activities. Whether economic planning aims at defining the types of activity in which the State will be involved (through direct financing, allocation of credit, activities of State enterprises, etc.) or at regulating the activities of non-government sectors (primarily private industry), the resultant effect would be the adoption of an economic strategy which includes a technological strategy and defines technology needs.

The first task is to spell out the technological implications of the plan, pointing out the types of technology required (for example, to satisfy growth and employment targets), the constraints imposed by the projects selected, the technologies required to exploit natural resources, the technical demands imposed by export targets, and so on. A second stage would aim at explicitly introducing technology as a strategic variable (in the same way as other multidimensional variables, such as employment and financing) in the formulation and implementation of economic plans.

As an illustrative example table 1 lists the types of technological consideration that could be introduced, taking the usual categories of long, medium and short-term planning, as well as the level of plans (global, sectorial, project). Another dimension that could be introduced is the regional, which would add spatial considerations to the issues being taken into account. The link between S & T planning and the incorporation of technology into economic planning takes place through several mechanisms, as can be easily seen from the table. Each of the cells can

TABLE 1

Technological Implications Derived from Economic Development Plans

Level	Term: Long	Term: Medium	Term: Short
Global	Formulation of technological "styles" closely linked to development styles and consumption patterns	Identification of general strategy, of priorities for the development of skills and capabilities, and of overall targets for resource allocation	Definition of total budget for S and T and project portfolio
Sectorial	Identification of the requirements to build-up domestic capabilities in priority sectors	Definition of sectorial strategies and identification of programs for S & T activities	Definition of projects, activities and budgets linked to sectorial strategies
Project	Assessment of the impact of investment projects and identification of technological constraints introduced (particularly for "heavy" projects)	Disaggregation of the technology package and identification of components to be supplied locally	Identification of firms and institutions to perform project-related activities (engineering design, adaptation, construction)

NOTE: The regional dimension would introduce variations due to specific environmental conditions be associated with a group of scientific and technological activities and hence will affect the process of scientific and technological planning.

The content of S & T planning

S & T planning has been frequently confused with research planning. There has been a tendency to leave aside scientific and technological activities other than research when discussing S & T planning. Yet research may not be the most important component of the S & T plan, particularly in underdeveloped countries. Assuming that the planning process identifies those scientific and technological activities which should be supported with priority in order to link S & T development objectives, it is possible to identify activities related to the importation and absorption of technology (identification and evaluation of technological alternatives, regulation of the technology import process, engineering design, technology adaptation, experimentation in plants, etc.), to support services (documentation centres, information and extension, education and training programmes, etc.), and to the promotion of the demand for indigenous technology (use of incentives, of industrial credit, etc.), that should be awarded equal or more importance than research.

There are many ways of defining and classifying scientific and technological activities. One which appears to be fruitful because it spans both S & T planning and the incorporation of technology into development planning, is to divide them into activities related to the promotion of demand for indigenous technology, to the absorption of technology, to the regulation of imported technology, to the production of technology, and to the supporting services, (primarily information and training). (2) Given that these categories are primarily linked to technology, a sixth category comprising basic and curiosity-oriented research should be added. Within each category further subdivisions can be introduced (by problem area, discipline, sector, type of activity, and so on), giving rise to the overall spectrum of scientific and technological activities to be considered in the planning process.

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

However, this is by no means a universally shared view. For example, at a meeting organized in Colombia in 1975 as part of the STPI project, at which S & T planners and policy makers from more than 10 developing countries were present, several participants felt that it would not be a good strategy to separate science policy and planning from technology policy and planning. In their view this would tend to leave science isolated, without worrying about its possible usefulness, and would also break the "innovation chain". There argument was that since moder technology involves the application of science, and there is a close interaction between these two sets of activity, it is not possible to distinguish clearly between them and they should be treated together. My own view is that this is only the case in the highly industrialized countries and in some special sectors in a few Third World countries, and that there is no point in assuming that they are the general rule at present. Of course, one of the aims of S & T planning of an endogenous S & T base (see below), but S & T planning should begin with a realistic assessment of the current situation for most Third World countries.

The anticipatory decisions contained in S & T plans have been usually referred to the definition of scientific and technological activities and the allocation of resources. The concept that a plan is a collection of projects has prevailed in most S & T planning exercises, and this has led to a neglect of other issues involved in relating S & T to development objectives. The most important among these are the anticipatory decisions regarding the institutional structure for the performance of scientific and technological activities, the patterns of interaction with the economic and educational systems, and the definition of a desired image or style for the development of S & T planning should be expanded to incorporate considerations of this type. (3)

The organization of the S & T planning effort

The process of arriving at the anticipatory decisions that constitute S & T planning imposes certain organizational requirements. Because of their participatory nature most of these exercises have adopted the same structure, consisting of a coordinating group with an executive secretariat, assisted by a number of technical

Table 2 Differences between science and technology policies at the national level

	Science policy	Technology policy
Objectives	To generate scientific (basic and potentially useful) knowledge which may eventually feed into social and economic uses, and which will allow understanding and keeping up with the evolution of science	To acquire the technology and the technical capabilities for the production of goods and the provision of services
	To develop a base of scientific activities and of human resources linked to the growth of knowledge at the world level	To develop the national capacity for autonomous decision making in matters of technology
Main types of activity covered	Basic and applied research, which generate basic knowledge and potentially useful knowledge	Development, adaptation, reverse engineering, technology transfer, and engineering, which generate ready-to-use knowledge
Appropriation of the results of activities covered	Results (in the form of basic and potentially useful knowledge) are appropriated by disseminating them widely. Publishing ensures ownership	Results (in the form of ready-to-use knowledge) remain largely in the hands of those who generated them. Patents, secret know-how, and human-embodied knowledge ensure the appropriation of results
Reference criteria for the performance of activities	Primarily internal to the scientific community. The evaluation of activities is based mainly on scientific merit, and in a few cases on possible applications	Primarily external to the technical and engineering community. Evaluation of activities is based mainly on their contribution to social and economic objectives
Scope of activities	Universal, activities and results have worldwide validity	Localized (firm, branch, sector or national level). Activities and results have validity in a specific context
Amenability to planning	Only broad areas and directives can be programmed. Results depend on the capacity of researchers (teams and individuals) to generate new ideas. Large uncertainties are associated	Activities and sequences can be programmed more strictly. Little new knowledge is generally required, and the systematic use of existing knowledge is involved. Less uncertainty is associated
Dominant time horizon	Long and medium term	Short and medium term

committees. These committees are usually integrated by researchers, staff members of the S & T planning agency, and in some cases by engineers and users of the results of S & T activities. They may be "vertical", dealing with a particular sector, problem area, or discipline, or "horizontal", cutting across these divisions and dealing with issues such as human resources, information, and policy instruments. *

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

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

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

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

The committees may be given a high degree of autonomy to define strategies, priorities, resource allocation and even specific projects from the beginning, limiting the role of the central group to one of assembling their proposals. When such a broad mandate is given to the committees it is almost certain that the S & T plan will derive in a collection of projects defined after hard bargaining among committee members. Another approach would give the committees, under strong central guidance, the task of defining first a strategy for the sector, problem area, or discipline of their competence, outlining areas of concentration and general priorities. After a first revision and integration of committee programmes, the coordinating group may ask the committees to revise their programmes within a framework of maximum and minimum level of resource availabilities. At this stage the committees may be asked to outline specific research projects to be contracted out or the scientific and technological community may be invited to present projects in accordance with the programme.

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

Comprehensiveness of the S & T planning approach

Closely linked to the organization of the S & T planning effort is the issue of whether S & T planning should be comprehensive, i.e., the attempt at an overall coverage, or whether it should be confined to a selected range of "leading sectors" which will pull along with them the rest of the S & T activities.

Experience favours the adoption of a comprehensive approach, primarily because one of the reasons for S & T planning is precisely the need to achieve an overall view. Specific government agencies usually do not have all the relevant information about their sectors, and in certain cases one sector is covered by several ministries. S & T planning should cut across different institutions, tie things together and establish programmes that are carried out jointly by several administrative jurisdictions. The administrative structure of government is not divided into areas that adequately match the areas of S & T planning.

However, because of practical considerations, efforts may be focused at the initial stages of the planning process on certain problem ares or sectors, though eventually comprehensive planning becomes necessary. Examples of planning for specific sectors and problem areas are given by the "Indicative Programs" of Mexico, the "Special Programs" of Colombia, and the "National Programs" of Argentina. These are organized by the respective S & T policy making bodies, which undertake promotion, provide financing, bring people together to define activities and formulate work programmes, etc., in areas such as food, health, housing, marine resources, electronics, and so on. The concerted attack on bilharziasis in Egypt provides an interesting example of the need to plan S & T activities in a problem area. This is not just a medical problem, to be handled exclusively within the medical disciplines or the health sector, but also a rather complex social problem which affects one third of the population, and has many different facets that must be tackled in a coordinated way.

The question of discipline-based S & T planning has also been frequently raised and it is apparent that only a small part of the S & T activities should be programmed in this way, for doing so may introduce an academic bias. A planner has to deal with problems and not with disciplines, and disciplinary committees tend to become fund-raising lobbies. Nevertheless, this should not prevent the allocation of a certain proportion of the available resources to non-oriented research in basic sciences, according to various disciplines.

The limits of S & T planning methods

There exists a relatively large number of formal methods and procedures divised to help the S & T planners in the definition of priorities and the allocation of resources, particularly for researcb activities. Most of them have been used in demonstrative exercises, and only a handful have been applied in real situations. (4)

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

However, it has also been suggested that a serious weakness in S & T planning is the dearth of practical and useful analytical tools or planning models for resource allocation, such as those employed in economic development planning. Until they are available, it is argued, S & T planners will have to rely primarily on informed judgment and on the political support for such judgments. The question would then be whether efforts should be devoted to develop analytical models to help in the formulation of S & T plans, to help S & T planners in legitimizing their work and to discuss with the economic planners on terms the latter will accept.

In think that it may be unwise to spend too much effort in this direction. S & T planning is much more complex than economic planning, a statement to which even economic planners will subscribe. In any case, it is false to regard all economic planning techniques as valid, being mostly founded on shaky theoretical grounds and many simplifying assumptions, and often being employed to legitimize decisions already taken, rather than as real decision-making tools. The nature of the product in S & T is rather different: knowledge cannot be added to knowledge in a similar way as economic quantities are, and it is not possible to express the "value of knowledge" in monetary terms. There is also the danger of developing quantitative techniques and using them whilst ignoring their strong and inherent limitations. Finally, there is an opportunity cost involved here since the developing countries have few good economists with knowledge of S & T issues, and they may be put to work on more promising tasks than the development of formal quantitative methods.

In addition to the shortcomings inherent in the planning methods, S & T planners often compound the problem by expecting too much from methodologies. This gives rise to a technocratic dream in which the S & T planners could plug data into a model in order to define priorities, resource levels, and projects. In practice this never happens.

There are a few heuristic rules which may provide some guidance for the identification of priorities. The first is to diversify as much as possible the sources of priorities, examining initiatives from the scientific and technological community, problem areas posed by the users, government policies contained in tha plan, invarient problems which will remain important for long periods, areas arising out of short-term social or economic problems, and so on. Priorities for scientific and technological activities would be determined through an interplay of various forces rather than through the expression of the planners' views and biases.

The second heuristic rule is to avoid treating the development plan as the primary source of priorities for science and technology. There is no automatic relation between economic development priorities and S & T priorities. Their time horizons are different, and giving too much importance to the development plan may lead to ignoring key contributions that S & T can make to development. In effect, there are probably many projects that are not included in the development plan precisely because the scientific and technical knowledge to perform them is not available. If priorities for S & T are extracted from the plan alone, then the necessary knowledge may never be developed.

Determining the appropriate level of resource allocation for a sector, problem area, or discipline has been a perennial problem of S & T planners. In the case of existing activities, actual allocations are bounded at the upper level by the absorption capacity of the S & T system, and at the lower level by the minimum necessary to continue the programmes. In the case of new activities, the limits are difficult to establish, although they can be related to the possibility of assembling a team of scientists and professionals that may absorb the resources without undue waste.

Remarks on the state of the art in S & T planning

S & T planning in developing countries is a young field in rapid evolution. Experience is not too abundant. Conceptual and theoretical approaches are still piecemeal and tentative, and refer to a complex subject matter that does not easily allow for wide generalizations or the use of formalized analytical models. This is not surprising if we consider that, though many significant statements may be made about the relations between science, technology and society in the Third World countries, they are yet to be woven into a solid conceptual structure. We still have much to learn about managing S & T as a factor in the development process, and, about planning the expansion and use of S & T capabilities. As a result, there is no coherent body of knowledge and practice that could be identified with the label "S & T planning". On the contrary, there is a wide diversity of approaches, points of view, experiences, conceptual frameworks, and methodologies which are far from constituting a "paradigm".

A rather obvious, but nevertheless important, observation is that the nature of its process will vary according to the stage of development of the country under consideration. For those countries that have already established an infrastructure of S & T institutions, resources and activities, the problem is mainly that of reorienting and using effectively their existing capacity. Where that capacity does not exist, the planning process acquires a rather different character and should emphasize the formation of human resources, the establishment and development of institutions, the acquisition of physical facilities, the expansion of higher education, and the creation of policy mechanisms to promote science and technology. When a country is at a very early stage of development, and science and technology activities are incipient, S & T needs are likely to be so obvious that there would be no need for a complex S & T planning exercise: priorities for S & T activities and for the allocation of resources could be derived rather easily using common sense. The size of the country also influences the nature of the planning process, as countries with a small economic infrastructure and with a limited endowment of qualified human resources may well be below the minimum critical level required to develop a viable S & T system. In this case elaborate S & T planning exercises would not make sense, unless cooperative arrangements with similar countries take place.

Therefore, even though we may consider the Third World countries as a whole in our discussions of S & T planning, it is clear that there are many differences among them, and that for the smaller and least developed countries the S & T planning exercise would mainly involve a series of qualitative judgments by a few knowledgeable people and practically no "mechanism" or "methodology" would be required. For the middle size countries, in which there is already the beginning of a viable S & T infrastructure, S & T planning efforts could have an important impact, although given the relative small size of the scientific and technological community, it may be more appropriate to engage in sectorial, problem area, or partial planning exercises, rather than attempting to develop a comprehensive S & T planning approach. Once again, if an international cooperation dimension is introduced into the picture, the situation may change significantly and the scope for engaging in a fruitful S & T planning exercise would be considerably enlarged.

There are also the relatively large Third World countries which have the necessary base of material, financial and human resources, and which already possess a well developed S & T infrastructure. It is appropriate to quote here the remarks of M. Roche on the types of country where S & T are most likely to develop, for these would be the countries where S & T planning activities would be of greatest importance:

> ...science and its related technology, stand their best chance of flourishing, at least quantitatively, in a young, underdeveloped country, rich, not not too rich, that has decided to devote considerable resources to scientific activities; it must have a very tolerant religion, or no religion at all; at the same time, it must respect science for its own sake and be desirous of gathering the good things of this world made available by science and technology; it must have an independent industry, including a war industry; it must be under the influence of an education that stresses a critical attitude, independence and creativity; it must be economically independent, and have a large market for its products (p. 83). (5)

These conditions exist in few Third World countries, and only in these is S & T planning likely to play a major role and become a well established activity. Furthermore, even though S & T planning may evolve independently from economic development planning, the existence of a "planning tradition" in the country may make it easier for S & T planning efforts to acquire legitimacy. However, we must be cautious that the existence of a well entrenched economic planning techno-bureaucracy may well be an obstacle for the acceptance of S & T planning since economic planners may resist the attempts to introduce technological considerations into the development planning process.

Thus the state of the art in S & T planning can be summarized as follows: First, formal analytical methods have advanced beyond the actual practice, even though they still lack the coherence and soundness that derives from a well established theoretical and conceptual framework, and from the contrast of advances in formal methods with practice. Second, there are several examples of planning the development of scientific and technological activities, and the similarity of structures and approaches employed for this purpose suggest that it may be possible in the near future to develop generally acceptable procedures for this aspect of the S & T planning process. Third, there are just a handful of cases in which S & T considerations have been integrated successfully into the economic development planning process and this is an area that requires further research and exploration. Finally, the lack of a well organized conceptual and theoretical framework that would link science, technology and the development process constitutes an obstacle that will have to be surmounted before achieving a more satisfactory treatment of S & T issues in the development planning process.

TOWARDS A CONCEPTUAL FRAMEWORK TO LINK SCIENCE, TECHNOLOGY AND DEVELOPMENT

A technological reinterpretation of underdevelopment

The concepts of development and underdevelopment have not remained static. As new knowledge about the complex interrelations between social, economic and political factors emerged, it has become necessary to reinterpret the meaning of these two concepts. Considering the importance that modern science and technology have acquired, it is appropriate to advance a scientific and technological interpretation of the phenomena of development and underdevelopment so as to highlight the close interactions between science and technology and the design of development strategies.

The relations between technological progress and the emergence of underdevelopment as a historical phenomenon have been characterized by Furtado in the following way:

> As a consequence of the rapid spread of new production methods from a small number of centres radiating technological innovations, there has come into existence a process tending to create a worldwide economic system. It is thus that underdevelopment is considered a creature of development, or rather, as a consequence of the impact of the technical processes and the international division of labour commanded by the small number of countries that espoused the Industrial Revolution in the 19th century. The resulting relations between these societies and the underdeveloped areas involve forms of dependence that can hardly be overcome. The dependence was initially based on an international division of labour in which the dominant centres reserved for themselves the economic activities that concentrated technical progress. In the following phase, the dependence was maintained by controlling the assimilation of new technological processes through the installation of productive activities within the dependent economies, all under the control of groups integrated into the cominant economies. (6)

Following a similar line of thought, it is possible to distinguish between two types of country: those where the evolution of scientific activities led directly to or was clearly linked with advances in production techniques; and those in which the knowledge-generating activity was not related in any significant way to productive activities. We shall refer to the first as countries with an endogenous scientific and technological base, and to the second as countries with an exogenous scientific and technological base. This division corresponds to that established between industrialized or developed countries, and Third World or underdeveloped countries respectively (see figure 1).

Whether as a result of an internal cumulative process (Western Europe), or of a transplant that grew its own roots (United States, Japan), in the developed countries the systematic generation of knowledge and the production of goods and services were linked through the development of technologies related to scientific findings. The emergence of an endogenous scientific and technomogical base in the West was the result of the evolution of the ideas that led to science, the successive transformation of productive techniques, and the merging of these two currents.

From the scientific revolution during the 17th century emerged the idea that the universe was predictable and obeyed certain laws that could be tested, which radically changes man's conception of the world, giving sense to the Baconian statement that nature can be mastered through understanding. There was a parallel evolution of crafts practised by artisans which were gradually transformed into manufacturing activities and later into industrial activities. This took place concurrently with a shift from a "polytechnic" era of varied local technological responses towards a "monotechnic" era in which the variety of responses was reduced and a few specific production techniques predominated in each field of activity.

The merger of both currents - the evolution of thinking and the transformation of productive techniques - constitute what is known as the scientific and technological revolution. This was a complex process of interaction between science and production that took place among considerable social upheavals, and concurrently with the emergence of capitalism as the dominant mode of production. At the same time, Latin America, Asia, the Middle East and Africa became incorporated into an international division of labour as colonies, thus helping to sustain the industrial revolution through the supply of cheap raw materials and the provision of markets.

As a consequence of these historical processes, Third World countries did not establish a basis of productive technologies linked to scientific findings of their own. There was no link between the development of activities devoted to the generation of knowledge and the evolution of productive techniques.

The diffusion of Western science to countries with an exogenous scientific and technological base was an irregular process entailing a partial acceptance of results but without full awareness of the cumulative process that originated them. Science in these countries was an activity limited to a few isolated pioneers whose efforts were inherently out of phase in time, since the frontiers of knowledge were being explored in other parts of the world. As a consequence, the pursuit of science did not grow roots in the majority of these countries until the first decades of the 20th century, and even then it acquired a fragmentary and imitative character divorced from the productive sphere.

The nature of modern productive activities was conditioned first by the interests of the colonial powers and then, after some regions became independent (particularly Latin America), by the way in which their economies were incorporated into the international division of labour that accompanied the expansion of the capitalist system. This meant that they were oriented primarily towards the extraction of natural resources and to the generation of surpluses for transfer abroad.

The implanted or modern productive activities used imported technologies that brought with them skill requirements, use of materials, organizational habits and technical traditions that were alien to the local environment. Furthermore, the technological capabilities associated with modern production were expanded primarily through new technology imports, which meant that the technological traditions - developed slowly and cumulatively over a long time - were left aside and even eliminated. This led to a reduction in the variety of indigenous technological responses.

These three components - scientific activities, technological capacities associated with modern production and the traditional technological capabilities - have had very little interaction in the countries with an exogenous S & T base. The evolution (involution in the case of traditional technologies) of these currents has taken place in isolation: the marriage between science and production did not take place in the Third World.

From this perspective, one of the key problems in the design and implementation of development strategy consists in relating the conduct of scientific activities with the evolution of the technologies associated to modern production and with the

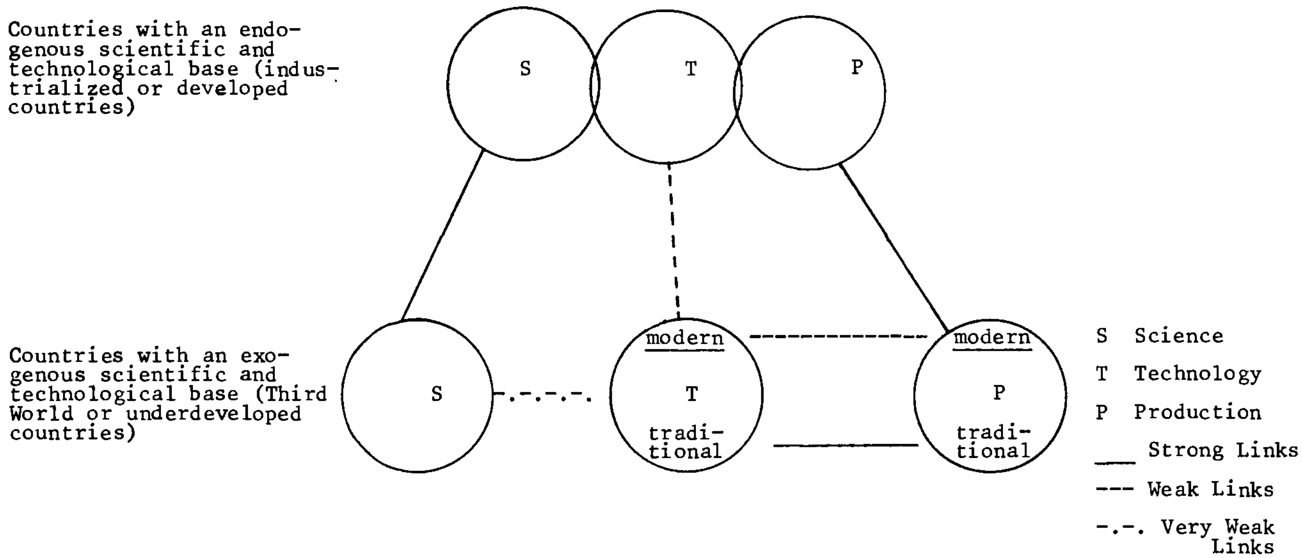

Figure 1

Relations between science, technology and production in development and underdeveloped countries systematic and selective recovery of the traditional technological base. These three components must be combined around problem areas of critical importance to the country's development, leading to a gradual replacement of the exogenous technological base.

