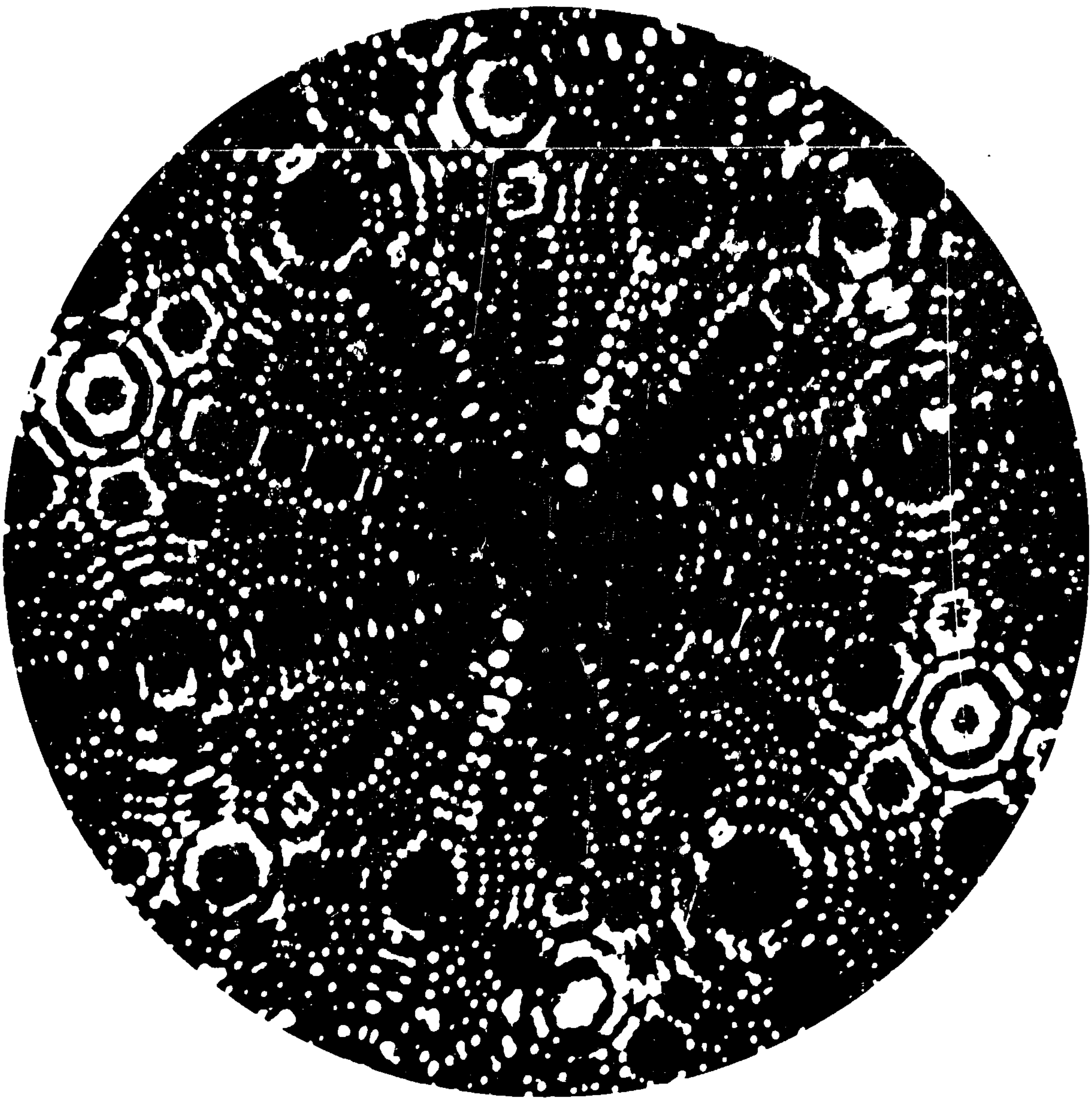
No. 46

An Introduction to Policy Analysis in Science and Technology

Science policy studies and documents



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ISBN 92-3-101725-X

Published in 1979, republished in 1982
by the United Nations Educational,
Scientific and Cultural Organization
7, place de Fontenoy, 75700 Paris

Composed in the Workshops of Unesco
Printed by Joseph Floch, Mayenne (France)

Preface

The Unesco series "Science policy studies and documents" forms part of a programme initiated by the General Conference of Unesco at its eleventh session in 1960, which aims at making available factual information concerning the science and technology policies of various Member States of the Organization as well as technical studies of interest to policy-makers and managers.

The country studies are carried out by the government authorities responsible for policy-making in the field of science and technology in the Member States concerned.

The selection of the countries in which studies on the national science and technology policy are undertaken is made in accordance with the following criteria: the originality of the methods used in the planning and execution of such policy, the extent of the practical experience acquired, and the level of economic and social development attained. The geographical coverage of the studies published in the series is also taken into account.

The technical studies cover planning of science and technology policy, organization and administration of scientific and technological research, and other questions relating to science and technology policy.

This same series also includes reports of international meetings on science and technology policy convened by Unesco.

As a general rule, the country studies are published in one language only, either English or French, whereas some of the technical studies and the reports of meetings are published in both languages.

The present publication represents a synthesis of considerations on science and technology policy that have emerged over the last decade from a variety of Unesco sources: the sessions of the General Conference of the Organization, Regional Conferences of Ministers responsible for the application of science and technology to development, meetings of governmental experts, and publications issued by Unesco on related subjects.

In some instances, reference is also made to United Nations meetings or publications, such as for example the World Plan of Action published in 1971 under the auspices of the United Nations Committee for the application of science and technology to development.

The first part of the publication deals with some fundamental concepts and principles as well as organizational practices in the field of science and technology policies; it is structured in nine sections which have all attracted ministerial attention over the last ten years.

The second part concerns the four major resources which characterize a nation's scientific and technological potential, e.g. manpower, finances, information and facilities.

In the third part an attempt is made to situate the processes governing the transfer of operative technologies in the productive sectors of the economy, within the conceptual framework of national science and technology policies.

The fourth and last part addresses the problems encountered by policy-makers concerned with the promotion of international scientific and technological co-operation.

The publication closes with a statistical annex in support of the sections dealing with human and financial resources.

Each part of this volume is followed by a short chronological list of references which can be consulted for further reading.

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PART I

Science and Technology for Development

1. The nature and interrelationship of science and technology

Science is a way of life and a never-ending search for knowledge and truth. In his attempt to understand natural phenomena and the relationship between various elements in nature, including himself, man has indeed embarked upon an exhilarating intellectual adventure.

Etymologically, the term "science" signifies "special wisdom" in Sanskrit, and "knowledge" in its latin derivation. Nowadays "science" may be defined as mankind's organized attempt, through the objective study of empirical phenomena, to discover how things work as causal systems. By means of systematic thought, expressed principally in mathematical terms, it brings together the resultant bodies of knowledge in an effort to reconstruct the world a posteriori by the process of conceptualization. The purpose of science is to explain and comprehend in order not merely to describe phenomena but also to forecast them. Its different branches thus constitute an interlocking complex of experimentally established facts and speculative theory. It is also worth noting that there is a modern school of thought which tends to extend the definition of science even further, to embrace all intellectual and imaginative effort aimed at establishing a consensus of rational opinion over the widest possible field. Regardless of the validity of this particular claim, there is no doubt that there are a number of varying conceptions of science in the contemporary world reflecting both differences in the levels of material civilization attained by various societies, and profound widely-ranging cultural differences in their attitudes to nature and the physical world.

Although science is characterized by a rational approach to natural phenomena, other approaches exist as certain beliefs or metaphysical systems make clear. And even in those societies in which science and technology are highly developed, the long standing debate continues as to the relative value of these differing perspectives.