However, that the growth of endogenous S & T capabilities is necessary for development does not imply that there is just one and only one route - that of the Western industrialized nations - to be followed in the acquisition and use of S & T capabilities. Considering that science and technology evole in particular social environments, it is possible to design and pursue alternative paths for the development of S & T just as it is possible to follow alternative development strategies in general.

Towards endogenous S & T development

From the preceding discussion we can identify three groups of action necessary for the development of endogenous scientific and technological capabilities: the expansion and reorientation of the S & T system, the selective and systematic recovery of the traditional technological base and the transformation of the productive system.

First, it is clear that without science there cannot be science-related technologies. Even though it is generally recognized that there is little connection between the scientific community in Third World countries and the problems of development, increased support should be given to scientific activities that are related in some way or other to the development prospects of the country rather than curtailing basic research. Priorities for science should be derived from the resource endowment of the country, the range of technological activities that require basic science support, the requirements of traditional technologies that could be improved through scientific inputs, and from the need to keep up with the world scientific frontiers in areas of particular interest to the developing country (such as the development of synthetic materials that may complete with local natural products).

Second, it is necessary to recover selectively the traditional technological base, which in most developing countries has remained dormant for decades and even centuries. Traditional productive activities and technologies still have great social and economic importance in the majority of the less developed countries. They are an integral part of their cultural heritage and will continue playing a significant role for many years to come. The recovery of the traditional technological base involves linking moder science with traditional technologies to upgrade them selectively through the systematic application of the scientific method and through the integration of products of science-related technology with those of traditional activities.

The contribution of traditional productive and social systems can go beyond specific technical aspects and help in identifying, preserving and affirming a nation's cultural and social identity. For example, the pre-Hispanic Andean civilizations maintained an egalitarian tradition, shared broad and diverse economic and ecological spaces - through what has been called the "vertical control of a maximum of ecological levels" - and evolved a complex political and social structure than enabled the region's resources to be used appropriately and ensured the survival of all the population. These traditional ways of relating to the Andean environment and of using a spectrum of available technologies suitable for a wide variety of local ecological conditions was practically abolished during the Spanish conquest. Nevertheless, some traces still remain and could be recovered, linked to scientific activities and incorporated within the framework of alternative development strategies.

The selective recovery and upgrading of the traditional technological base could encompass a wide variety of social and economic activities, although agriculture and rural industry provide the most fertile fields for this approach. The management of tropical ecosystems in the Amazon region, where Western agricultural methods would probably lead to a significant deterioration of the delicate ecological balance, provides an example of the need to examine traditional methods to provide a starting point for systematic scientific research. The design of alternative irrigation schemes in Sri Lanka, examining carefully traditional methods that involve limited storage in small village tanks and the reuse of irrigation water rather than large-scale irrigation systems; the adaptation of traditional agricultural systems rather than their replacement by Western "modern" methods; the design of "combined technologies" that incorporate both "modern" and "traditional" technological components; and a systematic evaluation of efforts to link scientific research with rural technologies: all are examples of the various approaches that can be followed to improve on traditional technological practices through the use of scientific research.

The third group of actions for endogenous S & T development involves the transformation of the productive system. Here we are considering the transformations that are necessary in the productive system for increasing the demand for local S & T activities and knowledge, even though it is clear that transformations in the productive system are required for more substantive reasons than this.

These transformations involve the reorientation of production away from an imitative pattern of consumption that favours a great diversity of goods for higher income groups, and thus requires a widespread importation of technologies, to a different productive structure based on the satisfaction of basic human needs and with greater emphasis on collective rather than on individual consumption. This could reduce substantially the need for imported technology and lead to an increased demand for local scientific and technological activities. Furthermore, by reducing the spectrum and concentrating productive activities and the provision of services on basic human needs, it would be possible to direct the development of indigenous science-related technologies better and to forge links between the S & T and productive systems. Specific proposals regarding the Indian case have already been made.

The restructuring of production should also place emphasis on the vertical integration of activities involved in the processing of natural resources so as to generate demand for a variety of S & T activities (basic research, technology adaptation, engineering design, information systems, etc.) related to the country's resource endowment.

The transformation of productive and social activities also involves changes in the provision of services to the community and a re-examination of conventional Western approaches to social services. Education, health, housing and transportation programmes that take into account explicitly the needs and potentialities of the community, with emphasis on participation, on self-reliance at the local level, and on the use of indigenous capabilities and resources, would generate an expanded and sustained demand for local S & T activities.

For example, educational programmes that involve innovations such as senior students teaching those at a junior level rather than relying exclusively on teacher inputs; health programmes that emphasize prevention and primary health care by "barefoot doctors" rather than high-technology and capital intensive medical treatment; housing programmes that emphasize self-help construction and the use of local materials rather than standardized designs, commercial construction and the use of conventional materials; and transport systems that emphasize mass transit and low-cost personal transportation (bicycles, scooters) rather than relying on the private automobile: all present opportunities to exert ingenuity and to increase the demand for social, biological, physical and engineering S & T activities that could be performed locally in Third World countries.

Summarizing, the development of an endogenous scientific and technological base requires a careful marshalling of efforts to expand and reorientate scientific activities, recover and upgrade traditional technologies and transform productive and service activities. However, because of the limited financial and human resources available in most less developed countries, it will be necessary to concentrate efforts on a few critical problem areas while at the same time improving the capacity to import and absorb foreign technology. Furthermore, because of the resource requirements of modern S & T activities, the great majority of Third World countries will not be able to develop endogenous S & T capabilities on their own, at least for a considerable time. It is imperative therefore to join efforts, pool resources and establish cooperative arrangements with other less developed countries with the aim of developing a collective endogenous S & T base.

Transformations in the social context for science and technology

It is clear that to an alternative development strategy there corresponds an alternative strategy for the development of S & T capabilities. The growth of science and technology in any society is conditioned by the nature and characteristics of the social demand for knowledge which, in turn, depends on the path of development followed. It is also clear that the pursuit of science has its own internal dynamics, and that scientific discoveries often move in directions that are relatively independent of the social context. However, the general orientation taken by the transformation of scientific knowledge into socially useful goods and services is shaped by social demands. It may be said that the growth of science presents society with a range of knowledge options from which the dominant social forces select those aspects of direct relevance to them for transformation into science-related technologies.

It is not generally realized that if the phenomenon of underdevelopment is interpreted in S & T terms from a historical perspective, the lack of an endogenous S & T base emerges as one of the major factors contributing to it and that there will be no escape from the condition of underdevelopment unless an endogenous S & T base is fully developed in Third World countries. But in turn, the possibility of building such an endogenous S & T base will be conditioned by the broader socio-economic context within which S & T are inserted and, therefore, if the postulates behind the development of endogenous S & T capabilities are accepted we are led to the conclusion that socio-economic transformations must take place before endogenous S & T capabilities could be developed in order to escape from the condition of underdevelopment.

Consider the three groups of actions mentioned in the preceding section as necessary to achieve a measure of endogenous S & T development: the transformation of the productive system, the selective recovery of the traditional technological base, and the expansion and reorientation of the S & T system. The transformation of the productive structure away from exports and higher income groups and towards the satisfaction of the basic human needs of the majority of the population would lead to a reduction of imports of advanced technologies that are beyond the S & T capabilities of most less developed countries and towards a better integration of local S & T capabilities with the productive system.

However, such reorientation of the productive system cannot be expected to be the outcome of "market forces" acting on their own. There is a need for the State to intervene actively in defining the structure of production, providing basic services, regulating the flow of foreign investment and technology, orienting foreign trade, setting priorities for industrial development, establishing a framework for the activities of the private sector, and so on. In most Third World countries this would require substantial changes in the mode of state intervention in socio-economic activities and a reorientation of the state machinery towards the satisfaction of basic human needs. But for this to take place the State should represent the interests of the majority of the population rather than those of one or another privileged elite; there should be the political will to introduce radical transformations in the productive system rather than piecemeal reforms; and there should also be the possibility to carry out the necessary transformations, neutralizing both external and internal interferences. Unless these changes are put into effect little can be expected in the form of a substantial increase in the demand for local S & T activities.

An essential condition for the recovery of the traditional technological base and its gradual improvement through the use of scientific inputs is to ensure the co-existence of techniques of different productivity levels, at least during a certain period. This would require institutional arrangements of compensatory nature for fixing prices and determining wages so that modern techniques with higher productivity do not displace those traditional techniques that have lower productivity, giving time to test whether the latter can be substantially upgraded. Narrow economic efficiency considerations must therefore be discarded in favour of a broader framework for the evaluation of technologies thus incorporating social, educational, technological and cultural criteria such as employment generation, learning possibilities, adpatation potential and preservation of the cultural heritage. Further institutional arrangements would be required to ensure that the wage differentials associated with techniques of different productivity levels do not lead to a small elite of high wage earners and a large number of unemployed workers. It is evident that the installation of these institutional changes would mean major social reforms in most Third World countries.

Concluding remarks

There is an inextricable connection between the growth of endogenous S & T capabilities and the pursuit of alternative development strategies: one cannot be achieved without the other. Both of them require major socio-economic and political transformations in the Third World which are not likely to take place spontaneously and without social conflicts. Furthermore, substantive changes are required in the structure of international power releations before Third World countries could embark in a collective search for 'Another Development" and in the building up of endogenous S & T capabilities.

But then what are the implications of these interconnections between the development of endogenous S & T capabilities, the changes in the socio-economic context and the processes of S & T planning and of general development planning? If the hypotheses put forward in this part of the paper are accepted then it will be necessary to change the perspective for S & T planning, which has been characterized by a deductive approach from socio-economic goals and objectives to S & T requirements, and to introduce a new point of view that would examine the impact of endogenous S & T capabilities on socio-economic development, treating S & T and the development process in an integrated way.

POSSIBLE NEW DIRECTIONS FOR S & T PLANNING

Contrasting the appreciations made on the state of the art in S & T planning in the first part of the paper with the hypothesis on the interactions between science, technology and development put forward in the second, it is possible to suggest several new directions for the future evolution of S & T planning. In the paragraphs that follow, a few ideas for future research into this field are proposed.

A first observation is that the general thrust of S & T planning approaches at present is characterized by a deductive approach, deriving requirements for science and technology from socio-economic development objectives and goals. What is now necessary is a more integrated approach that would examine the influences of S & T considerations on socio-economic objectives, particularly in terms of creating new opportunities for the development process. It will no longer suffice therefore to subordinate S & T planning to development planning in general, as has been the traditional practice. Both will have to be dealt with concurrently, examining the social, economic, institutional, etc., implications of endogenous S & T development.

Second, there are several new advances in planning theory that are challenging traditional conceptions of development planning. New concepts of long-range planning, the increasing use of qualitative scenarios, the introduction of social considerations, the more extensive use of mathematical models, the increasing attention paid to participatory planning, and several other features that characterize the impact of "systems thinking" on planning theory, need to be taken into consideration when examining the future evolution of S & T planning in the context of development planning in general.

For example, a conceptual framework for planning has been suggested in terms of five categories of anticipatory decisions: those referring to long-term ideals and the desired future image of the system; those regarding the pattern of interactions with related systems and their decision areas; those related to the institutional infrastructure of the system, including organizations and "rules of the game"; those referring to the scope and nature of the activities to be performed; and those referring to the allocation of resources of all types. These are the domain of stylistic, contextual, institutional, activity and resource planning. The interactions among these categories can be summarized by saying that <u>resources</u> are allocated to <u>activities</u> through <u>institutions</u>, taking into account the <u>context</u> in order to approach the <u>desired future</u>.

Planning methods have been mostly developed in industrialized countries where relative stability could be assumed for the long-term objectives and ideals, the structure of environmental and contextual relations, and the institutional fabric. The emphasis was therefore placed on the development of methods to help decision makers on the last two categories of decision. However, if the role of development planning is to provide assistance in decision-making for the transformation of socio-economic structures, then the categories of stylistic, contextual and institutional planning acquire greater importance than is customarily given to them by planners and planning theoreticians. Therefore, in the light of these advances in planning theory, it may be necessary to reappraise the nature of development planning in general and to examine the way in which S & T considerations could be brought into the planning process explicitly from the beginning. (7)

A third line of possible future developments in science, technology and development planning involves the use of "strategic technologies" to be mastered as key decisions in the development planning process. This would mean that instead of - or rather in addition to - making decisions on investment projects on the basis of products to be manufactures, decisions should be made on the basis of particular technologies involved in the projects under scrutiny. The South Korean Development Planning Agency has already tried this approach in a limited form.

However, perhaps a more fruitful way of approaching the integration of S T & into the development planning process, particularly considering the ideas advanced in the sceond part of this paper, would involve selecting an initial group and a sequence of problem areas in which the development of endogenous S & T capabilities - involving the fusion of the current of knowledge-generating activities, together with the evolution of technological capabilities linked to modern production, and with the discriminate recovery of the traditional technological base - could be attempted.

As an initial approximation, it is possible to suggest five criteria for the identification of problem areas around which to centre efforts. The first criterion derives from the need to secure a critical mass to undertake scientific activities, and this should be examined from the quantitative, qualitative and interfacial points of view. Considering the quantitative aspect, the problem is to ensure the availability of human, physical and financial resources above the minimum level required to generate scientific knowledge of direct interest to the problem area. From the qualitative point of view, the resources available should have the characteristics that make them suitable for the selected activity (trained and experienced scientists, equipment satisfying certain specifications, etc.). From the interface point of view, it is necessary to gather a qualitative and quantitative base of resources not only in the scientific field of immediate interest for the problem area but also in those neighbouring fields which interact strongly with that which constitutes the main axis, since advances in science arise frequently from the combination of knowledge generated in adjoining fields.

The second criterion derives from the fact that problem areas in which to promote the merger of scientific advances with traditional and modern technological capabilities must be country-specific, and determined taking into account the social and historical context as well as the availability of natural and human resources. The identification of problem areas should also be country-specific in the sense of being closely linked to the style of development that is chosen and designed.

The third criterion for the identification of a problem area would stem from the possible societal impact of the fusion of the three currents. The idea is to ensure the largest possible multiplying effect of the integration of science with modern and traditional technological capabilities, both in the possibility of facilitating their integration in other problem areas, as well as in the diffusion through society of the value and points of views related to the organization of the scientific and technological base.

The fourth criterion to be considered should be the possibility and the opportunity of exercising world leadership, so that the country would become an internationally recognized centre of scientific excellence in a particular problem area. This would be achieved through the concentration of efforts and could eventually pave the road for a more balanced exchange of scientific knowledge and technologies with other countries.

The last criterion would lead to the selection of problem areas based on the possibility of obtaining concrete results in a reasonable period of time, expressed in terms of producing the utilizing technologies related to scientific findings and of linking the scientific activity with traditional technological capabilities. Moreover, the merger of the three currents in a specific problem area should serve as a starting point to undertake the integration process in other areas, thus generating a cumulative sequence which would facilitate the growth of an endogenous scientific and technological base.

Finally, even though it has been mentioned as one component of the strategy to develop endogenous S & T capabilities in the preceding paragraphs, it is necessary to emphasize the importance of linking the development of scientific and technological capabilities with the systematic and selective recovery of the traditional technological base. This issue is just beginning to gain attention and much work is needed in this area, particularly because planning approaches and methods usually have dealt with the modern sector of the economy in developing countries. As the emphasis is beginning to shift and the traditional sector is recognized as an integral component of the development process, development planning, and S & T planning in particular, will have to find ways and means of incorporating these issues into its sphere of concern.

It is clear that this short list of possible new avenues to be explored in science, technology and development planning is far from complete, and that a very large number of new issues and topics for research could be added. For example, the interactions between technology issues and "payment systems" being explored by Stewart and her colleagues constitute a most promising field to explored. (8) However, the purpose of this essay was to contrast the state of the art in S & T planning with some new ideas on the interaction between science, technology and development, and to outline some possible new directions and avenues for research. More substantive contributions will have to wait until research efforts now in progress produce substantive results.

Footnote

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

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13. National Financial Institutions and Technology Development; a Preliminary Review

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INTRODUCTION

The choice of technology has always been accepted as a critical element of a nation's development strategy. Of late, however, attention is being focused more on the entities making the choice and developing countries are becoming increasingly concerned with the issue of 'who makes the choice?' as determining the nature and the impact of the technology. In this connection, the World Bank has come under closer scrutiny as far as the impact of its policies like that of competitive bidding, use of consultants and local cost financing, on the nature of technological development. This paper, while appreciating that policies of international financial institutions are indeed important determinants of technology in developing countries, is concerned mainly with the national development finance institutions.

Over the past three decades, developing countries, sometimes with the assistance of the World Bank, have created and promoted 'development banks' and 'development finance corporations' to supply capital, enterprise and managerial and technical advice to speed up the process of development. In itself, as an institution to mobilize capital and promote industrial investment, the development bank is not an innovation. Such activities have been carried out for a long time mainly through the commercial banking network in countries like India, Turkey, Indonesia, and Chile. What is new, however, is the view that policies of such institutions exercise a critical influence on the nature, direction rate, adoption and diffusion of technological innovations.

However, this view that the operations of financial institutions have a vital bearing on a nation's technological capability has yet to be fully explored. This paper attempts to highlight the nature, extent and scope of the links between the financial and technological systems. This link will make its impact felt on the economy through the introduction of new products and processes, opening of new markets, use of new sources of raw materials and the creation of new forms of organization.

FINANCE AND TECHNOLOGY: A HISTORICAL PERSPECTIVE

Studies of economic history have shown that financial institutions have played a critical role in the process of technological development in the industrialized countries. Schumpeter [1] identified the banking system and entrepreneurship as the two key agents of economic development. Drucker [2] writes "Swedish technological strategy has not been formulated by technologists. It seems to have come mostly from the industrial development bankers". High voltage transmission, automobiles combining passenger-car styling with the ruggedness of poor roads, aircraft capable of landing and taking off on very short runways - these were some of the technological problems identified by the bankers.

Gerschenkorn [3] describes the "truly momentous role of investment banking in the economic history of large portions of the continent", citing Germany as an example where "banks acquired a formidable degree of ascendancy over industrial enterprises, extending far beyond the sphere of financial control into that of entrepreneurial and managerial decisions. German investment banks, as Gerschenkorn [4] puts it, very often mapped out a firm's path of growth, conceived far sighted plans, decided on major technological and locational innovations and arranged for mergers and capital increases.

In Italy, Gerschenkorn [5] observes "if one were to look for a single important factor that succeeded in offsetting at least some of the great obstacles to the country's industrialization, one could not fail to point to the role performed by the Italian banks after 1895".

Cameron [6], after a study of eighteenth century England, points out that "(the) available evidence indicates a positive and significant contribution thereto by the banking system." Early entrants to the banking profession in England were people engaged in trade, commerce, mining and manufacturing.

Epstein [7] claims that while elsewhere banking was the product of economic evolution, in Russia economic evolution was the product of banking.

Crisp [8], while providing a more sobering view attributes the late nineteenth century renaissance of the Urals to the activities of the banking houses. The construction and expansion of railways, and the financing of cotton growing, ginning and marketing and assistance to the glass and cement industries, were some of the more significant activities of the Russian joint stock banks who provided both short-term and long-term credit.

Tokugawa and Meigi Japan is an interesting case because it borrowed the American, Belgian, French and English models of banking institutions and created a uniquely indigenous system that was as Patric [9] put it, "at the core of and the dominant component of the industrialization strategy." The critical financing was concentrated on agriculture domestic commerce, small-scale industry (mainly the processing of primary products) and later on the importation and adaptation of Western production techniques. "In the early periods of industrialization and economic development, to quote Patrick [10], an adequate monetary system and comprehensive financial structure were developed, industrial enterprise promoted and entrepreneurial activity in industry stimulated, and funds to finance productive investment were provided."

Green [11] writes in the contex of Louisiana: "In addition to the financial aid that they gave to canals, railroads and other improvement projects, the Louisiana banks contributed to less tangible forms of social overhead capital. Several of them had stipulations in their charters that required them to pay annual bonuses to support education. In a few cases bank financing may have helpted industry to adopt improved technology, as in the application of steam power to sugar refining or to the cotton press."

The main functions served by the banks acting as planners, entrepreneurs, financiers and often managers as Diamond [12] explains were (a) mobilizing large amounts of capital; (b) using that capital for equity investments and long-term financing; (c) promoting new enterprises in basic facilities, mining, and secondary industries; (d) lending to public authorities; (e) facilitating the use of the joint-stock company; and (f) helping to create the institution of a capital market. These banks like the Credit Mobilier and the Credit Foncier as in France were designed to simultaneously relieve the shortages of capital, entrepreneurship and managerial and technical skills which faced nineteenth century industrializing Europe and Japan).

In retrospect the <u>indirect</u> contribution to development were probably more important and widespread than the <u>direct</u> impacts, for example, through actually financing new production techniques or technological experimentation. As an example of Europe and Japan, Cameron and Patric [13] write "bank credit granted to importers of industrial raw materials enabled the importers to extend credit in turn to the manufacturers. Bank financing of improvements in transportation lowered the costs of raw materials and fuel to manufacturers and of fuel products to purchasers, thus facilitating the extension of markets and bringing about economies of scale. Even mortgate loans to improving landlords and farmers contributed directly to industrialization by increasing productivity in agriculture and releasing labour for other uses."

Gradually, however, as industrialization progressed and considerable capital accumulated from earnings in trade, modernized agriculture and industry itself, the importance of banks declined and that of the factories increased. Growth could now be financed through entrepreneurial profits and retained earnings of the firm. This is what happened in England and therefore the widespread feeling that the English tradition of banking, unlike that of the continent who were 'latecomers' to the industrialization process, has been conservative and passive.