However science is viewed, it is clear that as man pursues knowledge and wisdom, his relationship with the universe is in constant mutation. Indeed, each fresh scientific breakthrough or newly discovered "law of nature" is both a source of power and a principle of renunciation, enhancing man's ability to adapt himself to his environment. However, although scientists throughout the world have been taking an increasing interest in the practical implications of this knowledge and the relationships it generates, they have not hitherto controlled it to any great extent.(1)

At this point, care should be taken to distinguish science from technology which denotes the whole - or an organic part - of scientific and empirical knowledge relating to industrial activities, material and energy resources, modes of transport and communication, and other similar fields in so far as it is directly applicable to the production or improvement of goods and services. Making technology operative is the task of engineers who are concerned with the design and effective application of new processes, equipment, machines or installations in the productive sectors of the economy.

In regard to governmental policy, the concept of "science and technology" applies to the following basic activities:

(i) scientific and technological research (R) or the study, experimentation, conceptualization and theory-testing involved in making discoveries or developing new applications.

(ii) experimental development (D), which consists in the processes of adaptation, testing and refinement which lead to practical applicability;

(iii) scientific and technological services (STS) representing a mixed group of activities crucial to the progress of research and to the practical application of science and technology. These services collect, process and disseminate the scientific and technological information needed for such purposes.

(iv) innovation or the development of a new product or process with a view to ensuring that fresh ideas and inventions are used effectively in

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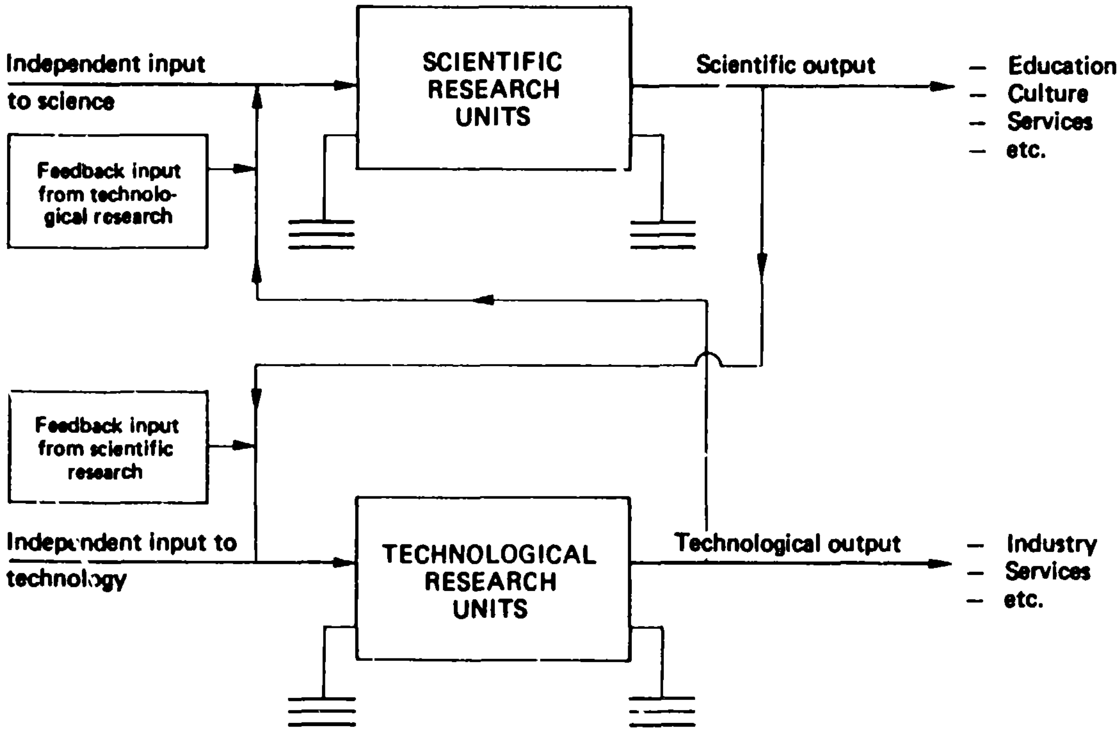
1. See in this connexion Section II on "scientific researchers in the context of national policy-making" in the Recommendation to Member States on the "Status of Scientific Researchers" adopted by the General Conference of Unesco at its 18th session in November 1974.

Relationship between science and technology



the national economy. Innovation also includes the "transfer of technology" involving the introduction of products or processes into countries in which they were previously unknown.

Deliberate attempts to promote the diffusion and propagation of innovations throughout the productive sectors of the economy are also sometimes included in this category.

It should be clear from the preceding definitions, that science and technology have nowadays become symbiotic and interdependent. Thus, while scientific and technological policy may be regarded as different from the point of view of their respective finality, they cannot be separated, in terms of research and development, public services, transfer of operational knowledge or innovation.

Furthermore, while it is widely recognized that technology has its roots in scientific knowledge, the dependency of science on technology is not so readily acknowledged. In fact, much contemporary scientific research, both fundamental and applied, depends on modern technology, and would have been impossible without highly sophisticated equipment for observation, measurement and data processing. The relationship constitutes a double feedback system, as illustrated in the diagram above which shows at the same time how science and technology have independent inputs.

The output from scientific research is split into two components, one of which feeds into education and cultural channels while the other feeds into technological research. Similarly, the output from technological research is split into two streams. The first flows into industry and services, while the second flows back to scientific research in the form of new and improved instruments, equipment techniques, and so on.

2. Science and technology in society

Today, science and the role of science mean very different things according to the type of society to which one belongs. In the most industrialized countries, the means which scientific and technological research bring to bear, and the advances which they have made possible, are tangible realities for the majority of citizens. Every inhabitant of these countries knows that most of the sophisticated products used in daily life derive from fundamental scientific discoveries, and that the level of general well-being and security enjoyed by the population is the result of scientific and technological activities which are constantly being developed.

This is however not true for the great bulk of the world's population, who live in the developing countries where per capita income and educational levels are very low; for most of these people, scientific and technological research are unfamiliar, indeed alien concepts, whose purpose and effects they cannot clearly discern.

Furthermore, the benefits of modern technology have barely reached large areas of the world because these benefits are beyond the means of nations whose populations live for the greater part, and almost permanently just above subsistence level.

While science and technology are already capable of providing society with significant material benefits, its future needs and wants and how these might be expressed in specific objectives for scientific and technological research are not altogether clear. Nonetheless, it is obvious that systematic planning, organization and conduct of scientific and technological activities will remain vital elements in any society striving for increased welfare and overall development.

Modern science and technology have been significantly influenced by the evolution of advanced industrial societies which have proclaimed a particular type of consumerism based on a generalized acquisitive spirit. But this system of values is probably in no way perennial or universal although it certainly has affected the historical growth and development of science and, even more so, of technology.

The relationship between science, techology and society cannot therefore be reduced to a single pattern and the problems with which it is associated are not always comparable. It is obvious that the developing countries exploit the results already achieved by science and technology in order to ensure economic growth, a rise in their standard of living and the development of their scientific and technological potential. But the need to study the human aspects of science and technology peculiar to non European cultures is now becoming a matter of great urgency. What are the effects of science and technology on traditional cultures in the developing countries, and how can they be assimilated? What are the effects of culture on the development and applications of science and technology? What is the place of scientific creativity among the highly individualized forms of creativity which characterize different civilizations? A further reason for attempting to deal with these questions is that their importance for the success of endogenous scientific and technological development in these countries is becoming increasingly evident.

Meanwhile, the relationship between science, technology and society also presents problems in countries in which the industrial revolution of the nineteenth century has now given way to a post-industrial era. Prior to the expansion of production characterizing the first industrialization phase, the techniques used in industry and agriculture were generally of empirical origin and, in the case of the mechanical arts, the result of individual invention. The social impact of major scientific theories and experiments was small, as was the interest shown in them by governments. The position of science in society changed when research and experimental development (R and D) appeared as a key to technological progress; a belief in the limitless advance of science for the good of mankind - "scientism" - emerged. Science and technology came to be indissolubly linked and, as the growth of government policies demonstrated, their relations with society became institutionalized.