Nevertheless, the conservatism of the Anglo-Saxon tradition has not always been true and its influence exaggerated in seeking explanations to the current performance of the banking system in developing countries. It is worthwhile to remember that financial institutions are not independent units of the economy but instead are governed by state legislation and policies which can either facilitate or hinder the flow of capital and entrepreneurial guidance. There is probably no such thing as bankers being 'inherently' conservative. Cameron [14] mentions government laws in nineteenth century England that forbade limited liability and limited banking partnerships to six persons that determined the structure and limited the functions of the English banking institutions.

Such a historical perspective is valuable while studying the developing world of today where in many respects similar obstacles to industrialization can be found. In most developing countries capital may exist in the form of savings, but only a fraction of this is actually available for industrial investment, the bulk being invested in land or commercial enterprises. There is no effective capital market for channelling into productive investment a sufficiently large portion of such savings as exist. There is a relative shortage of entrepreneurial talent and limited initiative on the part of the industrial community to seek out and venture into new areas of activity. In addition, few enterprises in developing countries combine investment capacity with innovative ability in technology - the ability to finance growth through retained earnings or internal research and development activities is extremely limited.

FINANCE AND TECHNOLOGY. A CONCEPTUAL FRAMEWORK

While there has been some appreciation of the importance of financial institutions from the point of view of technology policy in developing countries, so far, in practical forms this has only meant changes in project appraisal and evaluation procedures and emphasis on the use of social cost-benefit analysis and economic rates of return. What this overlooks as Little and Mirrlees [15] and Bhatt [16] have written is that technological choices have already been made at the project design and formulation stage; consequently, financial institutions become involved at a stage where they can do little to affect the choice of technology. Different studies have shown that local and foreign consulting and design engineers and equipment and machinery salesmen are primarily responsible for the choices, both in large and small-scale enterprises, and that the choices they make, by virtue of their basic orientation, are not necessarily appropriate to local factor endowments.

Other than use of 'right' evaluation criteria for the selection of projects for financing, major emphasis has been placed on appropriate interest rate policies. This is understandable in the light of the impacts of continued inflation and exchange-rate adjustment problems in most developing countries, and the interest rates determine how financial institutions can mobilize resources from different markets and allocate credit, the level of administrative costs that they can bear and the risk to which they can expose themselves. Nevertheless, increasing the supply of capital does not necessarily ensure that it will indeed be used by enterprises and entrepreneurs in a way to satisfy development objectives. Interest rates are rarely efficient devices for determining areas of investment. It is also questionable whether resource mobilization and allocation can indeed be influenced by interest rates in an industrial structure that is either run or tightly controlled by the state, or if there is no competition and investment decisions are not strictly techno-economic.

This is not to suggest that these policies relating to the pattern of resource mobilization and use for development banks are unimportant; rather they are only a small part of the 'enterprise' providing functions of these institutions. Such functions could encompass:

(i) promoting regional development and industrial decentralization;

(ii) identifying projects, preparation of project profiles, feasibility reports, pre-investment studies and design engineering plans;

(iii) identifying and training of potential entrepreneurs for implementation of projects;

(iv) providing of technical and administrative assistance for the promotion and management of enterprises;

(v) providing domestic and foreign market intelligence and information on technological alternatives to enterprises;

(vi) increasing availability of risk and venture capital for development of indigenous technology and upgrading traditional technology;

(vii) assisting enterprises to develop new or improved or to adapt technology in product design and production techniques;

(viii) identifying research problems and financing R & D in laboratories and technological institutes; provision of subsidies for the commercialization of R & D;

(ix) assisting enterprises to arrange technical and financial collaboration agreements with foreign partners negotiating for favourable terms and enhancing bargaining positions vis-a-vis foreign suppliers;

(x) coordinating provision of technical and managerial assistance to small-scale enterprises with commercial banks; creation of special capital mechanisms to overcome the problem of lack of equity capital for small enterprises;

(xi) providing special credit lines for strengthening local consultancy services and encouraging their participation in project identification and formulation;

(xii) evaluating governmental sectoral policies, especially those related to price controls and their impact on technological improvements;

(xiii) carrying out special sectoral and sub-sectoral studies to understand factors affecting investment and technological decisions of enterprises and influence of government policies, particularly industrial licensing policy, trade policy and policy regarding impact of technology;

(xiv) encouraging the use of local manufacturers and industries in development projects and promoting development of ancillary industries (i.e., subcontracting units) that have export and small-industry implications; and

(xv) introducing technological criteria into loan evaluation.

The functions are important because they link a tool-technology with the investment machinery that accounts for much of economic growth. The idea is not merely to pick up the relevant technology 'off-the-shelf' but to use technological innovations as a means of increasing the effectiveness of a given investment as well as its multiplying effects over the entire economy. Just as foreign direct investments are considered to be one of the most important channels for technology transfer, so also investments by domestic financial institutions must be considered as promoters of technological links and technological capacity. As Quinn [17] points out "the growth impacts of technological multipliers can vastly outweigh the Keynesian demand-stimulation effects of the investments which initiated them. Large increases in productivity or value added can actually be accomplished through introduction of a series of management techniques or minor process improvements which involve almost no capital investment." While investment is a prerequisite for economic development, growth is stimulated by the technology embedded in the investment and its backward and forward linkage effects. Several studies done in the 1950s and 1960s for the U.S. and Europe confirmed that technological advance contributed immensely to productivity increase and measured economic growth. [18]

Depending on a country's level of development, a bank will either stimulate others or itself assume responsibility for carrying out these functions. Obviously, not all banks can create the in-house capacity to cover these functions: nor should they, for then they risk losing their effectiveness by undertaking too many diverse activities. What is important, however, is the coordination that can be achieved with other entities that have the capability (e.g., local and foreign research institutes and consulting firms) to complement their primary function of supplying investment capital.

But the financial institution has to be the lead agency simply because a project cannot be implemented without adequate finance. As a World Bank policy paper points out in the context of development of small enterprises, "A satisfactory arrangement, in the World Bank's limited experience, is a technical assistance agency outside, but closely linked to the financial intermediary for small-scale enterprises; the financial institution would thus act as a sponsor of technical assistance to its clients (actual or prospective) and of its clinents to the technical assistance agency. The entity that provides or controls financing seems often to have the most leverage or catalytic influence on the other two parties." [19]

It is perfectly possible that banks finance technological innovations and experiments without ever being consciously aware of or even bothering about them or their impacts. After all, technical innovation is primarily the responsibility of the enterprise or the entrepreneur. It would be more common for the financial institutions to be concerned with the <u>diffusion</u> or commercialization of innovations, after the initial costs have been borne either by the enterprise or entrepreneur.

All said and done, the major responsibility of the banking system is still the introduction and adoption of financial innovations which are no less important than the technical changes introduced in production processes. For instance, liberalization of the terms of financing relating to the promoters' contribution to the capital cost of a project and provision of soft loans to cover the promoters' equity is a necessary condition to encourage the use of indigenous technology. Another example would be the change in requirements in collateral for lending to small farmers and village artisans where future expected output or income can be used as mortgage instead of fixed assets like land and equipment. Concessions in the rate of interest, repayment and amortization periods, margins of security and underwriting commissions are some other changes that the banks can introduce to increase the availability of capital. Increased availability of funds from financial institutions can help the entrepreneur to undertake larger investments by providing him with a better debt margin than otherwise possible.

FINANCE AND TECHNOLOGY: THE INDIAN EXPERIMENT

India has an elaborate institutional infrastructure for industrial finance both at the national and state levels. At the national level, the Industrial Development Bank of India (IDBI), the Industrial Credit and Investment Corporation of India (ICICI) and the Industrial Finance Corporation of India (IFCI) provide term-finance for medium and large industry and equity investments and underwrite public issues. The Industrial Reconstruction Corporation of India (IRCI) provides financial and technical assistance to "sick" industries (industries that are plagues by under-used capacity). The Life Insurance Corporation of India (LIC) and the Unit Trust of India (UTI) are responsible namely for securities, capital markets and rupee loans and the National Small Industries Corporation of India (NSIC) provides hire-purchase financing for small-scale enterprises.

At the state level, the State Industrial Development/Investment Corporations (SIDCs/SIICs) provide loans and equity investments to medium and large-scale industry, the State Finance Corporations (SFCs) lend to small- and medium-scale industry, the State Small Industries Corporations (SSICs) provide hire-purchase financing for small industries and are responsible for the allocation and distribution of raw materials for small-scale industries, and the State Small Industries Development Corporations (SSIDCs) provide financial and managerial assistance to industrial estates.

In addition to these financial institutions, there is an extensive network of commercial banks comprising the State Bank of India, 14 nationalized banks, 14 foreign banks and 450 other scheduled banks. These banks also provide term-financing (in addition to their usual functions of providing working capital), estimated at about 10-15% of their total outstanding.

Table 1 gives an idea of the relative importance of institutional assistance as a proportion of the capital formation that is taking place within the private corporate sector. The sample of 1650 companies on which the figures in table 1 are based represent a significant proportion of the non-financial private corporate sector. As can be observed, term lending is still a negligible fraction of total gross fixed asset formation but when combined with the borrowings from the banks comprise approximately 40-50 percent of gross fixed asset formation.

While there has always been an appreciation of its promotional role, nationalization in 1969 provided a much needed impetus to the banking system to expand its developmental activities, particularly in the rural areas and in small and medium-scale enterprises (both farm and non-farm). The commercial banks (mainly the State Bank of India, Bank of Baroda and the Syndicate Bank) have set up multi-service agencies to provide technical assistance to both modern and traditional small enterprises. The Bank of Baroda, for example, provides assistance to the development of very small industrial units like carpentering, leather working, tailoring, etc., where the technical help required is very rudimentary. Assistance is also provided to enterprises in areas like handloom weaving and woollen khadi which are based on local technology.

At a different level, assistance is also provided to petrochemicals, light engineering and solar energy, where considerable links with local R & D laboratories and universities are required. These multi-service agencies provide technical assistance in project identification and formulation as well as in project operation to a large number of very small enterprises. This attention to small enterprises is only to be expected because their extensive branch network puts them in an ideal position to undertake small-industry financing and because they alone can provide both term finance and working capital. This latter aspect is important because small-industry financing is essentially a matter of providing working capital and nearly 60-80 percent of the capital employed in small-scale units is in the form of working assets. Table 2 provides a comprehensive picture of the total advances by the commercial banks.

TABLE 1

AVAILABILITY OF FUNDS AND GROSS FIXED ASSET FORMATION IN MEDIUM AND LARGE PUBLIC LIMITED COMPANIES

(in Rs million)

	Borrowings					
	Banks	Deposits	Financial Institutions and Government	Retained Earnings	Depreciation Provisions	Gross Fixed Asset Formation
Sample of 1650 companies						
1971/72	852.3	633.3	-155.0	1,444.6	3,045.1	3,780.8
1972/73	- 551.9	866.6	17.5	1,475.5	3,297.2	4,695.0
1973/74	1,556.9	487.0	184.6	2,402.2	3,487.4	5,262.6
1974/75	3,321.2	930.3	222.1	3,672.9	3,892.9	6,909.4
1975/76	2,635.6	1,049.1	629.8	1,396.1	4,046.3	7,472.3

Source: Various issues of the Bulletin of the Reserve Bank of India

TABLE 2

SCHEDULED COMMERCIAL BANKS' ADVANCES TO PRIORITY SECTORS

(Amounts in rupees crores)

Items	December 1975 (Provisional)				December 1976 (Provisional)			
	State Bank Group	Fourteen National-ised Banks	Public Sector Banks (2+3)	All Scheduled Commer-cial Banks	State Bank Group	Fourteen National-ised Banks	Public Sector Banks (6+7)	All Scheduled Commer-cial Banks
1	2	3	4	5	6	7	8	9
I. Total Bank Credit	2895	5544	8439	9874	3788	7344	11122	12909
II. Advances to Priority Sectors								
(a) Agriculture	314	623	937	1024	433	797	1230	1335
Of which:								
(i) Direct Finance	228	430	658	725	326	590	916	1003
(ii) Indirect Finance	86	193	279	299	107	207	314	332
(b) Small-Scale Industries	420	624	1034	1147	477	798	1275	1421
(c) Road and Water Transport Operators	23	130	153	191	44	193	237	278
(d) Retail Trade and Small Business	37	118	155	179	52	170	222	257
(e) Professional and Self-Employed Persons	5	38	43	51	9	60	69	78
(f) Education	–	5	5	5	–	6	6	6
Total of (a) to (f)	789	1538	2327	2597	1015	2024	3039	3375
Percentage share of the bank group in all banks' advances to Priority Sectors	30.4	59.2	89.6	100.0	30.1	60.0	90.0	100.0
Percentage of advances to Priority Sectors in total bank credit	27.3	27.8	27.6	26.3	26.8	27.6	27.3	26.1
Percentage share of advances to Priority Sectors in total bank credit excluding food credit	30.7	30.9	30.8	29.1	33.4	33.5	33.5	31.4

Source: Reserve Bank of India Annual Report 1976-77

TABLE 3

INDUSTRY-WISE ALLOCATION OF ASSISTANCE UNDER TECHNICAL DEVELOPMENT FUND

(up to June 1977)

(Amount in crores of Rupees)

Industry	Assistance No.	Sanctioned Amount
Machinery (incl. electrical)	12	1.68
Metals and Metal products	4	0.79
Automobiles, Ancillaries	5	0.88
Chemical, Textiles, etc.	--	--
	21	3.35

Source: Industrial Development Bank of India Annual Report 1976-77

TABLE 4

SUMMARY OF OPERATIONS OF KERALA INDUSTRIAL TECHNICAL CONSULTANCY ORGANIZATION 1972-77

	No. of enquiries attended to	Assignments taken up	Reports completed		Assignments withdrawn *		Assignments on hand as on 30.6.1977	
			No. of cases	Project cost (Rs. lakhs)	No. of cases	Approximate project cost (Rs. lakhs)	No. of cases	Approximate project cost (Rs. lakhs)
1. Project reports for entrepreneurs	1,268	165	67**	1,191.84	88	3,056.44	10	137.00
2. Project reports under Mini Industrial Estates (MIE) Programme of Gvt. of Kerala	729	611	595	616.55	-	-	16	16.00
3. Feasibility Reports	-	43	43	1,410.24	-	-	-	-
4. Appraisal cases from Financial Institutions	140	140	103	2,383.27	24	296.05	13	76.01
5. Market surveys	15	11	9	-	2	-	-	-
6. Sick unit studies	6	6	5	-	-	-	1	-
7. Industrial potential surveys	1	1	1	-	-	-	-	-
8. Credit plan surveys	2	2	-	-	-	-	2	-
	2,161	979	823	5,601.90	114	3,352.49	42	229.01

* Dropped due to lack of interest of entrepreneurs or non-viability of the projects

** Includes 4 valuation reports and one project brief

Source: Industrial Development Bank of India Annual Report 1976-77

By far the most dynamic technological role is being provided by the Industrial Development Bank of India which has set up eight technical consultancy organizations (TCOs). The main objectives of the TCOs are to identify project ideas, prepare project profiles and feasibility reports, select and train potential entrepreneurs and interact with research laboratories and government agencies. They do not undertake actual implementation of the projects which is the primary responsibility of the entrepreneurs and engineering consultants. Instead they provide a variety of consultancy services at subsidized rates to entrepreneurs who find it beyond their means to approach the higher-priced private sector consultancy firms and service the needs of financial institutions (including commercial banks) for project identification, appraisal implementation and supervision.

It is still too early to assess their impact and judge their performance. However, some qualitative information on some of the more well established TCOs can provide some indications of the range and nature of their functions. About 90 percent of the project ideas are in the small and tiny sector and nearly half of them are suitable for location in background areas. The 680 projects identified in this sector involved an investment of rupees to crores and an employment potential of about 9000.

Another interesting feature of the TCOs is the setting up of data banks which would make information readily available on technological alternatives, market information and product data sheets. The aggregate cost of operating these TCOs is approximately 0·5 percent of the capital investment involved in the projects for which the TCO prepared the feasibility/appraisal report.

Another technological dimension of IDBI's activities is the "Technical Development Fund" created in 1976 to promote fuller use of capacity, technological improvement and export development. The fund is used to pay for the services of foreign consultants and for the import of technical know-how, drawings and designs, the maximum limit of import being U.S. $2,500,000 per undertaking per year. The total amount sanctioned under this scheme is indicated in table 3.

In addition, a Technical Assistance Fund has been created out of IDBI profits to improve the capabilities of state-level promotional and financial agencies. The fund will be used to pay for the services of local and foreign consultants primarily in states that lack the necessary technical manpower to identify and develop export possibilities. Finally, in 1976, IDBI introduced the Seed Capital Scheme to assist in the implementation of technically feasible and economically viable project ideas that lack the promoter's contribution for projects with a cost of up to rupees 1 crore.

One of the most celebrated cases in IDBI's operations is that of the "Swaraj" tractor which is a fascinating study in the conflicts between indigenous and foreign technology. Briefly, the Government of India, largely at the insistence of a giant public sector undertaking which quickly needed to diversify profitably, decided on the import of a twenty horsepower Czech tractor (the 'Zeteor') for small farms on a turn-key basis. Just at about the same time, a government-run research institute had developed an indigenous design which was then picked up by a state industrial development corporation for engineering and manufacture.

This is not the place to go into the subsequent performance of Swaraj in detail. Morehouse [20] and Bhatt [21] provide a detailed description of the advantages and impacts of the indigenous effort. From the point of view of this paper, it is IDBI's role that is important to the initiation of the project to manufacture the tractor, in the face of competition from a national public sector undertaking. When the project was being floated in 1972, IDBI made important concessions in the terms of its financing - reduction in the proportion of promoters' equity and acceptance of a lower rate of return - which enabled the manufacture of the tractor. Subsequently however, it was the internal technical innovative capacity of the manufacturing enterprise that was responsible for the adaptations and technological improvements that occurred to maintain the market viability of the tractor. But the initial stimulus and encouragement provided by IDBI's policies was a major factor in the commercialization of the indigenous design and, once it became IDBI's "pet project", continued financial assistance at liberal terms was assured for the project because IDBI had every incentive to see it succeed.

Most of the IFCI's assistance has gone to the sugar and textile and industries in the cooperative sector. These labour-intensive units are usually located in the rural and semi-urban areas. The support given to these industrial cooperatives is significant because it offers a profitable and productive outlet for agricultural savings and facilitates an organic relationship between agriculture and industry. Further, the setting-up of these cooperatives normally leads to the mushrooming of small-scale village or artisan shops and the creation of social infrastructures such as roads, electricity and water supply.

BRAZIL

Brazil is another example where the financial system is closely linked to the technological infrastructure. FUNTEC (the Development Fund for Science and Technology) is an operational division of BNDE (National Development Bank of Brazil) which provides non-reimbursable monies for research at the university and enterprise level. One of the early ventures of FUNTEC was the support given to the University of Sao Paulo to develop manufacturing processes for transistors and related micro-electronic devices to reduce dependence on foreign licensing sources. Subsequently, support went to private industrial enterprise, mainly in the electronics and metallurgical sector. Other BNDE subsidiaries provide finance for national and international sales of locally manufactures equipment, technical and managerial assistance to small-to-medium-size enterprises.

BNDE, the world's largest economic development bank, has been active in directly supporting the private industrial sector and in pushing for the utilization of local project planning skills. Studies conducted by BNDE have highlighted the total dependence of foreign technology in the capital goods sector. BNDE has also been a pioneer in using technological considerations in the evaluation of loan applications. For example in 1970 it decided to award loans only to cement firms that were planning to use the dry process in their investment projects. [22]

Apart from BNDE, two important agencies at the state level are the Sau Paulo Fund for Scientific and Technological Development (FUNCET) and the Development Bank of the State of Sau Paulo (BADESP). FUNCET emphasizes the building of technical capabilities at the enterprise level and finances specific technological development projects both at the firm and research institute level. BADESP provides direct loans to enterprises to upgrade their technology. Under an industrial technology fund (since discontinued), finance was made available for applied research and experimental development, purchase of laboratory equipment and provision of technical and related market information services to small and medium industry.

Finally FINEP (Financiadora de Estudos e Projectos) - the Agency for the Financing of Studies and Projects - provides loans to business firms for R & D infrastructure in the form of laboratory facilities and technical manpower training. Along with BNDE, FINEP established the Centro Prasileiro de Asistencia Gerencial a Pequena y Media Empresa (CEBRAE) to provide management and technical assistance to small and medium industries and carry out studies in the area of industrial promotion. Some topics covered in these studies include investment and feasibility studies of individual projects, and identification of managerial weaknesses in specific industrial sub-sectors.

COLOMBIA

Another innovative programme is the Technology Laon Fund administered by the Central Bank of Colombia. The objective of the Fund is to increase the productivity, self-reliance and competitiveness of Colombian enterprises in domestic and international markets. As Baranson [23] describes it, "the specia line of credit, by providing funds at about one-third below the commercial interest rate helps to overcome the risk aversion Colombian firms generally have towards investments in R & D and other forms of technological experimentation." The following types of expenditure are eligible for financing:

(i) Research and development programmes sub-contracted to national or overseas technical research institutes for new or improved production designs, materials processing or production techniques;

(ii) training of technicians or consultants to advise on improved product designs and production techniques;

(iii) hiring of foreign technicians or consultants to advise on improved product designs and production techniques;

(iv) lump-sum payments for licensing or know-how agreements;

(v) purchase of equipment for quality control, materials testing, and product and process research.

An interesting feature of the Fund, which was created with a U.S. $5 million line of credit from the World Bank through the Central Bank of Colombia to private investment banks, is its background; as part of the project preparation, a survey was undertaken to ascertain the problems and opportunities facing Colombian enterprises while carrying out technological adaptation and improvements. The types of expenditure have been identified by individual firms; they are in direct response to the needs of Colombian enterprises as articulated by the users.

CONCLUSIONS

A recently concluded multination study on the science and technology policies highlighted that "the variety of technological criteria that can be introduced into loan evaluation makes industrial finance one of the most powerful policy instruments to promote the demand for local S & T knowledge". [24]

Although there is accumulating evidence that financial institutions are indeed being used more actively by the governments in developing countries to promote technological development, there is as yet no serious attempt to provide a technological analysis of development banking performance. Consequently much cannot be said about the impact of all the activities described in the paper. But what is becoming clear is that the activities of financial institutions (both national and international) must be closely integrated with the technological infrastructure and the productive sector, if they are not to undercut the attainment of explicit technological goals.

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14. The Role and Function of a Scientific and Technological Infrastructure in the Context of Development Policy

MICHAEL J. MORAVCSIK

INTRODUCTION

This discussion was prepared for an international symposium, the aim of which was to generate ideas, proposals and programmes for the consideration of the United Nations Conference on Science and Technology for Development (UNCSTD) to take place in Vienna in August 1979. Since that conference as all United Nations evens of similar character, is in the danger of being merely a string of oratories with no tangible effect on the actual state of science and technology in the developing countries, it is important to orient any input into such conferences toward a realistic and frank analysis of the situation followed by a set of specific recommendations.

Since the problems of science and technology in developing countries have by now a large literature (perhaps too large compared with the amount of action generated by it), I will limit myself to a relatively brief exposition of the analysis and of the recommendations without giving arguments or examples to the extent that I would like to if I had unlimited time and space. (1) The basic concepts will be reviewed so as to avoid semantic ambiguites. Then the roles, functions and the importance of a scientific and technological infrastructure in a developing country will be listed. This will be followed by an account of some of the most common deficiencies in development policy pertaining to scientific and technological infrastructure. The discussion will end with specific recommendations to UNCSTD with respect to an enhanced and improved support in the building of scientific and technological infrastructures in developing countries.

CONCEPTS

Science and technology (2)

Science is a human activity resulting in knowledge about nature, utilizing a particular methodology called the scientific method. This method, based primarily on observational verifications of ideas about and explanations of natural phenomena, is characterized by the existence of criteria which can resolt disputes and build up an "objective" set of knowledge and understanding. "Objective" here means merely that the members of the scientific community form a consensus in accepting that method as the arbitrator of disputes.

Technology is a human activity resulting in procedures, processes, prototypes, gadgets, oriented toward the ability of doing certain things or making certain things. In the old days technology was primarily based on trial-and-error type of tinkering with out immediate environment but in the last hundred years or so technology has become increasingly science-based, that is, technology now utilizes the knowledge created by science to replace the mere trial-and-error approach prevalent earlier.

It should be noted that the difference between science and technology is in terms of their results, their products. The product of science is new knowledge, the product of technology is a new process or gadget.

People are motivated to do science by a number of aspirations. Among these are the delight in expanding the realm of scientific knowledge *per se*, and the urge to generate new knowledge because of its possible applicability in other human activities. According to these two motivations, scientific research can be characterized as "basic" or "applied" research. The two labels are not very distinct ones, however. The two may be present simultaneously in the same person. One may be predominant in the researcher but the other in the provider of research funds. All good scientific research, even if it appears exclusively "basic" at the time of its creation, becomes "applied" sooner or later, so that the division between "basic" and "applied" is also fuzzy in time. In spite of this lack of a sharp division between the two categories, in the management of science and technology it is useful to set up a somewhat arbitrary boundary between them. For example, one might call "applied" research some activity in which the dominant expectation is knowledge that is likely to become applicable in an *a priori* specified area within the next 8-10 years.

Development (3)

Development is a set of actions leading to the increased realization of aspirations. This concept holds both for individuals and for groups. Note that development is action, not plans, intentions, or preparations.

Aspirations of individuals and of groups of people are varied. Some aspirations are material, pertaining to either the basic necessities of life, such as food, shelter, health, or to more luxurious items like TV sets, cars, or swimming pools. Others are non-material, such as religious or spiritual fulfillment, intellectual growth, artistic achievements, achievements in sports or in exploration, ideological domination, wide-ranging political power, etc. Throughout human history, non-material aspirations of people have played a much more dominant role than the material ones. (4) A quick analysis of the small and not so small wars and conflicts taking place in the world today will show the extent to which these non-material aspirations dictate the events on the international scene. Similarly, the behaviour of few individuals, if any, can be analyzed successfully in terms of only material factors. Indeed, the world would be a much easier arena to manage if only material motivations propelled its inhabitants. In fact, however, the non-material factors ernormously complicate the situation while, at the same time, also make life infinitely more interesting and absorbing.

Policy

Policy is a set of actions working in the direction of the realization of some goal. Sometimes policy is conscious, enunciated in advance and coordinated, while at other times policy is *de facto*, developing *en passant* and consisting of a mosaic of seemingly disjointed elements. Whether centralization and planning constitute the more effective policy is open to debate and may depend on the nature of the goal and the environment in which the realization of the goal is to be effected. For example, happiness is a policy goal for every individual, and it is also a policy goal of society as a whole, but whether this goal can be achieved better by centralization and planning has been an often debated question in human history.

Explicitly or implicitly, policy consists of four stages:

(i) Planning, that is, the projection of action to be taken;

(ii) decision making, that is, the choice among alternatives in the course of the realization of the goal;

(iii) implementation, that is, the actual efforts converting intention into reality;

(iv) evaluation, that is, the assessment of the success or the failure of the previous three stages, as compared with the original goal or aspiration.

THE IMPORTANCE OF A SCIENTIFIC AND TECHNOLOGICAL INFRASTRUCTURE IN A DEVELOPING COUNTRY

An analysis of this importance can be neatly arranged in terms of the three main motivations (5) of science and technology. Each of these may include several specific roles.

Infrastructure as a generator and as a carrier of science into technology and technology into production

This is, for the most part, the material aspect of science and technology. In this respect the infrastructure has the following three essential functions:

(i) Receptor and channeller of scientific and technological information knowledge and know-how from abroad into the country

All countries in the world are net importers of science and technology. Even the United States produces only about 30% of the world's science, and hence imports 70% of it. In the case of a developing country, this ratio may be 0·1% *versus* 99·9% or even more extreme. Thus such a country will be dependent to an overwhelming extent on science and technology generated elsewhere. Only an indigenous scientific and technological manpower, kept *au courant* through personal research and development activity, can serve as an effective recipient and channel of such worldwide scientific and technological knowledge. Centralized and computerized information systems, tapes, libraries, journals, reports, seminars and other tools are of no use whatever in the absence of such a high quality local group of scientists and technologists.

(ii) Selector and adaptor of science and technology

The amount of raw information on scientific and technological developments around the world is of a staggering magnitude. To be able to use that information in any sense, a broadly educated, highly competent and imaginative scientific and technological manpower is needed to make selections among the flood of information available and to adapt the selected information for the specific use in question. Such an adaptation is an essential step both in scientific research and in technological development work. In science no two research problems are identical, and hence previously generated scientific knowledge must either be brought down from a general plane to the specific problem in question or must be transmuted from its application to a very different problem to the application to the problem on hand. In technology, the particular environment of a developing country, both physically and in terms of the human, cultural and economic aspirational aspects is likely to be different from the environment where the technology was invented, and hence adaptation is necessary.

(iii) Generator of new science and technology

Although, as we saw, in the case of a developing country, this function of the scientist and technologist may, on average, be a small fraction of his role in terms of the previous two functions, the ability to generate new science and technology is nevertheless of crucial importance both in the short term and in the long term. Quite apart from the non-material motivations to be discussed below, new science and technology also play prominent roles in material considerations. Imitative science and technology are likely to result in products of relatively low specific value, not optimally suited for the domestic market and not highly competitive on the international market, unless propped up by the availability of cheap and yet sufficiently skilled labour. To be sure, this last combination is often quite effective and can bring a temporary boost to the country's economy, as we have seen in the examples of Japan, Hong Kong, Korea, Singapore, and other countries, at one time or another. Sooner or later, however, the time comes when the rising standard of living in the country eliminates this mode of operation and the country can progres further only if it also has the discovering, innovating and investing capability at the forefronts of science and technology. Japan passed this stage some time back, Korea and Singapore are at it and many countries are fast approaching it. To prepare for having such a capability at the proper time, the scientific and technological infrastructure must be carefully nurtured for decades prior to that time since it takes a long time to bring it up to a significant level.

Infrastructure as a foundation for the country's dignity and independence in science and technology

(i) Science and technology as human aspirations

At any given time in history, people and peoples have many and different aspirations. In the 20th century, one of the many highly valued human activities and achievements is in science and technology, and scientific discoveries and technological inventions are matters of individual and collective pride thus forming an important part of the *raison d'etre* of an individual or a country, far transcending the purely material tools of human survival. Forefront achievements in science and technology can raise the country's morale the same way as achievements on the soccer field, in art, in mountaineering or in entertainment can.

(ii) Science and technology bring independence

Perhaps the foremost burden of a developing country, even transcending that of material poverty, is a feeling of complete dependence on forces external to the country and the feeling of having no choices and no options. In a world in which knowledge and know-how are so pivotal for power in all walks of life, the relatively few countries in the world which are advanced in terms of such knowledge and know-how automatically dictate the life patterns for the whole human race, whether they wish to be thus "imperialistic" or not. Specifically, without a scientific and technological infrastructure in a country, everything in these areas will be determined by organizations, individuals and groups from abroad. Slavery in a pedestrian sense was presumably abolished some time ago but the status of being a slave (with intentional or unintentional masters) very much continues to be in existence and will remain so until knowledge and know-how are more equally distributed around the world. Such a distribution is impossible without strong indigenous scientific and technological infrastructures in existence in every country. Only such an infrastructure will permit the country to begin to be its own master, to develop several options and to choose among them and, in general, feel the degree of independence and dignity that befits an equal partner rather than a subordinate.

The feeling of frustration and inferior status brought about by a lack of capability and independence is very much in evidence today around the world. It shows up in a tour given by a visitor through the scientific and technological facilities of a country, during which the visitor is often left with the impression that "deep down" the demonstration of the country's participation in a worldwide scientific and technological activity takes precedent over concerns about the specific, short term, and material results of the research and development that is done, even though that concern is stressed in formal documents. It manifests itself in the international political arena, where many hot issues are directly attributable to a desire to assert dignity and pride in the face of the realities of a helpless and inferior status in de facto self-determination. For this reason alone, the development of the country's capability in science and technology is an urgent and highly desirable task.

(iii) Infrastructure as an influence on the country's world view

While science and technology do not constitute a whole culture, they can be powerful forces within any culture. The basic assumptions implied in scientific or technological work, such as the emphasis on change, the openness of human knowledge and capability, the ability of Man to influence his fate, the existence of a consentaneously objective method to resolve disagreements and thus facilitate and define progress, and many others, are ideas and attitudes without which any definition of "development" or "progress" is hard to imagine, and which therefore can have a crucial influence in determining whether the country will "develop" or not.

It is, therefore, advantageous for any country to have the opportunity to incorporate into its own traditional culture some of the view and attitudes science and technology provide. Such an assimilation process can take, and has taken, place without altogether killing the traditional value systems. In fact, throughout history, the successful and influential countries and civilizations have excelled in amalgamating the new with the old, the borrowed with the traditional, the foreign with the local.

The message of science and technology concerning Man's view of the world must be transmitted to the country by natives to that country who are themselves personally involved in doing science and technology. Talking about it is not enough. Few people will cherish a book on sex written by a virgin with twenty years of voyeurship.

The creation of a scientific and technological manpower that can thus radiate the ideas and attitudes of science and technology to the population as a whole is a special challenge, since by no means all scientists and engineers will be suitable for this function. This is one more reason why the establishment of such an infrastructure must begin very early in the country's overall development, so that one can count on statistical fluctuations over a long time to produce publicly influential leaders of science and technology. The particular examples one can find in the history of the developing countries in the last 3-4 decades suggest that such leaders can have a monumental impact on their country's attitudes and morale.

COMMON DEFICIENCIES IN SCIENCE AND TECHNOLOGY POLICIES

A complete list would be a long one indeed. It will simply select a few representative problems, some of which might be particularly appropriate for attention by UNCSTD.

(i) The false equation: Development = Economics

As was evident from the previous discussion, the development process is a highly complex conglomeration of cultural, philosophical, economic, social, political, attitudinal, geographic and other elements, both in motivation and in evolution. It is, therefore, shocking to see the widely pervading practice of equating development with economics, that is, considering only short-term material elements. That single-purpose, simplistic organizations like the Agency of International Development of the United States would exhibit such as attitude is perhaps not surprising.

But the malady is much more widespread. Formalistic and vacuous science and technology councils, ministries, committees and directorates in many countries, as well as many United Nations agencies, fall into the same trap. It "policy" is formulated on the basis of such narrow conceptions, it is not surprising that most of them fail even in the narrow area in which they are intended to be applied.

(ii) The false time scale - how the crisis is perpetuated

There is an overwhelming tendency in *de facto* development activities pertaining to science and technology to concentrate on the tomorrow and ignore long-term considerations. Countries order their young people to be narrowly trained in problems of momentary prominence, forgetting that by the time these young students reach maturity in terms of scientific and technological activity, different crises will be confronting them in which their narrow education is useless. Virtually all efforts are directed toward the existing problems thus enhancing the seriousness of problems arising in the future.

This attitude tends to upset the desired balance between scientific and technological activities in favour of low-grade technology, the tangible results of which are expected to manifest themselves immediately. The proper balance between basic and applied scientific research is also upset, disfavouring the former and hence *de facto* handicapping both.

This obsession with the immediate future may appear to contradict the other obsession of many countries, to be discussed next, namely that of planning. The resolution of this apparent paradox is simple and will be explained in the next subsection.

(iii) The false emphasis: "Planning, planning über alles"*

When a visitor is given a summary of the country's scientific and technological capability, the briefing always begins, and often continues and ends, with the exhibition of national science and technology development plans. Indeed, much of the time and effort of the national science and technology policy apparatus appears to be spent on planning. Marvellous organizational charts showing vertical and horizontal relations, time evolution charts, computerized planning facilities, etc., adorn the walls of the offices, and the training of personnel is concentrated in the areas of planning and forecasting.

In comparison, if and when the visitor has an opportunity to acquaint himself with specific research or development projects, he finds that very little if any attention is paid to the development of skills and capabilities in decision making and implementation. Decisions are often made haphazardly, by unqualified people, in the absence of pertinent information, and hence the actual activity resulting from such a procedure is feeble. There are, of course, exceptions and they readily stand out among the crowd: those projects which are led by imaginative, skillful, experienced, enthusiastic, and highly competent scientists and engineers can be easily identified merely by the exciting, lively and energetic atmosphere that prevails among the people in the project as well as by the results of the project itself. Yet, on the whole, the appearance of the overall system suggests that many consider planning 90% of the whole job, with a meagre 10% assigned to all the rest.

But not only is planning so prevalent, it is also poor in quality. A functional model of planning involves some goals, an input, some processes and an output. Planning for science and technology is particularly deficient in working with output. As we saw earlier, the output of science is knowledge and the output of technology is a process, a method, a prototype. Neither of these is easy to quantify. When we talk about the output of a tomato factory things are infinitely simpler: the number of cans of tomatoes, with some minimal attention to quality, might do the job. But neither science nor technology is directly connected to such easily quantifiable production. Furthermore, the quality of the output in science and technology is extremely crucial, something that is completely ignored in most planning processes. In fact, national plans often simply ignore output altogether and substitute input for it, thus resulting in such grotesque statements as "the goal in science for Country X in the next five-year plan is to produce 500 more scientists", as if the purpose of science were to produce scientists.

It is not surprising that planning for science and technology turns out to be so poor and pointless. Apart from the conceptual question of limits on the extent to which scientific and technological activity can be planned at all, such planning is done mainly by people who are not scientists or engineers, know very little about the *de facto* workings of scientific research or technological development and thus the whole operation turns into an isolated academic exercise in economics.

The result of this is that the ensuing plans have very little relationship to what really happens in the country in science and technology. This is the clue to the apparent paradox mentioned earlier, between the predilection for planning (which presumably takes into account the future) and the almost exclusive emphasis on short-term considerations. Whatever the plans may say, the actual decisions made by a medium-level bureaucrat in the ministry or council are conceived in the light of a very narrow and short-term view of science and technology.

(iv) The false climax: No evaluation

One of the most amazing aspects of science and technology in most developing countries is the virtual absence of an evaluative procedure which could determine the success or failure of work in science and technology, either prior to committing support to it, or after the work has been completed. Infrastructure for such evaluation is non-existent. To be sure, nominal attention is given to research proposals to ascertain, usually from the title of the project, whether it "fits" the national "policy" or not, and completed projects are perfunctorily monitored in terms of whether the "progress report" written by the researcher himself satisfies certain formalistic requirements. But a substantive assessment, in terms of peer review or other well-established methods, is indeed very rarely used.

There are a number of factors contributing to this state of affairs, which have been discussed previously in the literature (6) and will not be repeated here. In this light it is however not surprising when, as mentioned earlier, planning is non-functional, decisions are divorced from plans and are frequently made badly and implementation is lagging, and then all this is left unchanged. Remedy is not forthcoming because in the absence of evaluation these discrepancies are not even discovered.

(v) The false classification: Applied scientific research versus technology

As we saw earlier, applied scientific research and technology are two different activities. The former results in new knowledge about natural phenomena, generated with the motivation that such knowledge may be applicable in some process or gadget in connection with some material problem. Technological development work, in contrast, is the utilization of existing knowledge (whether common empirical knowledge or knowledge generated by science) in investing processes, building gadgets or constructing prototypes which then can be utilized in production.

When a country is faced with a practical problem of a material nature, its solution generally involves both applied scientific research and technological development. The two types of activity will be carried out by two different groups of people, with different education, training, skills, motivations and capabilities, sometimes working together in a coordinated fashion but sometimes working separately and even at different times.

Nominally, a considerably fraction of the financial resources of most developing countries, earmakred for research and development, are spent on applied scientific research. Huge and expensive governmental institutes and laboratories are established, carrying names like Council of Scientific and Industrial Research, Federal Institute of Forestry, Applied Science Research Corporation, and the like. It turns out, however (7), that much of the activity in many of these organizations is low-level technological manipulation based on trial-and-error. There is simply no tradition of applied scientific research, that is the reaction of new knowledge which may be useful in applications.

One of the many reasons for the absence of such applied research activity is in the overly narrow scientific and technological education that often prevails in these countries. (8) Citing, curiously enough, the needs of applied research, the education of much of the scientific and technological personnel is narrowed and constrained at a much too early stage to deal only with matters that are judged "relevant", usually by people who themselves come from an overly constricted educational background. What is ignored by them is the fact that the more applied the research is, the greater need there is for a broad educational background, because while topics for basic research arise in single disciplines and can be determined by the internal criteria of science only (and by the researcher himself), problems in applied science are defined by external circumstances and hence are likely to be inter- and multi-disciplinary. Hence education for applied research demands a much greater breadth than education for basic research.

(vi) The false community: Lack of internal communication

Communication within a given country between scientists and others is often appallingly weak. (9) By "others" I mean other scientists, or technologists, or governmental figures, or the population as a whole. The same can be said for technologists who are isolated from other technologists, technology policy makers, from representatives of the productive sector of the country and from the public.

Such an internal isolation is in part a matter of a lack of communicative tradition, partly a matter of questionable personal relations within a small group but also partly a matter of negligent science policy. Stimulation of such internal interaction, in terms of administrative procedures, catalytic financial incentives and other relatively easy means is generally absent and in fact the problem itself is not well appreciated by the bureaucratic machinery handling the day-to-day matters of science and technology.

(vii) The false linkage: External isolation of the scientific and technological community

One of the most debilitating handicaps of doing science and technology in developing countries is the isolation from the worldwide scientific and technological communities. (10) This isolation manifests itself in all respects: scientific and technological journals (current issues and back volumes), scientific and technical reports, scientific and technological meetings and conferences, opportunities for "hands-on" technology transfer, short and long term visitors from abroad, opportunities for visits to institutions, laboratories, or development centres abroad, etc.

Analyses of the "communication gap" have also appeared frequently in the literature (10) and will not be repeated here. Although full remedy cannot be effected without the cooperation of the international scientific and technological community, some helpful programmes can be instituted even by local science policy organizations to benefit the scientists and engineers in that particular country. In reality, however, I know of no such programmes.

(viii) The false superstructure: The separation of science policy from the active scientists and technologists

In most of the countries where science and technology has a fairly long-standing tradition, the mechanism for making policy for science and technology incorporates representatives of the active scientific and technological community. For example, in the United States the President's Science Advisor is generally a reputable scientist with contemporaneous or recent active research involvement, and the innumerable advising committees of the various governmental departments consist of working scientists. The same is generally true for the top leadership of the important governmental agencies such as the National Science Foundation. Although there are always some grumbles, it would be quite unfair to charge that a gap exists between the active scientific and technological community and the science policy mechanism of the United States. A similar situation exists in Great Britain, Germany, France and the other scientifically significant countries.

In contrast, in many developing countries policy for science and technology is made exclusively by people with no present and, for the most part, no past credentials in scientific research or technological development. Civil servants with little if any scientific background, economists and politicians join with some people with scientific degrees but either no or no recent research involvement. Since seniority *per se* is often a strong force in the tradition of these countries, preference for older people is strong and such people either had no opportunity to participate in significant research (because the state of the development of science and technology in their youth was too primitive) or have given up research some years prior.

A particularly "dangerous" type often in evidence in developing countries is the young social scientist who received "training" in "science policy" and then is appointed to work in a "science policy organization". Such a person in "dangerous" for a number of reasons. First of all, his view of science and technology will be that of the voyeur already mentioned earlier. This view is likely to turn out to be a formalistic one, because for an outsider form is easier to grasp than substance. Second, he is in for trouble in his relationship with working scientists and engineers who, justly and unjustly, will consider him as a "mere bureaucrat" and will find substantive communication with him rather difficult. It would be an exaggeration to say that in my encounters with science and technology in developing countries I never met a person of the above type who was at least moderately successful in his activities. It is, however, an accurate statement that such successes are rare exceptions.

This concludes the brief listing of eight important deficiencies of policies for science and technology in developing countries. The next section will propose some action to be taken by UNCSTD to compensate for some of these deficiencies.

SPECIFIC RECOMMENDATIONS FOR UNCSTD (11)

Concentration on infrastructure building

Our discussion tried to indicate that the rapid and effective development of the scientific and technological infrastructure in a developing country, and in particular the energetic creation of a high quality and broadly educated scientific and technological manpower is the key to the future of the developing countries in science and technology. It is therefore recommended that UNCSTD concentrate its attention mainly or even exclusively to this problem area, in which international assistance and cooperation are very essential. Help in infrastructure building has lasting consequences and is not a band-aid type of measure. Also, the building of infrastructures is a politically rather non-controversial problem area. One of the big dangers of UNCSTD is that it will develop into a sterile shouting match between political demagogues of various persuasions, in which accusations are exchanged and labels thrown at each other while the actual issues affecting science and technology in the developing countries remain untouched. This danger is enhanced by the fact that a goodly portion of the delegates sent to UNCSTD by the various countries appears to be politicians and others ignorant about scientific and technological policy issues who therefore, because of this ignorance, will be constrained to engage in political rhetorics since they do not know anything else. It is, in my opinion, the duty of the professional community around the world to warn UNCSTD ahead of time and try to expropriate at least one or two days at UNCSTD during which something of substance will be discussed.