As a result of the wide-scale repercussions of scientific and technological activity and the considerable resources required to fuel it, States came to study all the problems associated with its development and with the applications of the resulting discoveries and inventions. This is the object of science and technology policy, which relates, in particular, to the organization of the means required for the production and use of scientific and technological knowledge and to the allocation of resources devoted to this purpose. In the process, the problem of relevance is readily apparent, since science as well as technology have increasingly become instruments for extra-scientific ends such as the survival and socio-economic development of national entities or groups of nations.

Although science and technology, viewed as a coherent system constitute one of the main sources of innovation and dynamism in society, much criticism has been directed during the past decade towards their deployment. Rightly or wrongly, most of the criticisms have emotional overtones, and were mainly directed towards operative technologies since the influence of the latter is much more evident in contemporary society. The conviction is growing that unplanned and undisciplined deployment of operative technologies can cause immeasurable damage to the quality of human life and may even destroy it, particularly if this occurs in an isolated, incoherent manner without reference to the ultimate purpose of man's existence, or to his needs and environment.

Since operative technologies represent an immence high-potential economic power, their selection and practical application are often shaped by societal[1] goals and demands. Decision-making in this field has therefore become a crucial factor in terms of the welfare of any society.

The misgivings and the disapproval of some scientists regarding the use of research results applied to war, domination, prestige or profit, have become increasingly frequent in recent years and have cast a slur on scientific activity. Signs of disenchantment appeared in the sixties when it became apparent that a substantial proportion of national resources earmarked for scientific and technological research was being used for the development of nuclear weapons likely to threaten the future of mankind and to generate irreversible forms of pollution. In 1967, the percentage allocated to the military sector in the budgets of five major world powers, although smaller than previously represented between 30 and 50 per cent of the national resources earmarked for research and experimental development (R and D). At the same time, the growth of major technological space research programmes required such vast financial and human resources that several governments were forced by public opinion to reconsider their economic and social consequences. Furthermore, as the potentialities of science and technology in spheres directly affecting men's lives-health, employment, education, communication, transportation, food, housing, etc. - were more clearly

1. The term "societal" here refers to the larger context of a society including its needs and wants, as well as its rational decision-making structures (political, legislative, administrative and consultative) and the related corrective feedback processes.

recognized, the relatively modest research resources assigned to these areas was increasingly criticized. The objectives of the science and technology policies adopted by States and the use made of the findings of scientific and technological research were challenged far more than science and technology themselves. In particular, questions were raised in regard to the direction in which science or rather R and D, was moving.

It is obvious that the same techniques can be geared to beneficial or to dangerous objectives. They may result in a spectacular saving in labour as in the case of electrification coupled with automation or threaten human rights as when social administration becomes computerized. For this reason, the problem of the intrinsic "neutrality" of science has been extensively discussed by scientists, and particularly by physicists during the period when vast progress was achieved in the nuclear field.

Different cases have been distinguished in the course of this debate. The steps taken to protect individuals and society when science and technology are misused, are the concern and responsibility of political authorities, and it is vital for nations to understand that this is a vast area in which they can technically and practically coordinate their efforts. Furthermore, when discoveries have practical applications the future repercussions on society of the resulting processes or products should be carefully considered before embarking upon applied research.

If the dangers involved were to be weighed in advance - which is generally possible with expert advice - useful guidance would be provided for those responsible for taking decisions. Finally, in the extreme and most critical cases, the very nature of the research undertaken prompts scientists to reveal their misgivings regarding the risks entailed in venturing into the areas concerned. In some forms of fundamental research, these risks are so great that the researchers may, like the Sorcerer's Apprentice, be incapable of controlling the consequences of their discoveries. In one instance, world opinion was alerted to this possibility by scientists engaged in experiments involving genetic manipulation of bacteria found in man's digestive tract. At present, awareness and an objective analysis of the norms and deontology governing research in such cases, could help to clarify the prospects for the long-term development of science and technology throughout the world.