Breadth of education

As is evident from our discussion, the narrowness of education in science and technology is a significant cause of the weak position of many developing countries in these areas. There are a number of specific measures, both in local education and in the education abroad of students from developing countries that can be taken to remedy this defect. Many of these have been outlined in the literature (11) and hence will not be repeated here. UNCSTD should direct its attention to these proposed programmes and find ways of implementing them.

Reorientation of policy activities

The education of science policy makers, as well as the actual science policy activities, need urgen reforms. In particular:

(i) The overbearing emphasis on planning should be replaced by a much greater concern with decision making and, above all, with implementation.

(ii) The personnel involved in science policy making should be revamped to attain a new balance: many fewer economists, civil servants, bureaucrats, politicians and pro-forma scientists and technologists, and a much greater representation of working scientists and engineers.

These two objectives should be reflected both in the local structures in the various countries and in the science policy activities of international organizations, for example UNESCO. To achieve this, some drastic personnel changes may be needed both locally and internationally.

UNCSTD might find it difficult to be very effective in this in the short run. If, however, a consensus is reached in this respect and mechanisms are established in the various bilateral cooperation programmes between countries to reflect this consensus, eventually relief will be achieved.

Establishment of evaluation

This is a large task. It consists, first, of establishing a generally acceptable, realistic and functional evaluation methodology for assessing the operation of scientific and technological institutions and of science policy bodies in the developing countries, as well as the operation of international agencies and organizations. Methods for assessing have in fact been developed in the past (12) and some are successfully used in some of the advanced countries so the task, while challenging, is far from impossible.

Second, mechanisms should be created so that organizations internationally and locally are able to use these procedures. This may involve schemes of utilizing international peer review networks, computerized "objective" indicators or whatever method appears most suitable for the purpose. UNCSTD would have a good opportunity to be effective in this area since it could enter this field without being tied to any particular country or group and its contributions to this field would therefore be less construed as a sign of weakness on the part of the Third World. Specific programmes have already been mentioned in the literature.

Boost for applied scientific research

As mentioned earlier, in many developing countries, apart from a tiny amount of basic scientific research, the resources for research and development are predominantly spent on low grade, trial-and-error type technical manipulations and applied scientific research is on the whole missing from the spectrum.

UNCSTD should direct its attention to this void and find ways to boost applied scientific research in developing countries through various means of communication, cooperative research, education, etc. Some of these have also been mentioned in the literature (7), and hence need not be repeated here.

Scientific and technological communication

This is a prime area for UNCSTD's attention since many of the defects are caused by the distorted patterns of communication within the worldwide scientific and technological community. A specific list of projects has been suggested to UNCSTD elsewhere in the literature. (13) It should also be stressed that at least some of the very helpful programmes in this area are financially extremely economical and hence are easily within the capabilities of the leading countries even in times of financial hardship.

Mechanisms to bring active scientists and engineers into science policy making

There are various vehicles to accomplish this objective. Among them are:

(i) Seminars and practical working experience in science policy and the science for practising scientists and engineers. These seminars should be conducted by scientists and engineers with a long-standing background in active work in science and technology and practical experience in decision making, implementation, evaluation and general management of scientific and technical projects.

(ii) Auxiliary education of students from developing countries who are being educated in a more advanced country, to expose such students to elements of practical science policy ranging from operating a workshop, a library, or a university, and performing in the electronic or glass blowing shop to elements of national science policy and the fundamentals of the science of science. (14) Such auxiliary education could be carried out during summer vacations and should be conducted by a staff with qualifications similar to those mentioned under. (1)

(iii) Special financial and other incentives for scientists and technologists in developing countries to be able to carry the double load and double duty of continuing with research and development work and being involved in science policy activities. In many advanced countries where university teaching duties are lighter, laboratory assignments more flexible, and organizational, logistic and technical support for research as well as for policy are better developed, such double activity is somewhat easier to bear. Similar conditions might be at least approximated also in developing countires by some relatively minor special arrangements for deserving personalities.

Footnote

* A variation on "Deutschland, Deutschland über alles" (Germany, Germany above all), the supernationalistic German hymn between the two World Wars.

References

(1) I will, however, give references to other papers of mine where some of these points are discussed in greater detail. In fact, most of the references will consist of such "selfcitations". The many interesting writings by others will not be referred to here explicitly but can be found as references in the other papers of mine that I am referring to

(2) See for example M. J. Moravcsik, "What is Science", Science Centre Bulletin (Singapore), 4:1, 6 (1977), and M. J. Moravcsik, How to Grow Science (book now in manuscript form, to be published), Chaper 1

(3) See for example M. J. Moravcsik, "Scientists and Development", Journal of the Science Society of Thailand 1, 89 (1975)

(4) See for example Kenneth Clark, Civilizations, Harper and Row, N.Y. (1969)

(5) See for example M. J. Moravcsik, "The Context of Creative Science", Interciencia 1, 71 (1976) [reprinted in Everyman's Science (India) 11, 3, 97 (1976)], and M. J. Moravcsik, How to Grow Science (book now in manuscript form, to be published), Chapter 2

(6) See for example M. J. Moravcsik, "Developing Countries and the Fruits of Science", Leonardo 11, 214 (1978). See also Reference 11

(7) See for example M. J. Moravcsik, "Applied Scientific Research and the Developing Countries" Science and Public Policy 5, 82 (1978)

(8) See for example M. J. Moravcsik, Science Development - The Building of Science in Less Developed Countries, PASITAM, Bloomington, Ind. (1976) (Second Printing), Chapter 2

(9) See for example Reference 8, Chapter 4

(10) See for example Abdus Salam, "The Isolation of the Scientist in Developing Countries", Minerva 4, 461 (1966)

(11) See for example M. J. Moravcsik, "Science and the Developing Countries", position paper toward the United States national paper for the United National Conference of Science and Technology for Development (1977). Copies obtainable from Andrew Pettifor, Room 1229, National Science Foundation, Washington 20550, USA

(12) See for example M. J. Moravcsik, "A Progress Report on the Quantification of Science", Journal of Scientific and Industrial Research (India) 36, 195 (1977)

(13) See for example M. J. Moravcsik, "Something Concrete for Vienna", International Development Review (to appear in the April 1979 issue)

(14) See for example M. J. Moravcsik, "Foreign Students in the Natural Sciences: A Growing Challenge", International Educational and cultural EXCHANGE 9:1, 45 (1973). The summer seminar described there is yet to be implemented, in spite of various attempts to attract funds for such a programme

PART V

International Cooperation

15. Science and Technology in Development Planning: the International Dimension

GUSTAV RANIS

INTRODUCTION

As in other areas of the current North-South discourse, the subject of the ideal role of science and technology in development is not a value-free topic; nor inevitably is the question of how it should be treated in the context of national plans and international collaborative efforts. As elsewhere, DC analysts and spokesmen are likely to emphasize the importance of the proper internal LDC policy setting, and LDC analysts and spokesmen the importance of the international environment, if science and technology are to make their appropriate contributions. Moreover, since, in this particular realm, both the multinational corporation, the sacred cow of many advanced Western countries, and the market mechanism, viewed as a neo-colonial transplant, are directly engaged, the volume of emotion and political heat generated tends to make efforts at positive analysis unusually difficult. Finally, with the role of science and technology (S & T) transfer from DCs to LDCs constituting a peculiarly messy, multifaceted, difficult to model and difficult to measure area, ideologies on both sides have had themselves a field day.

My paper cannot hope to remedy that situation. Nor, written by a member of the "Gringo Establishment", can it realistically expect to be "above suspicion". All I can, and will try tp do is state the case for what I conceive to be the potential role for international collaborative action in an area in which the idealized working of the system does depend heavily on the developing countries' own planning and policy structure. Accordingly I shall briefly outline out conception of the internal policy posture LDCs should ideally take to obtain maximum benefits from S & T in a world of nation states differing in levels of per capita income, resource endowment and human capacity. The last section will be devoted to the role of external DC and international action in bringing us closer to this ideal.

THE ROLE OF S & T IN DEVELOPMENT

Defining any idealized role for science and technology in development is, of course, itself an unduly ambitious task but one that cannot really be entirely avoided if wer are to be able to place both national and international actions in their proper context. Accordingly, with such a wide terrain to cover, we will have to resort to rather cavalier treatment of some weighty subjects as well as the occasional use of admittedly challengeable undocumented assertions.

We start with the assumption, as to objectives, that the typical contemporary LDC development effort is aimed beyond traditional growth, to include wider participation, employment and distributional equity; this means that not <u>any</u> growth path will do if these objectives are to be mutually reinforcing rather than possibly conflicting. Secondly, as to means, we assume that the LDCs attitude towards the DCs is essentially "pragmatic" in the sense that the problem of DC/LDC contact is viewed as an intrinsically positive sum game from which both parties can, at least potentially, benefit rather than as an inevitable loss situation for the LDCs, in which case complete de-linking might well be the preferred option. A strong corollary to this proposition is that the very existence of a "rest of the world", very different in virtually every respect and further "up" on the development ladder, constitutes perhaps the single most important fact of life affecting an LDCs science and technology choices - and performance - whether for good or ill.

At a less cosmic level we should, moreover, consider the notion that science and technology, though often discusses as if they were of one piece, are really quite different (if related) animals and must be analyzed differently in the context of both development theory and planning.

If by "science" we mean the accumulation of systematic basic knowledge about the natural universe around us, and by "technology" the application of such knowledge to construction of ideas useful in production, we should in all candour admit at the outset that the exact relationships between these two and development are not at all well understood. Causality exists, we are quite sure, but it may be indirect, lagged and, above all, complicated; at times we may not even be sure of the direction of causation. While admittedly small comfort, it should not surprise us therefore, that we do not have a very clear handle on which to harness the bounty of S & T for LDC development efforts.

The easier part is that relating technology to development, i.e. measuring the consequences of technology change once it has occurred, for growth, employment, distribution and/or any other societal objective. The harder question is what causes technology change, as between imported capital, imported R & D, or domestic R & D; we are not even sure whether R & D is simply something richer countries can afford rather than what makes countries richer, via technology change. Sliding along the R & D spectrum, from applied to basic, we often assert that science must precede technology, which causes growth. Certainly, for any given country, it may be possible to rely more on the universality (and non-appropriability) of international science - instead of trying to establish a frontier capacity everywhere. Yet what renders decision-making in this area doubly vexing is that puzzles borne out of technological failure may well be the ideal stimulant for further scientific progress. LDCs are thus typically not only uneasy about how much technology should be home-grown, imported and/or adapted, but even more so with respect to the resources to be allocated to basic science which can have quite a voracious independent appetite. Yet some level of scientific capacity is undoubtedly required to choose technology wisely and adapt and absorb it well. This capacity to ask the right questions and be catalytically involved in providing the answers is likely to be a national, not a supra-national, asset. But it does not just happen; it requires resources, for example in education, and attention, for example via the types of direct and indirect government intervention.

Our position on these difficult behavioural underpinnings is that the LDC cannot afford to "sit back" and let the DCs incur all the costs of international science and of the trial and error that go into basic R & D and inventions - especially now when the pace of science has accelerated and narrowed the gap to technology. Yet it cannot afford, and should not try, to "show the flat" in every field of basic scientific endeavour. The less developed world has many scientific institutes which contribute neither to science nor to technology. Most observers agree that the biggest waste of all is second-rate basic research. Our suggested "middle road" points in the direction of a broad enough spread of science and technical education and a flexible enough economic environment to permit both appropriate scientific and technological choices as well as indigenous improvements and adaptations. International science is only slightly more a "free good" than technology; there are important search, identification, transfer and assimilation costs involved here as well. And there are fields of scientific endeavour such as agriculture and health which must be represented within LDCs because of their country- or region-specific character.

Without basic agricultural science-oriented research on a country or at least regional basis, the recent chemistry and Mendelian law-based innovations which have gone under the name of the Green Revolution would not have had the necessary sustaining power and the necessary defense against specific local (e.g. pest and disease) problems. Similarly, in the field of health, few people would argue that one transnational science can reailly be equally responsive to the very different conditions around the globe. Even in industry, e.g. agricultural implements, or leather goods, or textiles, specific technological problems related to soil type, pasture quality and humidity may at times clearly require the puzzle-solving response of science. This holds, in spite of the higher risks of science, given the difficulty of predicting the precise nature or even direction of the two way interactions.

We must, moreover, be clear as to what we do and do not mean by the "appropriateness" of technology for a given LDC at a given point in time. We do not have in mind any particular set of "labour intensive" or "intermediate" or "traditional" technologies; rather, we have in mind the notion, both profound and tautological, that there exists many alternative ways in nature both to produce a given specified product and to alter those specifications slightly. "Appropriateness" then constitutes the joint selection of processes and products relevant to the maximization of societal objectives, given a society's endowment and S & T capabilities. This means that the appropriateness of technology choice includes product quality as well as technique choices and that it must be defined relative to the society's time-specific endowment, as well as its objectives.

"The" appropriate technology will thus in most product cases vary across countries according to differences in endowment, in tastes, as well as over time within a country. Moreover, while there may be a presumption in these directions, the "appropriate" process for a poor labour surplus economy is not always labour intensive and the appropriate good is not always a basic good. There clearly exists an empirical but not a religious presumption that the more severe the population pressures on the land, the larger the population, the greater the shortage of capital and human skills, the more likely that appropriate technologies will locate themselves at the labour intensive end of the spectrum. But all the empirical evidence we have come across would lead us to conclude that appropriate technologies are as likely to be "modern" machine-paced - based on current vintage blueprints - as of the "traditional", "handicraft" or "second-hand" machinery variety. In other words "advanced technologies" are not to be necessarily equated with "advanced country" technology. They can be modern _and_ labour intensive, or modern _and_ capital intensive, use imported _or_ domestic core technology, made use of extensive local adaptations _or_ not. There is no easy, comfortable answer; it "depends" - on the place, the resources, the preferences and the time. "Appropriateness" can do little more than sensitize us to the existence of a wide potential array of technologies among which the one best suited to the particular circumstances can, at least potentially, be located - or devised.

The problem today is no longer, we believe, as it was a decade earlier, related to the failure to recognize the existence of such a wide diversity of potential choices, certainly not with respect to alternative processes. The literature now recognizes the existence of a wide range of alternatives for all but a small subset of continuous process industries. The problem today is how to ensure that advantage is taken of the wide choice which potentially exists.

The adoption of an appropriate process and/or appropriate good within a developing country almost always requires the combination of a process of selection from the existing vast array of blueprints man has been accumulating over time with the major or minor modifications required to suit the always slightly different precise local conditions. Each private or public entrepreneur makes both these choices - often simultaneously - whenever virtually any production decision is contemplated. When he does so he has, at least potentially, available to him a vast array of techniques for a given bundle of quality attributes as well as a large number of attribute bundle alternatives. Why then is he not more selective?

There is absolutely no need for one more listing of typical LDC human or physical capital shortages, or one more critique of the typical LDC import substitution policies. But there is a need to remind ourselves that the international market for appropriate technology has at least two domestic dimensions which must be considered before the scope for international actions can become even remotely relevant. The first of these is the LDCs own human and institutional capacity to generate indigenous innovations and adaptations "on top of" imported technology, i.e. the domestic supply side, if you will; the second is the extent to which LDC entrepreneurs, public and private, are really seized with the importance of making more appropriate S & T choices, as opposed to ensuring that they do not lose their place in the queue for government favours, i.e. the domestic demand side, if you will. Let me briefly touch on each of these dimensions, and only to the extent needed for discussion of the topic which I have been assigned - and not to transgress needlessly on the turf of others.

It is well known that LDCs do only a miniscule 5% of the world's "official" R & D, i.e. what might be called the "white collar" variety. The question is what happens if we add the less spectacular, more informal, "blue collar" R & D, associated with the minor adaptations carried out in machine tool and repair shops and on factory floors, on which no statistics are available. Some LDCs have a lot of this activity going on in their industrial plants, large and small; others very little.

The reasons for this disparity on the supply side are not so well known. First and foremost, of course, is the relative overall shortage of the required capital and human resources, an intrinsic part of the very state of underdevelopment. Second, and often less fully understood, is the absence of appropriate institutional and information networks which permit existing process and product choices to be known and/or to be adapted. Even if we should accept the clearly misleading notion that the full storehouse of human knowledge, outside and inside a country, and across time, is really potentially available "for the asking", it takes domestic capacity ot illuminate - and it takes domestic capacity to effect the always necessary, if sometimes minor, local "twists" and adaptations. There is always the problem of relatively high search costs, of undue reliance on foreign salesmen, of a lack of indigenous problem-solving skills. Consequently, with respect to foreign technology we almost inevitably encounter the neglected "third factor" syndrome which tends to render the simple transplantation of foreign technology permanently x-inefficient. And even with respect to indigenous or import-based adaptive technology change, diffusion from one village to the next may be inhibited by ignorance and by lack of appropriate networking systems. The gap between "average" and "best" practice is likely to be much larger in a developing country which cannot count on the formal and informal intelligence networking systems provided by banks, extension services, catalogues, fairs, salesmen, etc.

Given the relatively small volume of resources spent on scientific and technological endeavour in the typical LDC, the problem would be less serious if these resources were better allocated. Science and technology institutes, of course, do exist in the most LDCs but, as is also well known, they are often less concerned with appropriate technology selection, adaptation and diffusion and more with meeting the approbation of the "invisible international college" of scientists and engineers. There thus clearly exist supply constraints in the technology markets of most LDCs, with resources and attention frequently addressed to the imitation of advanced country techniques and consumption patterns in the heavily favoured urban areas rather than the building up of indigenous technology search and adaptation capacity to serve the needs of a dispersed rural development effort. As Rosenberg has put it, "economic forces and motives do not act within a vacuum but within changing limits and constraints of scientific and technical knowledge". (1)

But there also exist less clearly understood demand constraints. An important side effect of the typical import substitution policy syndrome is that it channels the energies of the human resources that are available away from creative innovative effort and towards the maintenance of policy-generated windfall profits. When 25% or 30% rates of return are practically guaranteed, by virtue of obtaining a subsidized loan or an import license or some other rationed "goodie", the desire to seek out a more appropriate technology or appropriate good may be severely blunted. An entrepreneurial preference for the "quite life", or some sore of satisfying behaviour, can be ill afforded in an LDC already suffering from severe shortages in the capacity to innovate effectively. It is likely to be more important to the system's ability to reach its development objectives than the much more frequently discussed relative factor (and commodity) price distortions.

The resource, human, capital and organizational constraints affecting the internal LDC market for technology thus cannot be ignored in any discussion of what the DCs individually or jointly can do to be helpful. It is neither a form of "buck passing" or paternalism to recognize that the development problem - and its crucial science and technology components - cannot be "solved" from the outside; what is more it cannot even be effectively assisted from the outside _if_ the domestic parameters and constraints are not well understood, and _if_ domestic planning and policy changes do not propel the system in more appropriate directions. Only in that context, i.e. one in which the "typical" LDC is itself committed to strengthening the internal dimensions of the technology market, can the contribution of the rest of the workd - itself by no means inherently benign - be harnessed on the positive side of the ledger.

This point is most patently obvious with respect to the demand side. Nothing that outsiders can do - or fail to do - can have much effect on the intensity with which indigenous decision-makers are really concerned with the generation of an enlarged volume and an improved direction of technology change. The greater the flexibility of the virtually inevitable LDC import substitution regimes and the shorter their life spans the less severe the problems of inadequate attention, public and private, to a technology which permits the economy's changing resources endowment to be effectively deployed over time - and neglected urban squatters, rural industrialists and small-scale farmers to be effectively absorbed in the process. But there are central LDC policy matters which foreigners can only affect by discourse and persuasion, and possibly by providing some additional facilitating resources - _if_ the LDC is itself fully convinced on the merits. If, in the typical mixed economy case, millions of individual decision-makers are not being increasingly nudged towards the production of more appropriate goods - instead of import replacements - and towards more appropriate technologies - instead of prestige items - there is very little than can be done except continue with the current prevailing pattern of depending heavily on large-scale turn-key technology transplanted from abroad.

A balanced rural development plan, focusing simultaneously on domestic food producing agriculture and decentalized industry is needed to ensure a really effective domestic demand for appropriate technology. The agricultural sector, as is well known, has frequently received too little attention in past development efforts, especially during the primary import substitution sub-phase of development. It is important to avoid continued distortions in the internal terms of trade against agriculture since we attach great importance to the increased rural purchasing power as a precondition for balanced rural growth, i.e. the rapid expansion of both industrial and agricultural appropriate goods production in local, largely rural, markets. The more severe the distortion of the terms of trade against agriculture, the more serious the lack of purchasing power in the rural areas as a necessary precondition for such balanced growth, and the more unlikely the selection of appropriate techniques and commodities.

The pursuit of broadly defined development objectives usually also requires the evolution of a strategy for the spatial expansion of industries, especially in activities not subject to pronounced economies of scale, keeping in mind the extent of dispersion of the population, for both market and labour supply reasons, as well as the transport system. The reallocation of government overhead investments towards the rural areas, thus assisting rather than, as is so frequently the case, inhibiting the spread of internal markets can be of the greatest assistance in such development and diffusion of appropriate technologies and appropriate goods.

Building on local appropriate goods and local technological traditions may seem rather primitive but in many instances it really constitutes rebuilding traditions destoyred by a tendency to import reproduction rather than import replacement and an LDC government's frequent willingness to let existing village industries go down the drain. We are not proposing the artificial preservation of out-dated handicraft industries but the realization that such industries may well provide the core for modernized competitive production.

Turning to the supply side, the absence of the full range of information actually available to the individual economic agents cannot easily be exaggerated. This is not just due to the inadequacy of the book of international blueprints available to the typical LDC industrialist; more telling is the lack of sharing of information among similar situated LDCs and even among different regions - even villages - within the same country. Bamboo tubewells available only in one part of Bangladesh illustrate how often it becomes necessary to reinvent the wheel, or do without. While similar problems obtain in both agriculture and industry, their solution via government research institutes and extension services is further along on the agricultural side. No equivalent industrial R & D and extension service exists within most developing countries. The problem is not, we believe, tackled effectively by concentrating unduly on international reference or other types of "question and answer" services; rather, the basic networks within the developing countries themselves must be strengthened.