Although a postulate implicit in many traditional approaches to the problem of the relationship between science, technology and society is that knowledge advances by virtue of an autonomous process governed by its own specific and internal logic, this standpoint no longer seems acceptable. It is apparent that research and experimental development (R and D) are subject to trends which reflect those of the society in which they occur. Their role is no longer simply to ensure man's greater control of nature or the solution of technical problems in different fields of human interest such as the standard of living, health and welfare; they are now also confronted with the major task of moulding economic, social and cultural systems, and transforming them in accordance with the goals of society.

Reconciling two fundamental aspects of science and technology (their universality in regard to knowledge and their specificity when harnessed to the goals of society) constitutes a major contemporary problem. The exchange of ideas and experience required to tackle it will allow for an exploration of new methods of framing and formulating national science and technology policies. Indeed, it is increasingly obvious that in order to define national research objectives, one has to grasp the complexity of the given economic, social and cultural situation as well as the possible repercussions, beneficial or otherwise, that technological innovation in one field - such as housing or the production of consumer goods - may have for others such as health or agriculture. It is therefore more important to identify means of progress which will facilitate the attainment of a globally optimal future situation in accordance with a chosen system of values, than simply to seek outstanding results in particular fields of research. To do this, new methods of societal utilization of R and D have to be found. This problem exists both in highly industrialized countries with advanced technologies which are arguably dehumanizing, and in developing countries seeking appropriate technologies consistent with their material and cultural objectives. Its solution will entail new conceptual approaches to interdisciplinary research drawing on all the sciences (social and human as well as natural and engineering).

The relations between science, technology and society are continually changing and it is essential that they be considered objectively. In view of their sharply contrasting cultural traditions, different peoples have reacted in a great variety of ways to the large-scale introduction of new scientific concepts and technologies. The international exchange of ideas on the interactions between science, technology and society itself is therefore likely to provide a substantial contribution to our understanding of the problem. It will also probably enable us to identify deficiencies in our knowledge of certain fields of research which, until recently, had been subject to relatively little systematic exploration. In general, efforts to stimulate reflection and analysis in countries at all levels of development should be directed towards the following: an evaluation of scientific and technological trends in relation to society; identification of the cultural and moral problems posed by the advance of existing scientific and technological disciplines; and a study of the human aspects of science and technology peculiar to developing countries.

The control of operational technology in a given society should be the concern of all its members, including scientific researchers who should have special responsibility in regard to the practical applications of their work. Two principles of action follow from this. First, steps must be taken to facilitate public understanding of the socio-cultural effects of different scientific disciplines and their technological applications, so that those responsible for national science and technology policy are able to curb or stimulate technological advance. Secondly, great importance must be attached to the definition of the ethical problems confronting scientific researchers.

Finally, it can be said that the development of science and technology is primarily governed by the degree to which there is an acute public awareness of the need to expand knowledge and use it to promote action in the general national interest, as in encouraging increased production, or an improvement in living conditions. The demand for science and technology expressed by certain social groups, such as individual production sectors or rural communities, is addressed to one particular group, only composed of research scientists, engineers and technicians, and the size of this demand which depends on social, economic and cultural factors, involves different motivations and sets of values. An idea of the relations which should be established between science, technology and society is therefore normally reflected in all governmental policies determining the scale and nature of the efforts to be devoted by the community to science and technology. In view of the growing role of both science and technology in society and of the pressing need to improve living conditions in the developing nations, the world-wide promotion of scientific culture and of public awareness as to the importance of science and technology for economic, social and cultural development is hardly surprising.

Furthermore, there is a special need to develop a "scientific outlook" towards the future of mankind. This would ensure recognition of scientific and technological research (R and D) as a most useful vehicle of social, economic and cultural development in all countries. Promotion of public awareness of the role of science and technology through campaigns in which scientists actively participate, and the use of mass media are crucial in meeting this need, both in relation to the general public and to those with special authority or influence in society.