An institutional network focusing simultaneously on both static information and the capacity for R & D capacity should be encouraged. It is highly unlikely, given the best information network, that a particular process or quality bundle attached to a comodity will ever be precisely "right" for a particular rural industry and/or a particular local market. In our view, the kind of network which will effectively carry information must therefore at the same time be capable of adapting shelf technology - foreign or domestic - to local specifications.

It is likely that the place to start with is the existing networks within the developing countries themselves, either by redirecting their energies towards these more "mundane" tasks - and by the same token away from "breakthrough" or frontier science and technology efforts - or by creating new capacity focused on these rather non-traditional areas. The same networks which carry information about the so-called shelf of alternative processes and alternative appropriate goods must also have the R & D capacity to help individual entrepreneurs, public or private, to effect the inevitably necessary adaptations and help with the diffusion across the country-side.

A combined information, adaptation and dissemination network is thus essential because information about and adaptation of existing technology and output modification choices cannot and should not be separated. What is likely to become necessary in each developing country is centres of excellence in particular major industries where R & D on appropriate technology can go forward at the national level, but with related local adaptation and dissemination centres spread throughout the country. The whole system must, in the mixed economy content, be related to entrepreneurial responses which, in most developing countries, migh mean a role for rural branch banks, for instance, rather than the reaction of the industrial equivalent of an agricultural extension service.

The financial implications of such a network in a developing country are not all that large. But what is even more encouraging in this respect is that very few additional resources are probably necessary. As we have pointed out above, most developing societies already have a substantial science and technology-oriented institutional network which has, however, typically shown only a marginal interest in the area of appropriate goods and/or appropriate processes. The redeployment of some of these resources, away from frontier science and in the direction of the diffusion of information on the feasibility of alternative attribute combinations, as well as on experimenting with appropriate technology change possibilities, could be of the greatest value. One way to ensure that reconstituted institutes of this kind become part of the network we have described is that they increasingly have to pay their own way be means of private sector contracts and that an effort is made to permit their scientific/technological staff to be rewarded in relation to these objectives rather than exclusively by the applause arising from the "invisible college". Assuming that demand exists, it would take very little to shift some of these resources into the kind of networks I have described, including a provision for the support of an appropriate technology/supervised credit dimension within a development or commerical rural banking system.

Appropriate R & D activity could presumably include both hardware prototypes, e.g. focused on the scaling down of advanced economy technology, and such software activities as are required for in-plant floor level adaptive technology change. A particular target of attention would be the creation of an indigenous capital goods capacity, especially at the village level. Some such capacity already exists in most country situations in the form of repair shops, foundries, village blacksmiths, etc. It is in such individually non-spectacular, nevertheless quantitatively impressive, places that indigenous innovative capacity usually exists and could be substantially enhanced with a minimum of additional outside inputs. Industrial co-operatives, for examples, aided village blacksmiths in the case of Sri Lanka reported by Jequier. (2) Elsewhere, links can be forged, perhaps with the commercial banking system or with rural development banks, in contrast to a separate rural agricultural and industrial bank structure. Encouragement of mechanical engineering industries is likely to be helpful not only because they are themselves normally labour intensive but also because they provide additional indigenous technology choices within each of the customer industries. (3) Nowshirvani (4) has documented this same process in the Iranian agricultural machinery industry where many of the small scale machinery producers started out as seasonal repair shops but, as their skills developed, moved into spare parts and final products, including making the considerable effort required to standardize and simplify capital goods production.

To summarize, the typical LDC always has the option of going it along and rejecting all foreign science and technology as inherently injurious; in such cases its own development planning and the role assigned to technology change can be clearly assessed. The closest, I suppose, to any real world cases of this type in the developing world are Albania, Burma and China. Little is known about Albania; Burma has been stagnating; and the Chinese experience after the Russian pull-out and before the re-opening to the West requires further study. The majority of the contemporary LDCs, socialist or non-socialist, do not seem to be convinced that technological autarky represents the best way. They apparently continue to believe that the co-existence of technologically more or less advanced countries in this shrinking globe, while undoubtedly a continuing source of friction, can, at least potentially, also be rendered beneficial to them. I shall now turn to an examination of the conditions than can make this a reality, i.e. bring us closer to the idealized role of international science and technology in contributing to LDC development objectives.

SCIENCE AND TECHNOLOGY: THE INTERNATIONAL DIMENSION

The usual assumption, of course, is that the most helpful contribution the rest of the world can make to any given LDC is to transfer to it capital and the embodied or disembodied results of its previous basic and applied R & D efforts at the lowest possible price. Thus most of th discourse, and many of the complaints of the LDCs, have been directed towards the terms on which advanced country technology has actually been transferred rather than on the content of what has been transferred. This is not to imply that the discussion on terms is irrelevant - especially in reference to the operations of multi-national corporations which we shall turn to in a moment. But we do feel that it has been given too much attention relative to the identification of what it is the LDC should really be seeking abroad in terms of its own objectives. It is quite candidly our conviction that the biggest failure in the realm of international co-operation in this field has been not recognizing that the first, and essential, step must be to help enhance the LDCs own capacity to make better scientific and technological choices. The kind of general scientific literacy Japan achieved in the 19th century was infinitely more valuable than any specific transfer of science or technology from the U.K. or Germany. This is even more true of the achievement of a broadly based indigenous technological adaptive capacity. Both of these capacities must be developed at home but can be aided by the intelligent application of help from abroad. They do not, however, involve simply transferring things in a massive fashion from here to there, as the conventional wisdom so often seems to imply.

Let us being with help on the illumination of existing technology choices around the globe. The importance of the absence of the full range of information actually available to an individual LDCs economic agents cannot easily be exaggerated. This is not just due to the inadequacy of the proverbial "book" of international blueprints available to the typical LDC industrialist; more telling is the lack of sharing of information among similarly situated LDCs and even among different regions - even villages - within the same country. This problem is not, as we have already indicated, tackled effectively by setting up international reference or other types of "question and answer" service. Rather, the basic networks within the developing countries themselves must be strengthened; and the same networks which carry information about given alternative processes and goods must also have the R & D capacity to help individuals effect the inevitable twists and adaptations. (5)

One such an internal network has been established, the LDC can be inserted into existing or new international research and information networks. Organizations such as VITA in the U.S. and ITDG in the United Kingdom currently act as clearinghouses for new appropriate technologies. IMAT (An International Mechanism for Appropriate

Technology) was proposed by the Dutch Government to be a catalytic agent for strengthening LDC capacities in this field, but has apparently been stillborn. The U.S. is about to establish an Institute for Scientific and Technological Cooperation (ISTC) which, along with its Canadian and European counterparts, might provide the beginnings of a diversified but integrated international system. But we believe that an essential first step must be to help create the internal capacity to ask the right questions and provide adaptive responses.

The developed countries can help to strengthen this technological choice capacity within the developing countries in a number of ways - if asked. For one, public sector DC actions could begin to concentrate on the transfer of financial and human resources focused on enhancing LDC capacity to ask the right questions and to choose more appropriately, rather than on simply transferring final packages of foreign technology and capital. This could entail a wholesome change in emphasis in both bilateral and multilateral foreign assistance and in technological cooperation generally. Outsiders could be especially helpful with the creation of a few national centres of excellence in important industries relevant to a particular LDC or region. Instead of imitating, on the industrial front, what was accomplished for agriculture in the realm of the various international crop research institutes, the idea here would be to let such national centres gain regional acceptance via the demonstration of performance over time. Moreover, outside human resources, seed money and the encouragement of regional "traffic" can be helpful in building a South/South dimension into such national centres of excellence which become part of an overall LDC technology information, adaptation and dissemination network.

A second potentially fruitful area for international cooperation is concerned with the exercise of influence on the reallocation of indigenous budgetary and human resources, away from the big breakthrough/big science emphasis of yesteryear and towards selective import and adaptation choices across a number of industrial sectors. Since the existing institutional incentive systems reinforce the concentration on "frontier" activities, new priorities and an associated reward system could be devised to redirect some of the research. The DCs can help here by establishing international awards for significant contributions to the development of more appropriate technology, by encouraging the exchange of scientists, establishing a sabbatical leave system for LDC personnel, and supporting cooperative research activities among "neighbouring" LDCs and, selectively, between some DC and LDC institutions.

Much can also be done by making additional financial and human resources available through financial intermediaries of one kind or another. Adaptive process and product changes of an individually non-spectacular but cumulatively impressive magnitude are typically made, or not made, in thousands of dispersed locations all across an LDCs heartland - e.g. in village foundries, bicycle repair shops as well as on factory floors and machine tool shops. The kind of "blue collar" R & D involved here, tending towards capital and skilled labour saving innovations, may be much more relevant than the normal DC version of an official white collar type of R & D, tending towards ever high capital intensity.

The extent and depth of available rural entrepreneurial/technological capacities will, of course, vary substantially across countries. The only thin we can be quite sure about is that such resources are usually underestimated by government planners just as the existence of responsive peasants was given unduly short shrift a brief decade ago. The best way to reach such dispersed actors in the rural areas of an LDC may be via existing or new financial institutions including development banks or the rural branches of a commercial bank. Additional resources could be made available to create and, for a time, subsidize supervised credit cum adaptive technology facilities within an essentially commercial rural banking structure in an effort to provide for the necessary fusion between credit, technological information and problem-solving capacities at the local level.

It is our conviction that the main drama linking science technology and development will be played out away from the urban centres of the typical LDC which usually get most of the attention. Foreign influence today is nevertheless felt most pronouncedly, in the first instance - and sometimes in the last - where the contact with imported technology is most pronounced, i.e. in the large scale urban industries and via the influence of private investors. I now turn to this aspect of the international dimension.

The supply-side impact of imperfect competition in international markets, both with respect to processes and (especially) with respect to products - as exemplified by the transfer of patents, trade-marks, licenses and the like from DC to LDC - should not be minimized. We are not disputing the necessity for some guarantee of innovation profits, for a time, for the advanced country's investors in R & D; but there can be little doube that the extent of socially necessary private appropriability of technological information is much less that what is often encountered on the ground in LDC markets. In this sense, international patent legislation, to cite but one example, coule be usefully reviewed to ensure that patents are actually used (and technology transferred) rather than serve as a way of controlling markets and inhibiting the flow of information.

There has been an unusual volume of debate on the role of patents in technology transfer and indigenous technology change. One side has taken the position that patent protection is necessary to encourage domestic industrial R & D, and that the granting of patents to foreigners is necessary to induce the transfer of technology and capital. Opponents point out that patents granted by LDCs to nationals generally represent only 10 to 25% of the total and that patents awarded to foreigners, mostly large MNCs, often have not yielded the expected technology and capital transfers. These is evidence that up to 80% of the patents registered by foreigners are not utilized but employed to protect markets and restrict entry to both local and competing foreign technology suppliers. Even when patents are "worked" in the LDC they have often not brought the expected new flows of investment. Vaitsos (6), for example, cites the case of Colombian pharmaceuticals in which the granting of patents not only did not promote foreign investment but was used as a device to force the sale of local firms to transnationals. All of this is conceptually different from the additional problem, taken up below, that technology transfers themselves may not be conveniently separable from other parts of the foreign investment bundle, for example, the movement of capital, management, technical assistance, etc.

The relative performance of multinational corporations in the selection of appropriate technology is very much in dispute. Their supposed superior scanning capacity across countries is usually pitted against their supported tendency to apply domestically grown rules of thumb and to misuse patents, trademakrs and licensing arrangements by tying up technology with other items of transfer, rather than effectively choosing the processes and goods most appropriate for a particular host country.

We would argue for an unbundling of the MNC into its component parts and a much more explicit examination as to just what is being transferred and what is being paid for, and at what rate, at each stage of the development process. Most misunderstandings arise because of the mystique of the powerful, footloose MNC, bargaining with the poor, optionless LDC, the latter thus being pressured to buy what is essentially a "pig in a poke". The capital, technology, management and entrepreneurship components of any deal should be spelled out as fully as possible and each component priced out. Screening procedures which exist in virtually every LDC, especially during the import substitution subphase, should concentrate more on disaggregation and full disclosure, thus permitting comparative shopping and other than all or nothing acceptances or rejections. Fade-put and divestiture agreements can similarly be negotiated much more intelligently <u>ab initio</u> in the light of some historical perspective which might provide, for example, for a transition from the wholly owned subsidiary to the joint venture form after ten years, and possibly further reassessments in the direction of licensing or management contracts thereafter.

The encouragement, via the various DC bilateral or multilateral investment guarantee programmes (like OPIC) of more flexibly time phased contractual arrangements entered into by MNCs could also make a large contribution here. It is entirely possible that transnational enterprises which do possess unusual cross-sectional scanning opportunities could be induced to exchange information on their appropriate technology adaptation experience across subsidiaries. This could be done on a basis which would not violate supposedly sensitive proprietary information constraints. Before favourable OPIC-type action is taken, actions which usually involve DC taxpayer-prodided subsidies, MNC sensitivity to the role of export prohibitions, their insistence on exclusive market and market sharing arrangements, as well as additional protective legislation, should also be explored. We cannot, of course, expect a U.S. or other transnational enterprise to be concerned with other than profit maximizing criteria in any particular country situation. But international cooperation in this field means working togehter on an improvement in the environment within which these institutions operate. In that sense at least the large foreign subsidiary is no different from the large LDC domestic firm - though it may have a shorter time perspective, given the higher real or imagined risks it thinks it is contending with, and the even greater preference for policy stability as opposed to "average quality" it demonstrates. DC governments certainly should insist that their public funds not be used to facilitate private investment flows which are indirectly inimical to the trend of policies, e.g. towards greater LDC export competitiveness, agreed to by both governments.

If we read the record of the past quarter century correctly, substantial real world obstacles exist to any such idealized or "normal" phasing of a naturally changing relationship between an LDC and multinationals. The bargains struck during early import substitution are almost bound to guarantee the MNC an extremely high rate of return, based in substantial part on the public grant of monopoly power, which it is later understandably loath to surrended. The LDC, for its part, often wants the MNC presence at that point for easons of pestrige and bandwagon effects, along with the capital - and almost regardless of the terms which are frequently in excess of what it would take to attract it. Witness not only the protection and market power granted through import licensing and other controls but also the lavish tax holiday and other fiscal favours customarily bestowed.

Over time there has been a clear reluctance on the part of the MNCs to move from the wholly-owned subsidiary to the joint venture, licensing and so on, as host LDC entrepreneurial capacity matures and pure saving and management contributions assume a lesser importance. On the part of the LDC there is often a desire to retain these import substitution controls long after their rationale has lost its force. Consequently as the MNC mystique declines and what appear to be unreasonably large profits are noted, nationalistic resentments increase, often together with attempts to change the original bargain struck with the foreign investor. Threats of expropriation and the deployment of the Calvo doctrine against Hickenlooper amendments follow. A good deal of confrontation may be avoidable if there is less mutual misunderstanding of the predictable dynamics of any such relationship over time from the beginning. Regardless of one's precise judgment about the relative benefits acrruing to the two parties as a result of a particular foreign investment, there must be a general recognition that both the advantages to the recipient LDC and to the investing MNC will decline over time, arguing for build-in flexibility in the nature of the contractual arrangements.

However, we can observe a marked lack of sensitivity on the part of the MNC to the changing capacities and needs of the LDC as it attempts its transition to modern growth through various historical subphases, and an equal lack of sensitivity on the part of the LDC as to how it can really maximize the benefits and minimize the costs of this foreign presence at different points in its life cycle. All the actors are likely to be guilty of causing major departures from the ideal. There may be good underlying reasons for such "deviant" behaviour. First, the MNC whose profits may initially be based mainly on market imperfections may find itself naturally unwilling to shift voluntarily from windfall to earned profits as required by the nature of the phasing. Second, the LDC government which often "blow hot and cold" with respect to its regulatory attitude on foreign enterprise may refuse to try to differentiate among the various organizational manifestations of the MNC in any consistent fashion and end up either welcoming all parts of the bundle or rejecting all. (It may thus be obtaining the worst of both worlds, in extension of the well-known shibboleth that a consistent, if tough, policy vis-a-vis the MNC would be much preferred by foreign investors to one that is better "on average" but fluctuating and unpredictable.) Third, the private LDC investor who initially almost unthinkingly welcomes the presence of large foreign companies to help him "test the waters" and provide political support for government policies favouring the industrial class, later often turns on the MNC when he finds himself unable to compete effectively with foreigners who have favoured access to capital markets, bureaucrats and so on. Fourth, the governments of developed countries seeking to support the actions of their own investors abroad - which they claim are also in the interest of the LDCs - often do so without any perception of changes in the landscape and the consequent need for changes in the nature of a potentially symbiotic relationship. Often, the policy approaches are of "right or wrong, this is my MNC". Aid is tied to the host country's treatment of foreign investment in the form of Hickenlooper and Gonzales amendments; and manifestations of moder extraterritoriality extend as far as the application of Antitrust and Trading with the Enemy Acts of U.S. subsidiaries abroad (as in the celebrated recent case of Argentine motor sales to Cuba).

Public aid procedures and their impact on public or private capital movements also often exercise a restrictive influence on the range of information and choice actually available to an LDC industrial entrepreneur. This does not mean that we believe in the realism of a perfect information perfectly competitive international aid and trading system. It is, rather, an affirmation that some of the mystery and secretiveness surrounding the transfer of technology is often not warranted by the basic economics of the situation but is instead the conseqient of artificial, and often misguided, interventions by DC governments as well as by the unduly proprietary behaviour on the part of private interests.

Most obviously, and as is well known, aid itself is often doubly tied, once to the country of origin, restricting technology choice, and once via the unwillingeness to incur local costs, by eliminating the recipient country's own capital goods industry from supply consideration. As a minimum contribution traditional aid agencies should be forced to seriously consider real world technology alternatives in their own project lending; their willingness to permit more flexible rules on the local cost financing of projects and more extensive resort to programme lending would helf reduce built-in preferences for capital imports. This observer is sceptical on the number of projects whose approval has really been determined by rate of return analysis rather than political considerations. But he is less sceptical about the potential for changing the technology of an already agreed upon project if something is done to correct today's surprisingly* low pressures for really forcing the consideration of technological alternatives within the cost/benefit analysis structure. The use rather than discouragement of indigenous engineering consultants on such projects could constitute an important component of this effort.

In some, this particular view of what international cooperation can do to help LDC planners provides considerably optimism as to what can reasonably be accomplished to help render technology choices more appropriate. The central concept is clearly multi-dimensional and the effort to search for simplistic or emotional solutions is likely to mislead us. As to what we are searching for, neither the solar cooking oven type of indigenous technology often favoured by the self-reliant autarky school nor the imported "big fix" break-through type often offered by the transnational corporation represent a necessarily helpful image to capture its essence. The centre of gravity of the dynamic appropriate technology concept rests, rather, with thousands of modern adaptive responses and modifications of modern processes and goods across a vast range of applications and landscapes. The strengthening of a relatively decentralized indigenous innovation and technology information cum adaptation network is not only more likely to get the job done in terms of today's resource endowment but also to build the necessary confidence for the continuous changes dictated by product and process cycle considerations. Neither the latest technology nor the most basic goods are necessarily superior <u>or</u> inferior. Poor people do not necessarily always wich to buy expressly "poor people's" goods and advertising propelled cultural imperialism can alter preferences just as much as an imposed policy of national self-reliance. We certainly are not wise enough to preach on the exact nature of the socially optimal choice along this spectrum. All we would argue is that supply-side S & T planning be focused heavily on the elimination of barriers to information against legal and economic restrictions to technological diffusion and, most of all, on the enhancement of domestic scanning and adaptive capacities.

International action can be of help, but only if LDC policy makers know where they would like to go and insist on co-operative arrangements being fashioned with those objectives in mind. The incontrovertible fact, moreover, is that the LDCs may, in many areas, have more to learn from each other and/or from the less advanced DCs than from the most advanced DCs. There clearly are some advanced countries, such as Japan or Sweden, which may have more to offer than others such as the Soviet Union and the United States. This nation is perhaps better accepted today than the idea that the experience of countries slightly "up" the development ladder, e.g. the so-called NICs of East Asia and Latin America, may have more relevant technology and experience to offer than any of the DCs. One general policy implication of all this is the encouragement, with carefully selected help from the outside, of centres of excellence in particular industrial areas, with strong links to multipurpose national adaptive technology networks.

There is only one science and technology culture in the world, no separable LDC sub-cultures. Moreover, there exists a continuous chain between the very "white collar" basic sciences on one extreme and the very "blue collar" adaptive "twists" in technology on the other - just as a continuous spectrum runs between the full inappropriability of new information and the sway of public sector R & D, on one hand, and private monopoly versions of complete appropriability, on the other. The typical LDC is well advised not to try to show the scientific flag everywhere nor to restrict itself to a particular pre-determined range of scientific endeavour of technology choice. There are, I am afraid, no magic formulae or shortcuts. The only generalization I would stand by resolutely is that international cooperation can only be helpful if harnessed intelligently to removing the obstacles and strengthening the institutions which permit an LDC to participate on the basis of sensitivity to its own societal objectives and capacities.

<u>Footnote</u>

* Surprising in terms of the level of rhetoric on appropriate technology so frequently used by the same bilateral and multilateral aid agencies

<u>References</u>

(1) See Nathan Rosenberg, <u>Perspectives on Technology</u>, Cambridge University Press, 1976

(2) Nicolas Jequier, ed., <u>Appropriate Technology - Problems and Promises</u>, OECD, 1976

(3) For more discussion on the importance of the capital goods industries, see Howard Pack and Michael Todaro, "Technical Transfer,Labour Absorption and Economic Development" <u>Oxford Economic Papers</u>, Vol. 21, November 1969

(4) Vahid Nowshirvani, <u>Production and Use of Agricultural Machinery and Implements in Iran: Implications for Employment adn Technological Change</u>, ILO, 1977

(5) See also Amulya K. N. Reddy, "National Appropriate Technology Groups and Institutions", <u>ILO World Employment Program Working Paper No. 37</u>, Sept. 1978

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16. Negotiating with MNCs for Technology-sharing Agreements

JACK BARANSON

A growing number of international firms have been entering into technology transfer agreements that are significantly more responsive than previously to the emerging demands by the new industrializing nations for new modes and content in technology acquisitions. The nature of some of these new agreements between U.S. firms and Latin American enterprises and the underlying motivations on the part of purchaser and supplier of these new technology packages are set forth in this paper. These new agreements are largely the result of efforts on the part of Latin American governments to acquire technology packages that are more advantageous to the technological and commercial growth and development of indigenous enterprise. The new generation of agreements also reflect profound changes in the world economy and in the perceptions on the part of certain U.S. corporations of how they may use their technology assets and know-how in new and more imaginative ways and at the same time continue to earn a return on their corporate assets. The innovations in corporate involvements centre around the technology component of industrial systems, but also involve international marketing and production dimensions and logistics. In negotiating for technology sharing agreements, Latin American enterprises (and licensing and investment authorities) have to take into account their relative bargaining positions vis-a-vis the U.S. enterprise and its commercial considerations in the transaction.

LATIN AMERICAN MOTIVES AND STRATEGIES

Development authorities in Latin America have come to realise that the key to long-term growth and development lies in acquiring the ability to deisng and engineer industrial systems. This requires an indigenous build-up of an interrelated set of capabilities, including product design and engineering process and equipment design and construction. It is for this reason that Latin American governments have been rejecting ownership and managerial control of national enterprise by foreign corporations. Foreign-owned enterprises bring with them industrial technology and thereby obviate the need for developing indigenous design and engineering capabilities or supporting capital goods industries. Once established in an economy, foreign-based multinationals also pre-empt the development of indigenoud industry because of their comparative advantage in management and technology. (The recent exclusion of IBM from further expanding its manufacturing base in Brazil is a case in point.) By way of contrast, the new generation of technology-sharing arrangements enable the rapid implacement of internationally competitive facilities (to assure economic efficiency and to earn much needed foreign exchange) and for the training of managers and engineers (to take full operational control as rapidly as possible).

CORPORATE MOTIVATIONS AND STRATEGIES

An increasing number of U.S. Firms are finding that technology sharing is a preferred alternativt to investment commitments as a means to exploit a lucrative regional or specific LDC market or establish an alternative, inexpensive production source. In many cases, U.S. firms have decided that the risks associated with capital investments in LDCs are too high, especially in the face of what they view as diminishing repatriatable returns. There are also the added uncertainties of recurrent recessionary cycles and exchange revaluations in the world economy. Technology sharing with "sovereign" enterprise partners thus avoids capital commitments overseas.

Technology sharing generally implies profound changes in corporate management and organization. The transfer agents required to export and implant technology represent a quantum jump in operational requirements - moving from traditional manufacturing and marketing within the global corporate family to imparting these capabilities to LDC enterprise partners through training and other enterprise-to-enterprise contacts. In several cases, products and production processes have hade to be redesigned to accommodate not only specific LDC manufacturing capabilities and conditions, but also the unique characteristics of a given LDC market (see next section for specific cases).

From the incorporate viewpoint the demand by LDCs for assistance in world market entry may represent, as in technology sharing, a quantum jump in the logistical complexity of international operations. The successful incorporation of buy-back arrangements into company operations, for example, requires a new order of integrated planning among the functional areas of marketing, production, RD & E and financial management. Production sharing may also pose some difficult problems of maintaining the quality and technical standards of trademark items.

At the same time, however, buy-back arrangements which at one time were viewed as a necessary evil for market entry or retention of market share are gradually coming to be viewed as a hedge against import restrictions and exchange controls and as a means of remitting earnings in areas where companies retain equity positions. In some cases, companies find offshore manufacture of components and parts less costly than in the U.S. and, in those cases, have a double incentive to enter into buy-back arrangements. *

U.S.-LATIN AMERICAN TECHNOLOGY SHARING AGREEMENTS

The following are examples of the types of agreement that have been negotiated in recent years between U.S. firms and Latin American enterprises. They are drawn from case materials developed in policy studies for various U.S. Government agencies and reflect the movement by U.S. corporations toward a greater degree of technology sharing.

Pullman-Kellogg - Petrobras (Brazil)

In 1975, Kellogg contracted with the state-owned oil company, Petrobas, to supply the know-how, design and engineering for a series of nine ammonia plants. Under the contract, Kellogg provides current generation process know-how and performs, in Brazil, the necessary process and detail engineering. In addition, the U.S. firm has begun intensive training of Petrobras engineers both in Brazil and in its Houston Facilities, in the management and production operations of the plants. Payment to Kellogg is spread over ten years at a reducing scale as each plant is built. For any phase of the production which Petrobras feels competent to perform alone, as the contract develops, Kellogg can be relieved of those duties. After completion of all nine plants, Petrobras is permitted to duplicate as many additional plants as it wishes, but is prohibited from licensing others.

Piper Aircraft - Embraer (Brazil)

In 1974, Piper entered into a licensing and technical services agreement with the state-owned aviation and production firm, Emrbaer. Piper was fully apprised of the "rules of the game" - that the Brazilians intend to develop their own technical, managerial, manufacturing, and marketing capabilities in small aircraft production and to reserve the domestic market for Brazilian-produced aircraft in the future. The five-year agreement allowed Embraer: to fabricate any Piper aircraft for local production and sale and, on occasion, to jointly produce with the U.S. company for foreign market sales; gradually replace Piper-supplied components with Embraer products; initiate joint development and production programmes for a new aircraft aimed at domestic or foreign markets and to market either company's products through individual distribution networks. Piper's compensation is primarily a percentage return on components it ships, which progressively diminish. In addition, Piper receives a fre for service in aircraft support.

Sycor - Cobra (Brazil)

In 1976, Sycor signed an agreement to manufacture a mini-computer in Brazil with Cobra, a shared state- and privately-owned corporation. Under the agreement, Sycor will sell complete systems to Cobra and extensively train Brazilian personnel in the system's software, field engineering, marketing and managements. Cobra will begin final assembly of systems in Brazil with modules purchased from Sycor. An increasing portion of the modules will be manufactured in Brazil, and in the final phase of the agreement Cobra will be manufacturing the entire product. The contract effectively exempts Sycor from import quotas imposed on the Brazilian computer industry. Compensation to Sycor is derived from equipment sales and royalty payments.

Intercol Resources (Exxon) - Carbocol (Colombia)

In 1976, Intercol and state-owned Carbocol reached a major agreement concerning the exploration and development of Colombia's coal resources. The terms of the contract, which give Carbocol a majority equity position, call for Intercol to assume all mining exploration expenses, share management responsibility, and train Colombian technical and management personnel as well as construct railway and port facilities. Intercol receives a 50 percent share in production for any coal found, and, one production begins, the company will pay a 15 percent royalty to the Columbian Government. The agreement also requires that sales contracts for coal be made to independent third parties in order to avoid the possibility of unfair transfer pricing.

Hanna Mining - Econiquel (Colombia)

Hanna's involvement with the Colombian Government to exploit a large Colombian nickel deposit has been subject to two separate agreements. The first agreement, which lasted from 1970 to 1974, included Chevron, a subsidiary of Standard Oil Company of California, and called for the establishment of an equally-owned $94 million nickel mining and smelting operation. Yet Colombian equity participation occurred only after the existence of a commercially viable source of nickel had been proven - that is, after a significant portion of the uncertainy has been eliminated. A pilot plant was built in Oregon to verify the recovery processes, and an ore sample from the Colombian deposit was successfully processed. When Colombia unilaterally demanded the project investment be increased from $94 million to $200 million in 1974, Chevron substantially reduced its participation. Hanna and Colombia retained their one-third equity position, with the difference going to a consortium of Japanese and European firms. The 1975 agreement, principally between Hanna and the Colombian Government, refined and added to the original 1969 agreement and is considered a model for future agreements between MNCs and developing country enterprises. Colombia will complete control over a viable mining operation at the end of the 25 year agreement, as proven reserves under proposed production output levels are for 50 to 75 years. The project provides for basic infrastructural development and training and cooperation with local firms by Hanna.

Gray Tool - EPN S.A. (Mexico)

Over the past twenty years, Gray Tool has acquired a progressively greater share of the Mexican manufacturer of wellhead oil field equipment, Equipos Petroleos Nationales, S.A., and transferred successive generations of know-how in exchange for royalty revenue, enhanced access to certain regional world markets and, more recently, access to an alternative production source. What was originally a licensing agreement has become a joint venture arrangement since 1970 between the two companies, with 80 percent of its equity owned by the U.S. company. Gray International acts as the selling arm of EPN-Gray's products in world markets, exporting 15 to 20 percent of production annually. Products manufactured by the joint venture are virtually 100 percent Mexican content. Gray has been involved in extensive training of EPN engineers.

NEGOTIATING FOR TECHNOLOGY SHARING AGREEMENTS

The ability of Latin American enterprises to negotiate advantageous technology-sharing agreements in identified opportunity areas, will depend in large measure upon (i) the relative bargaining power of the U.S. and Latin American enterprises, and (ii) the risks of technology sharing as perceived by the U.S. firm in relation to expected returns.

Bargaining position

In negotiating with a specific Latin American country U.S. corporations have used as a major source of leverage either their technological pre-eminence or access to attractive alternative markets or both. In the first instance, the unique or proprietary nature of the technology in a U.S. enterprise's product or production process directly enhances that firm's bargaining power when negotiating with a Latin American country which has a strong interest in that technology. Similarly, the more sophisticated a technology the greater the bargaining power of the MNC, as the LDC purchaser is more dependent on the MNC for the successful utilization of the technology. Obversely, a U.S. firm's bargaining leverage is directly diminished by the degree that its technology is readily available on the world market and is relatively unsophisticated. A U.S. multinational corporation's bargaining power can be further enhanced if the firm has several feasible alternate markets available, thereby allowing the firm the luxury of choosing the most favourable conditions.

Yet it is most often the attractive size of a specific-country or regional market which involves a U.S. firm in a technology sharing agreement with an LDC. With increasing international competitiveness between multinationals for world market shares, Latin America markets take on an added significance to U.S. firms as an additional profit source, thus enhancing the host country's bargaining position in attempting to exact technology transfers. Latin American countries have also been able to exert bargaining leverage over MNCs due to those countries' attractiveness to corporations in terms of a low-cost source of production for that corporation's global operations. LDCs have also been able to strengthen their bargaining positions for exacting technology transfers by offering inducements to U.S. corporations, such as provision of R & D capital or exemption from various government regulations. A further source of bargaining leverage to a potential purchaser may lie in its access to alternative sources of a given technology. It is worth noting that in the case of U.S. corporations involved in raw materials extraction, they are subjected to bargaining pressure from resource-rich LDCs concerning access to specific raw materials. The price for extraction has increasingly been the transfer of extractive and process technology.

Earnings and risk perspectives

U.S. corporate interests in technology-sharing agreements are: (i) to earn an "adequate" return on corporate resources (including technology and management know-how); and (ii) to complement or reinforce certain international marketing and production logistics. As the realization of these objectives increasingly entails the release of firm- or industry-specific technology to host countries, the risk factor to U.S. corporations rises proportionately.

The central risk perceived by U.S. corporations that enter into technology transfer agreements is that the Latin American pruchasers may enter into direct competition with them in external markets. The ability and speed of a purchaser enterprise to evolve into a significant competitor is related to that enterprise's technical absorptive capacity to exploit the acquired technology in competition with the U.S. supplier. Two other factors which can substantially enhance a Latin American purchaser enterprise's ability to absorb foreign technology to the extent of becoming a marekt force are: (i) the purchaser's financial resources to "run" with the acquired technology; and (ii) government support, whether financial or regulatory, of a purchaser enterprise's movement into the marketplace.

Footnote

* It should be pointed out, however, that U.S. firms now face mounting opposition from labour unions because of the employment-displacing effects of those buy-back agreements. U.S. corporations thus find themselves in a crossfire of demands from newly industrializing countries and domestic constraints because of the possible adverse effects on the U.S. economy.

CHART 1

TECHNOLOGY SHARING BARGAINING PARAMETERS

Technology Supplier	Technology Package	Technology Purchaser
* Bargaining - Competitive world market position - Technological lead - Negotiating astuteness - Financial resources	* Distinctive Characteristics - Quantum and complexity - License to manufacture or turnkey-plus - Operative, duplicative, or innovative - General-, firm- or system-specific - Stage in product/process cycle	* Bargaining Leverage - Strong government support - National resource endowment - Ready cash - Attractive national market - Absorptive capabilities - Alternative source of technology
* Enterprise Strategies - Returns from technology sales provide funds to maintain technology lead - Continued access lucrative market - Possibility of future low-cost procurement source - Continued access to scarce resources		* Enterprise Strategies - Obtain internationally competitive technology - Entry into export markets - Fast, efficient technology transplants - Duplicative and/or innovative design and engineering capabilities - Training of technical managerial manpower

CHART 2

BARGAINING POSITION DETERMINANTS

	SUPPLIER ENTERPRISE	PURCHASER ENTERPRISE
TECHNOLOGY	Pre-eminent position (unique or proprietary)	Absorptive capability; alternative sources
MARKET	Inter-related entry and expansion opportunities	Intert/ability to enter world market; offset trading demands
FINANCIAL	Ability to fund available commercial-technological opportunities	Able to provide equity capital or incur international debt
POLITICAL	Balance of trade position and labour market adjustment problems	Government support of investment-licensing framework

17. Technical Cooperation among Developing Countries (TCDC) — a Viable Instrument of Collective Self-reliance?

DIETER ERNST

In this paper I will deal with some problems related to the concept of collective self-reliance. More specifically I will inquire into some implications of the currently evolving New International Division of Labour for Technical Cooperation among Developing Countries (TCDC), i.e. under what conditions will TCDC effectively"... promote and strengthen collective self-reliance among developing countries through exchanges of experiences, the pooling, sharing and utilization of their technical resources, and the development of complementary capacities..." (1)

I will also add some sceptical comments to these discussions. These comments relate to the effective possibilities of collective self-reliance to strengthen the accumulative, scientific-technological and developmental potentials of developing countries and to protect them against external influence, especially from major OECD-countries. Specifically I will focus on one variety of collective self-reliance which is being negotiated, i.e. TCDC. (2)

COLLECTIVE SELF-RELIANCE - AN ELEMENT OF THE NIEO PROGRAM, BUT STILL OF MARGINAL IMPORTANCE

The strengthening of South-South cooperation is one of the three basic elements of a strategy to transform current international economic relations into a New International Economic Order (NIEO).

Within this concept, collective self-reliance is the necessary complement to the restructuring of North-South relations and the promotion of a developing country's potential for national development, including its scientific-technological capabilities.

The logic of this approach has been stated in a recent paper from the Group of 77 for UNCSTD: "Greater bilateral and multilateral cooperation among developing countries on the basis of the principle of collective self-reliance, particularly in science and technology, would promote the attainment of a more equitable and stable framework for global development. Such cooperation is vital for initiating, programming, organizing and promoting the creation, acquisition, adaptation, transfer and pooling of resources, knowledge and experience for the mutual benefit of all developing countries. ... Scientific and technological cooperation among developing countries provides for the reinforcement of their position in such fundamental areas as permanent sovereignty over their natural resources, accelerated industrialization, increased participation in international trade, and the eventual eradication of technological dependence, as well as the monopolistic and oligopolistic conditions faced by developing countries in the international technology market. (3)

Defined in this sense, the concepts of collective self-reliance and of TCDC are basically sound concepts. Yet, all depends as usual, on the realization of these concepts, i.e. on the institutions and policies into which these concepts are translated.

Until now, South-South cooperation has been a marginal element of international relations. No viable institutional organisations exist which could promote and protect intra Third World cooperation. This applies especially to international economic relations and, even more so, to the international division of scientific and innovative capacities. Take, for instance, the case of exports of industrial products: less than one third of the Third World's overall exports of industrial products are dedicated to other developing countries. Or take the case of transfer of technology which still nearly exclusively consists of North-South arrangements. Only recently, a few private and state firms from so-called newly industrializing countries (NICs) like India, South Korea, Brazil, Argentina and Mexico have become involved as suppliers, but mainly as subcontractors within triangular arrangements. (4)

Obviously there is an urgent need for an increase of South-South cooperation. And, obviously too, the scope for such South-South cooperation is tremendous, as are the potential conflicts, both with regard to South-South and with regard to North-South relations. Any serious move therefore towards increased South-South cooperation requires a concerted and high policy level approach.

TCDC - A POSITION OF WITHDRAWAL RATHER THAN OF PROGRESS

TCDC in my opinion is a position of withdrawal rather than of progress. It is basically a defensive position which tries to consolidate some minimum requirements of the original NIEO-position. That is, TCDC might be best understood as the smallest common denominator between the requirements of global South-South cooperation and the countervailing (and still predominant) interests, especially of some major OECD-countries. Thus, its potential for bringing about the necessary breakthrough to global South-South cooperation seems to be rather limited.

A glimpse at the post-war experience of attempts to institutionalize South-South cooperation may clarify this point. Three phases may be distinguished. In the first, roughly until the beginning of the 1970s, institutional attempts at South-South cooperation were mainly restricted to regional free trade or common market schemes, accompanied by regional financing institutions. These schemes have been effectively subordinated, especially by multinational corporations, to their worldwide and regional sourcing requirements and thus have only marginally increased the developing countries' cooperative potential. (5)

After 1973, based on the first successful moves of OPEC, a new wave of Third World solidarity seemed to gather momentum. Further OPEC-like moves of developing countries exporting natural resources seemed to become possible. It was then widely assumed that these trends would help to prepare the ground for a much more far-reaching collective self-reliance among developing countries. These high expectations reached a climax during 1974. The "Declaration and the Programme of Action on the Establishment of a New International Economic Order", adopted May 1974 by the Sixth Special Session of the United Nations General Assembly and the "Charter of Economic Rights and Duties of States", adopted in December 1974 by the Twenty-Ninth Regular Session of the General Assembly seemed to guide the negotiations for a restructuring of the world economy.

Yet, less than one year later, in September 1975 during the Seventh Special Session of the United Nations General Assembly, the picture had considerably changed. Especially after the stalemate of the 1976 Paris North-South conference, there was definitely a retreat of most developing countries, even of the most active proponents of the NIEO-concept, to much more "soft" and accommodating positions. "International Economic Cooperation" became the new catchword which rapidly displaced the earlier notion of "Restructuring the World Economy". (6)

Obviously, the concept of South-South cooperation had to be adapted too. Whereas originally the concept of collective self-reliance had been defined as a concerted and comprehensive pooling of Third World resources for at least reducing the industrialized countries' overwhelming dominance in the international economic, political and military relations, emphasis was not increasingly laid on much more reduced and partial forms of South-South cooperation. The recent discussions, taking place for instance within the UN-Economic Commission on Latin America, on how to proceed with Latin American integration, are clearly indicating this trend. "Integration through (short-term) projects" is rapidly becoming the majority formula. It is purported that such a move towards a more "flexible" concept of South-South cooperation would help to eliminate"... unattainable or utopian objectives which over time - because of their lack of fulfilment caused by political factors - only contribute to a weakening of the process." (7) But if the relatively modest objectives of the Andean Pact, let alone of the Central American Common Market (CACM) and of the Latin American Free Trade Association (LAFTA) are nowadays called "utopian", what then about the objectives of collective self-reliance?

It is a part of this withdrawal of NIEO-related positions that the concept of TCDC was created, <u>inter alia</u> at the conferences of the Non-Aligned States at Colombo, 1976, and at the 1977 conference of the Group of 77 at Mexico City. Its inaugurating document, the "Kuwait Declaration on Technical Cooperation among Developing Countries" (8) still sues the aggressive terminology of 1974. Yet, the real focus is not any more on restructuring the world economy, but on the adaptation to the requirements of the New International Division of Labour.

So, in contrast to conventional wisdom and the high expectations wordily articulated in countless resolutions of international conferences, I tend to be rather sceptical that TCDC can improve the potential for collective self-reliance among Third World countries.

IDENTIFYING THE REFORMIST POTENTIAL OF TCDC

In spite of its shortcomings and basic structural deformations, TCDC could have a potential for certain "reformist" activities which might help to mitigate some of the negative effects of the current system of international transfer of technology.

One could argue that, given the current international economic, political and military power, TCDC is probably one of the few areas left where at least some isolated reformist changes might occur. There is a stalemate now with the reform of the international patent system and with attempts to establish a legally binding code of conduct on the transfer of technology. National policies to select and control technology imports have recently experienced significant drawbacks. On the "reformist front" there is little choice left for most developing countries but to participate in TCDC.

Any strategy to increase the collective self-reliance of developing countries should make use of trends prevailing in the political landscape anyway, trying to steer them in the "right" direction. So it should be asked under what conditions, for a period of transition at least and for certain restricted problem areas, TCDC, if carefully handled, might have a significant "reformist" potential with regard to an increase in South-South cooperation.

But let us first identify some essential elements of such a reformist approach to TCDC. These might include:

(i) The establishment of alternative networks of communication, be they of an institutionalized or informal nature. A selective 'delinking' from the predominant OECD-based networks of communication would be a precondition for building collective self-reliance. Some activities have recently occurred in this field. (9) Yet viable alternative Third World networks of communication are still missing.

A pragmatic approach would be to use the recently updated UNDP Directory of Institutions for TCDC in Developing Countries, UNIDO's preliminary compilation of "technologies from developing countries" and the forthcoming OECD-Development Centre Directory of Development Research Institutes in Developing Countries. This might be supplemented by different already existing information networks, such as those established by the African Regional Centre of Technology, the Third World Forum, the Association of Third World Economists, the International Foundation for Development Alternatives, the International Peace Research Association, the International Development Research Centre and the Research Policy Institute in Lund.

(ii) Cooperation with regard to the redirecting of the international brain drain to at least some South-South cooperative schemes.

Much lip service has been recently paid to this point. But next to nothing has changed. Most parts of the Third World still even lack reliable subregional and regional "skilled manpower inventories". Viable bilateral or multilateral schemes for scientific and technological cooperation among developing countries hardly exist. Furthermore, no effective provisions exist which would guarantee that at least with regard to devising and implementing TCDC projects, Third World brains would be given high priority. Instead, projects promoted for instance by the World Bank and the UNDP still primarily need engineering consultancy services from developed countries, be it for pre-investment studies, in the preparation of "tender bids", and for technical design. (10)

(iii) Cooperation with regard to the strengthening of national and regional basic engineering capacities.

For instance, the establishment of highly specialized engineering capacities, for certain priority areas, presupposes that the relevant engineering teams will display a minimum size and will be able to work together for a long period, TCDC could help to secure economies of scale and the necessary continuity of orders.

(iv) Selective and planful cooperation in pushing through alternative technology production routes, at least for some priority areas.

Examples abound: planned scaling-down, especially for resource-oriented industries; reduction in the degree of automation; increase of decentralization and changes in the organization of the labour process; and planned substitution of synthetics by locally available natural resources.

Furthermore, TCDC could be especially useful for the rediscovery and selective upgrading of traditional technologies.

(v) Cooperation on studies and preventive policy measures concerning the effects of major technological breakthroughs on the economic and social development and particularly on the scientific and technological self-reliance of developing countries.