In conclusion, while we can afford to be optimistic about the prospects which the applications of science and technology hold for the future of mankind, we should also remember that there are dangers. Investigation of the interactions between science, technology and society is of key importance both for individual nations and the international community since it enables decision-makers to establish a hierarchy of research objectives which duly reflect an acceptance of common and universal values as to what the basic aims of scientific and technological research should be. These investigations should also eventually lay the foundations for new types of relationship between those who develop science and technology and those responsible for the governmental policy decisions which ultimately determine the use made of research results. Finally, they should encourage a consideration of how the application of science and technology can be better adapted to the various societal and cultural situations which exist in the world today.

3. World situation in the field of policy-making for science and technology

(a) The geopolitical setting

Contemporary policies regarding science and technology operate essentially at the national level. Their principal aim is to increase and mobilize the scientific and technological potential of the nation in the service of the objectives which its government pursues.

When several governments share similar objectives, they may pool their activities and resources in the form of international co-operative research projects or, if their aims are long-term, set up international scientific organizations. However, research organizations of this kind are not generally successful unless they enable participating States to obtain the just reward expressed in the principle of "fair returns", or unless the field covered by the research does not involve direct industrial competition or military secrecy.

Of course, the sum total of national interests in matters of research and experimental development does not necessarily coincide with the interests of humanity. Considerable R and D expenditure serves military requirements and substantial sums are also spent on projects stimulated by industrial competition. By comparison, expenditure devoted to research in medicine, the natural and social sciences, education, town planning, air and water pollution and other urgent problems including those facing the developing countries is relatively insignificant. Consequently, we are still far from the day when humanity will undertake science based development with a truly common purpose.

The universal character of science and the importance of international scientific exchanges have always provided ample opportunity to consider the future prospects that science and technology offers different countries. However, it is only in the last decade that the concept of a world science and technology policy has gradually crystallized, a policy that would tackle problems raised by marked imbalances in the localization of research and the great inequality of national scientific and technological capabilities which entail inevitable consequences for the long-term trend in the distribution of wealth and power among nations. The search for a new international economic order is leading the community of nations to attach increasing importance to a policy of this kind. Whatever turn it takes, it must be based, first, on an increasingly accurate view of each different national context and, secondly, on more detailed awareness, derived from countries' common experience, and of its potential repercussions.

Although this world policy cannot be achieved immediately, the United Nations and its Specialized Agencies are already gradually co-ordinating their efforts[1] in order to develop a United Nations science and technology policy which will direct attention towards the solid contribution which scientific and technological activities can make to the economic, social and cultural development of all nations. Unesco, of course, participates actively in this joint venture. However, since emphasis is still currently attached to national programmes, the Organization naturally devotes its energies primarily to helping Member States devise or complete their own science and technology policies. These activities, as well as the Organization's methodological studies have indicated that the objectives, methods and plans appropriate to the scientific and technological policy of a given country, depend very closely on its stage of development. Consequently, they cannot be reduced to a simple or universal typology. Yet, while there is neither a standard pattern of this kind, nor a standard layout for national networks of scientific and technological institutions, generalizations are possible in regard to planning techniques, the tasks to be performed by the institutions and the way in which these relate to each other in an organized system.[2]

(b) The economic context

Although national patterns of economic development are never identical, a number of typical situations can be invoked in order to analyse the economic context governing the efficient use of research and experimental development as well as the growth of national scientific and technological potential.

Clearly, the economic situation of a country largely determines the objectives and resources of its policy regarding science and technology. Conversely, it is nowadays recognized that the latter has a profound influence on the "change" component of development (intensive growth) which in turn characterizes the upward movement of countries from the agricultural, pre-industrialized stage, to the stage of the so-called post-industrial societies in which more than fifty per cent of the total labour force is employed in the service industries.

Some of the principal features of this evolution in relation to national scientific and technological development is given below in the form of a four stage typological analysis.

(i) The pre-industrial stage depends on the exploitation - and export - of primary products obtained from agriculture, forestry, fishing and mining. Almost all manufactured goods and equipment are imported. Since the need for managerial staff in the economy is limited, higher education is poorly developed and devoted primarily to law, medicine, the humanities and, to a lesser extent, the basic sciences. There are no specialized governmental organs for the formulation of the national science and technology policy; neither is there any specific mention of scientific and technological progress in the national development plan. Some sixty countries fall into this category.