This would apply especially to the following areas:

(a) Development of synthetics and other forms of substitutive research induced by price increases of raw materials. This preventive synthetization of raw materials is a powerful countervailing instrument available to OECD countries against further OPEC-like attempts by Third World raw material producers.

(b) Technological innovations concerning seabed mining, offshore drilling, offshore prospecting, etc.

(c) New military technologies and their potential "civilian spin-offs", for instance: laser technology; optronics; weather modifications; bioweapons.

(d) New technologies concerning material testing and production in space.

(e) New technologies concerning the miniaturization and decentralization of automation systems.

(f) Technologies to increase the worldwide mobility of capital, for instance: factories on board ships; low cost or zero cost maintenance and repair; mobile building techniques.

(g) The technological potential of genetic engineering and bio-science-based industries.

(h) New technologies for the increased computerization of society.

(i) New technologies available for the (partial) humanization of the labour process.

(vi) Cooperation with regard to the conceptualization and implementation of alternative educational patterns and systems.

Currently, education systems are not only completely inappropriate for development needs but constitute a major factor of dependence. Education should instead be given the function of becoming a training place for self-reliance. (11) TCDC could help to pool resources, draw together diverse experience, and facilitate some first attempts of selective delinking from prevailing "Western" educational systems.

MINIMUM CONDITIONS OF SUCCESS

Even within a reformist approach to TCDC, contradictions and conflicts of interest abound, So let us try to identify some minimum conditions of success for the realization of such a reformist approach. I will focus here on three of them: priority of national self-reliance; role of OECD-countries; and timing and carriers of TCDC. Later, I will consider financial and institutional arrangements.

Priority of national self-reliance

Even if very limited, the possibilities of national self-reliance should be explored first. That is to say, that science and technology can only be effectively applied to development if the country's government deliberately strives to make the technology issue part of an autonomous decision-making process by means of selective technological delinking and by defining priority areas for technological self-reliance. (12) This requires a clear conception of the key development objectives to which these science and technology priorities should be subordinated. Key development objectives would include, (13): effective control of key sectors;

converging needs with effective demands; support of agriculture, especially to achieve self-succiciency in food; social optimization of using and processing natural resources; identifying and strengthening of "industrializing industries".

We must stress the priority of national self-reliance. Under no circumstances should cooperative schemes like TCDC be perceived as a substitute. Concepts like TCDC should be used as an instrument of extending, accelerating and deepening efforts to reduce the dependence of each one of the participating countries.

Role of OECD-countries

According to the Kuwait Declaration "TCDC should not relieve industrialized countries from discharging their responsibilities towards the development of developing countries. On the contrary, industrialized countries should substantially increase their contribution to development and to the implementation of structural changes of the international system ... ." (14)

Obviously, developing countries need a clear-cut conception of the role of industrialized countries if TCDC is to become a viable instrument for increaseing collective self-reliance of the Third World. For instance, instead of indiscriminate imports of Western technology, developing countries should aim for highly selective acquisition of strategic technologies for increasing the developing countries' technological autonomy.

To make this point more specific, I assume that the economically stronger OECD-countries, and some of the like-minded countries as well, will in the near future present new catalogues of incentives and pilot projects for TCDC. Governments of developing countries, before taking part in such projects, should, with due scepticism and care, identify those conditions under which they would not be roped into new forms of dependence.

For those of us living in the OECD-region, I think that it would be politically advisable to campaign for the expansion of such TCDC-assistance programmes. Yet we should always add the clearly spelled out caevat that it would be the developing country concerned which should have a direct say in their conceptualization and implementation. Furthermore, provisions should be included that new forms of democratic participation of the peasants and workers affected by these programmes should be established and that identifying social needs must and can be done as a social learning process.

Another equally important point would be to revert the prevailing trend towards new and more indirect forms of tied-in clauses of technical aid. The World Bank and the UNDP have been especially keen to include such indirect forms of tying into most of their projects, including the so-called TCDC-related ones. To the best of my knowledge, TCDC programmes sponsored by OECD-countries make use of these very same informal mechanisms of tying. (15) Obviously, TCDC projects based on implicit tied-in clauses are nothing but a new instrument of market penetration. Yet it is hard to see how developing countries could succeed in reducing their importance, given the increasing competition among major OECD-countries for world markets.

Carriers of TCDC and timing

To make TCDC a viable strategy one has to know not only what is should aim at and why but also who shall do it, i.e. the carriers of this strategy, and how they are going to do it. Only then could one hope to identify in an operational manner the socially and politically relevant forces behind TCDC, the areas of conflict and the areas where conciliation of interests is possible, the necessary institutional set-ups and, finally, the social and political coalitions necessary to realize this strategy.

Identifying carriers of TCDC and their conflicting interests is a highly complex task. It would not be enough just to take care of some global North-South conflicts. There is a clear need to interlink North-North- North-South, East-West, and South-South relations and their inherent conflicts. Take, for instance, the growing diversity of the Third World. As President Nyerere of Tanzania has rightfully stated in his address to the recent ministerial conference of the Group of 77 in Arusha (16), "... it was our nationalism which has forced us together... . The Group of 77 does not share an ideology. Some of use are avowedly 'scientific' socialists, some just plain socialists, some capitalist, some theocratic, and some fascits! We are not necessarily friendly with each other - some countries ... are currently engaged in a war with each other." Furthermore, as he points out, "... there is a tendency for sub-groups to develop within the Group of 77. ... sub-groups inevitably develop their own internal accommodations and their own sense of unity - which can become a unity against the other sub-groups rather than with them against the existing world order. When this happens it becomes difficult to use a negotiating advantage in one area to make a breakthrough in an area where the advantage is with the other side of the table. 'Divide and Rule' is an old technique of domination; the developed nations are not unaware of its usefulness."

Obviously, this growing fragmentation of Third World solidarity has considerable implications for TCDC. But obviously, too, we still lack systematic research on this problem.

Another crucial problem is the question of timing. Galtung has recently pointed out that it has two dimensions: the principle of ripe time, and the principle of correct time order. (17) If developing countries, participating in TCDC, would base their strategies and tactics on careful scrutinizing of the timing question, they would not anymore simply have to react towards the dominant activities of the North. Rather, they might be for the first time able to use the inherent imbalances and contradictions of TCDC as a driving force to increase the room of manoeuvre for collective self-reliance. Yet, the time factor has been nearly completely ignored in discussions on how to proceed with TCDC.

EVALUATING THE OUTCOME OF THE BUENOS AIRES CONFERENCE ON TCDC

For developing countries to be able to reap some of the benefits of TCDCs reformist potential, there is one further basic precondition, i.e. the financial arrangements and the institutions established for TCDC should be effectively controlled by the developing countries concerned.

Much of the controversy of the recent Buenos Aires conference revolved around who should control the "new intergovernmental machinery for reviewing TCDC activities" and the "new financial arrangements for TCDC activities". (18)

The conference was "successful" in the sense that it adopted the Buenos Aires Plan of Action for promoting and implementing technical cooperation among developing countries, which recommends a number of reforms at both the national, regional and international evels, all aimed at improving the possibilities for technical co-operation - but only on a voluntary basis. The conference did avoid earmarking special funds for TCDC, and it did not set up a special TCDC agency. Instead, it left effective control of all TCDC-related activities in the hand of the United Nations Development Programme (UNDP) secretariat and to regular high level meetings of all states participating in the UNDP. This procedure means that voting powers will be determined by the financial contributions to the UNDP budget. Thus, despite the seemingly accommodating provision that all decisions should be made "in close consultation with the developing countries concerned", major OECD-countries will effectively control most of the TCDC-related activities. (19)

To sum up, TCDC will not be very helpful for the strengthening of the collective self-reliance of developing countries. This conclusion applies even if one uses a much watered down reformist concept of collective self-reliance. Thus, although TCDC is itself in a position of withdrawal with regard to earlier concepts of how to bring about a new international economic order, even this minimum position of South-South cooperation will be effectively controlled by some major OECD-countries and, to a secondary degree, by some OPEC- and by some so-called key countries of the Third World.

TCDC may turn out to increase rather than to decrease the heriarchization of the North-South and South-South relations:

(i) New markets for technology exports will be opened up to private capital located in the OECD-region (including now an increasing number of medium-size firms).

(ii) Private capital, located in some OPEC and some key countries of the Third World, can expect to participate in this appropriation of new frontiers and global sourcing possibilities.

(iii) Reform concepts in the national and regional context of developing countries, aiming at the selection and control of technology imports and the strengthening of national and regional technological self-reliance, can be more easily coopted and controlled by the centres.

(iv) And, finally, the hierarchical structure of economic, political and military South-South relations will undergo a further increase. Those few countries of the Third World which are of a significant economic and/or geopolitical importance to the "Atlantic Community" can be most effectively upgraded to and integrated into the presently evolving new international division of labour.

CONCLUSIONS

TCDC is one of the attempts to reform the "International Scientific and Technological Order" which for one reason or another has received clearance for international negotiations. Other elements are: the UNCTAD code of conduct for the transfer of of technology and the reform of the international patent system. These reforms are clearly at crossroads. The overall balance to be drawn today is a rather bleak one.

None of the real issues of underdevelopment and domination has been touched by them. This applies specifically to the limitations imposed by the way in which science and technology are inserted into an increasingly hierarchical world order. However well-meaning intentions may have been behind the prevailing reform moves, at the level of implementation results are either dead-locked or turn out to be counterproductive. (20)

The real issues at stake are:

(i) The tremendous and accelerating increase of underdevelopment, misery and exploitation of most of the world population urgently necessitates a concerted effort to apply science and technology effectively to development. Development must be understood as a process of radical economic, social and political transformation which improves the material and social welfare of the underprivileged.

(ii) Reform through international conferences might not necessarily be the appropriate method of action. Evidence abounds that there has been a tacit consensus of power elites from North and South to use the international conference as a device for coopting, diluting, diverting and ultimately denying movements for change. This is so because international megaconferences, however "progressive" their agenda may be, still leave ultimate decisions in the hands of governments which, in most cases, are unlikely to give priority to the interests of the underprivileged.

(iii) The logic underlying the NIEO-programme has to be thoroughly reviewed. Obviously its effectiveness as a bargaining instrument has significantly declined as a result of the increased crisis of the world economic system. Furthermore, the NIEO concept turned out to be insufficient to secure a minimum amount of "Third World Solidarity" vis-a-vis the North.

It must be asked whether the NIEO has even been conceived as an instrument to change the current international economic and political power relations. As some insiders to the NIEO bargaining process would argue, it might very well be counter-productive in that it seeks to straight-jacket potential liberating forces. (21)

(iv) The strengthening of scientific and technological self-reliance in developing countries and the effective application of science and technology for development require major socio-economic and political transformations in the Third World. Furthermore, substantive changes are required in the structure of international power relations.

This argument should not be taken as an alibi for political apathy. Experience shows that what was perceived as unlikely or even utopian turns out to be routine. This applies that any attempt to devise an analytical framework for reformist policy action in science and technology should not exclude "concrete utopia".

To conclude, it is obvious that Third World countries have little choice but to participate in the "international reformist game", with much concerted efforts and aggressiveness. This applies too to negotiations on TCDC. But such policies should be based on a much sounder analytical framework. There is an urgent need for a fresh approach towards the conceptualization of such an analytical framework.

On a <u>fundamental level</u>, this would imply (22):

(i) defining a basic matrix of goals and instruments for self-reliant development;

(ii) a review of branch- and product-specific patterns of technological dominance/technological dependence, confronting developing countries;

(iii) redefining the criteria of success for industrialization strategies;

(iv) operating the concept of "technological self-reliance";

(v) identifying realistic options for collective self-reliance among developing countries; and, most importantly,

(vi) identifying institutions and social and political coalitions which are necessary to push through these new concepts.

Specifically with regard to TCDC, this would imply further in-depth analysis of the following issues:

(i) <u>The results of the Buenos Aires conference and its follow-on activities</u>

We need a rich body of case studies on decision making procedures and implementation criteria of TCDC programmes and projects, especially of those managed by the UNDP. This should include country and sector case studies, and case studies dealing with specific TCDC institutions.

Furthermore, we would need case studies on the involvement of specifice firms. Such research should help to establish differences of motivation, strategies and organizational structure with regard to firms from the OECD-region, those from COMECON-countries and those based in the so-called Newly Industrializing Countries (NICs). It should also help to identify the patterns of division of labour recently evolving between them. For instance, the growing involvement of private and state firms from India, mainly from the engineering consultancy, construction and heavy machinery trades, as technology suppliers, in the Near East, Avrica and some South-East-Asian countries (23) should be systematically scrutinized. This should help to find out what is "business as usual", what are simply new forms of international subcontracting and what, after all, are at least first steps towards an increasing South-South cooperation on mutual beneficial terms. The same would apply to companies from Yugoslavia, Spain, Rumania, South Korea, Mexico, Brazil and Argentina.

(ii) <u>Administrative inefficiency and bureaucracy as short-term impediments to TCDC</u>

For most of the public administrations of developing countries it is still a non-one's job to search out potential areas of cooperation among developing countries and to coordinate systematic follow-on activities including policy formulation. This is so despite the recent proliferation of science and technology institutions. On high policy decision making levels, questions like "What can we do among ourselves, for ourselves?" are still basically dealt with as rethoric devices.

Projects like the International Development Research Centre's Science and Technology Policy Instruments (STPI) Project (24) have amply documented the inconsistencies and contradictions of <u>national</u> science and technology policies. A similar research <u>approach</u> would be urgently needed on TCDC related policy instruments and institutions.

Furthermore, the considerable conservative influence of the international bureaucracy of the various special agencies should be thoroughly investigated. Agencies and their employees tend to be mainly concerned with preventing either an invasion of their sectoral fields or a loss of the prerogatives and power of their executives and governing bodies. The division of labour recently agreed upon between UNDP and UNCTAD with regard to TCDC and ECDC would be a case in point. Furthermore, international organizations are inclined to assume that countries and governments are their to service them rather than the other way around.

(iii) <u>The distribution of costs and benefits of TCDC</u>

To paraphrase Vaitsos (25), we have to ask: "Who cooperates and with whom, how and for whose benefit?" This presupposes the identification of the main actors with regard to countries, international organizations, governments (respectively fractions of the public administration), firms, classes, and segments of the labour force. Furthermore, the crucial issue of effective control and democratic participation has to be closely scrutinized.

Some first attempts of research already exist. Examples would be the ongoing UNITAR project on "Technology, domestic distribution and North-South relations", research peojects undertaken at ILET/Mexico City, and studies undertaken within the framework of IFDAs "Third System" project. (26) But this is only a beginning and a clear TCDC orientated focus is still lacking.

(iv) Divergent positions and conflicts of interest among industrialized countries: identifying new coalitions for the realization of TCDC

We still lack systematic research undertaken from a Third World perspective on how the crisis of the international economic and political relations is going to affect the positions of industrialized countries with regard to TCDC and other forms of collective self-reliance.

Clearly, the prevailing trends point to much more rigid and uncompromising positions. (27) But this is only a global picture and reality is much more complex. No doubt there will be differences with regard to countries and industrial sectors involved. This will be even more so with regard to political groupings and social classes involved.

Take, for instance, the case of the OECD-region. The recent successful moves to increase the homogeneity of OECD-countries' bargaining position vis-a-vis an increasingly fragmentated Third World notwithstanding, there is no doubt that the world economic crisis is permanently generating new conflicts and political frictions between different factions within this region. The same would apply to the global scene.

It would be even more important to analyse these conflict dynamics on the level of specific industrial sectors and branches. From the viewpoint of OECD-countries this has been extensively analysed, for instance by the OECDs Interfutures project and by the French think tank GRESI (Groupe de Reflexion pur les Strategies Industrielles). (28) Finally, it is no secret that trade unions, by and large, do have different ideas than, say, employers' associations on how to integrate developing countries into a restructured world economy.

Third World countries should be able to draw on research on such diverging positions and conflicts of interests among industrialized countries. Only then could areas of conflict and areas where conciliation of interest is possible be established in an operational manner and only then could realistic options be identified for collective Third World Strategies to diversify dependence.

References and notes

(1) Buenos Aires Plan of Action for Promoting and Implementing Technical Cooperation among Developing Countries, quoted after: "Report of the United Nations Conference on Technical Cooperation among Developing Countries, Buenos Aires, 30 August-12 September 1978", United Nations New York 1978, p. 5

(2) I will not deal here with ECDC (= Economic Cooperation among Developing Countries), one of the new formulae established for UNCTAD V. See, for instance, Ch. Raghavan - "Towards a New International Economic Order through Collective Self-Reliance and a Strategy of Negotiation and Confrontation", IFDA Dossier 5, March 1978

(3) "Position of the Group of 77 regarding a programme of action for the United Nations Conference on Science and Technology for Development. Target Area A - Strengthening the Scientific and Technological Capacities of Developing Countries" (A/Conf. 81/PC/CRP.2), UNCSTD secretariat, New York, 3 May 1979, P. 4

(4) An arrangement is called "triangular" if it includes, for instance, a firm from an OECD-country which mostly acts as project leader, a firm based in a NIC which supplies some essential subcontracting servies and local firms which are mostly restricted to lower levels of subcontracting. Take, for example, the contract recently concluded in Kenya for the establishment of a sugar refinery complex. A consortium had been established led by the German firm Buckau R. Wolf AG, Grevenbroich, her Indian daughter Buckau Wolf India Engineering Works Ltd., Pimpri, the Mehta Group International, Hamilton (Bermuda) and the Kenyan South Nyanza Sugar Company Ltd. (SNSC), Nairobi

(5) Constantine V. Vaitsos, "The Role of Transnational Enterprises in Latin American Economic Integration Efforts: Who Integrates and with Whom, How and for Whose Benefit? Report prepared for the UNCTAD secretariat", UNCTAD (TAD/EI/SEM.5/2), 15 March 1978

(6) See, for instance, the resolution on "Development and International Economic Cooperation", adopted during the aforementioned Seventh Special Session of the U.N. General Assembly

(7) UNDP, "TCDC Case Study No. 15. Central America: Joint Energy Programme", no date, New York, p. 6, quoting an article by Gert Rosenthal, director of the ECLA Mexico City Office, and Isaac Cohen Orantes, in the Revista de la CEPAL, first quarter of 1977

(8) The Kuwait Declaration has been published, inter alia, as a U.N. document entitled Organization of the UN Conference on TCDC. The Kuwait Declaration (A/Conf. 79/PC/18), New York, 22 June 1977

(9) See, for instance, various issues of TCDC News, published by UNDPs TCDC Special Unit

(10) Diego Pizano and Guillermo Perry, The Scientific and Technological Dimensions of the New International Economic Order: An Exploratury Study, Bogota, March 1979 (manuscript), p. 11

(11) This term is taken from Francois Le Guay, "Industrialization as Part of a Self-Reliance Strategy", IFDA Dossier 2, November 1978, p. 7

(12) This argument has been developed in Dieter Ernst (editor), The New International Division of Labour, Technology and Underdevelopment - Consequences for the Third World, Pergamon Press, Oxford, 1979 (forthcoming), especially in chapters I and V

(13) For more details see Dieter Ernst, "The Choice of Priorities for the Application of Science and Technoloty to Development", to be published in: Economic and Political Weekly/Bombay

(14) Kuwait Declaration, op. cit. p. 3

(15) See, for instance, the speech of Carl Werner Sanne, secretory of state in the FRG's Ministry of Economic Cooperation at the Fifth Symposium for Cooperation with Newly Industrializing Countries which took place at the 1979 Hannover fair, See: Suddeutsche Zeitung, 24 April 1979

(16) The following quotations are from IFDA Dossier 5, March 1979, pp. 4 and 5

(17) Johan Galtung - "What is a Strategy?", IFDA Dossier 6, April 1979, pp. 15-20

(18) All quotations are from: Report of the United Nations Conference on TCDC, op. cit., pp. 17, 18

(19) For a more optimistic interpretation see Ch. Raghavan "TCDC: Towards Collective Self-Reliance", IFDA Dossier No. 2, November 1978. According to him, the financial arrangements and the established intergovernmental machinery to oversee TCDC, in UNDP and the entire UN system, has "sufficient potential" for the Third World ultimately to ensure its view poing being accepted (p. 14)

(20) For a comprehensive treatment of these issues, see The New International Division of Labour, Technology and Underdevelopment ..., op. cit., especially chapters I, II and IV. For the UNCTAD code see Miguel S. Wionczek, "Prospects for the UNCTAD Code of Conduct for the Transfer of Technology", Mazingira (Oxford), No. 8, 1979, and Dieter Ernst, "A Code of Conduct for the Transfer of Technology: Establishing New Rules or Codifying the Status Quo?", in: Karl P. Sauvant and Hajo Hasenpflug (eds.) The New International Economic Order. Confrontation or Cooperation between North and South?, Westview Press, Boulder/Colorado 1977

(21) See, for instance, Karl P. Sauvant, "The NIEO-Programme: A Framework for Restructuring the World Economy?", in The New International Division of Labour, Technology and Underdevelopment ..., op. cit.

(22) For some tentative attempts to deal with some of these points see The New International Division of Labour, Technology and Underdevelopment ..., op. cit., chapter V

(23) See note 5, and, for instance, K. K. Sharma, "Indian Construction Industry. Mideast Contracts lead way", Financial Times, 18 April, 1979

(24) Francisco Sagasti, "Science and Technology for Development: Main Comparative Report of the STPI Project", IDRC/OHawa - 109e, 1978

(25) See note 6

(26) For the UNITAR project see: "Technology, Domestic Distribution and North-South Relations' Progress report by Graciela Chichilnisky and Sam Cole, UNITAR, New York, August 1978.

For ILET projects, see "Research Programme of the Division of Economic Studies" ILET, Mexico City, April 1978

For IFDAs "Third System" project see various issues of IFDA Dossier

(27) See, for instance, the article "New World Economic Order", in Business Week, July 24, 1978. With regard to Western Europe see: Constantine Vaitsos, "From a Colonial Past to Asymmetrical Interdependence. The Role of Europe in North-South-Relations", paper presented at the General Conference of EADI (European Association of Development Research and Training Institutes), Milan, September 1978

(28) Most of these OECD Interfutures and OECD-DSTI studies have only restricted distribution. For GRESI see: "L-evolution a long terme de la division internationale du travail" (Document de Travail), Paris, November 1975. See also: Yves Berthelot and Gerard Tardy, "Le defi economique du tiers monde", Paris, La Documentation Francaise, 1978, and Proceedings of the Hearing on "North-South-Interdependence" at the German Parliament, Bonn/FRG, Deutscher Bundestag, 1979 (forthcoming)