(ii) The first phases of industrialization aim chiefly at import substitution for the common consumer goods and some intermediate products, with industrial technology largely imported from abroad. The main purpose of the drive towards original technological innovation, backed by research and experimental development programmes is to adapt foreign techniques to the use of local raw materials or to the requirements of local customers.

When products are manufactured for export, research is directed primarily to the control and improvement of quality in order to make the goods competitive on world markets. Frequently, however, horizontal technology transfer following acquisition of patents or licences is supplemented by restrictive clauses forbidding exports. Nevertheless a country can always reinvest an annual minimum of 10 per cent of its Gross National Product (GNP), so as to strengthen economic take-off. Meanwhile, research potential is often maintained by creating co-operative research centres in all branches of technology operationally introduced in the economy. Most research is primarily agricultural since climatic, soil and biological conditions are generally those of the arid or humid tropical zones. Universities constitute at least 75% of the national research potential, of which medicine represents a significant proportion. The academic world tends to concentrate on the theoretical aspects of pure research since these are less costly and the research budget of a university rarely exceeds 15% of its total financial outlay as compared with 30 to 50% in highly developed countries.

The development of the scientific public services is not uniform and their deficiencies often seriously hamper the surveying and monitoring of the natural environment, the progress of society, the health of the population and the spread of scientific and technological innovations. The activities of the few governmental bodies set up to formulate the national science and technology policy are generally limited to the promotion of research in a few selected fields. However, efforts are being

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1. ECOSOC Resolution 1826 (LV) states, in its operational paragraph No. 7: "Further considers that the planning of activities in the field of science and technology in the various organizations of the United Nations system should be harmonized and gradually integrated into a United Nations science and technology policy".

   This resolution was later endorsed by the UN General Assembly in its Resolution 3168 (XXVIII), operational paragraph No. 4: "Endorsed further the idea of the need for the elaboration of a United Nations policy in the field of science and technology ...".
2. In functional terms, such a "system" comprises the national institutions in charge of research and experimental development (R and D), as well as the national scientific and technological services (STS); in short, the national R and D and STS system. Some authors use the term "national science and technology system" instead, without always defining its conceptual content.

made to transform science and technology into a high priority national development sector. These or similar characteristics are common to approximately 40 countries.

(iii) The industrialized countries are those which have completed their first industrial revolution. Their populations are most urban and fully educated at primary level. The so-called science-based industries are in full expansion while the service industries are in the course of development.

The techniques used are not noticeably less advanced than those applied in the most advanced industrialized countries, but the productivity of labour and capital is lower, mainly because the industrial processes are less automated. Management and decision-making have an increasingly scientific base, but are not yet fully computer assisted as in the case of modelization, multivariate analysis, statistical analysis, electronic archiving and data banks.

Economies of scale play a major role in this second industrial revolution. Here, the bigger countries have a decisive advantage, which gradually compels the medium and smaller countries to join multinational economic unions. Although transnational companies become a very important factor in the economies concerned, this is not necessarily accompanied by a growth of research activity in the countries in which their subsidiaries are located because the latter tend to concentrate most of their research capacity in the parent organization.

The research potential of the industrialized countries is no longer dominantly based in the universities; seldom do the latter represent more than 20% of the total national R and D personnel. The proportion is still less in terms of expenditures, since experimental development rarely takes place in the universities and is vastly more expensive than basic or applied research. The mechanical, electrical and chemical industries together account for more than half the research effort in the industrial sector. Agriculture and traditional industries still absorb a high proportion of the research potential as indicated by the size of the corresponding research institutions. Medical research remains largely based in the universities and medical schools, with national medical research institutes and pharmaceutical industries challenging their leadership. The medium-sized and larger industrialized countries have embarked on large-scale national programmes of research and experimental development - a major component of their national scientific and technological policies. Sometimes these programmes involve managerial and scientific secretariats integrating a number of research units and institutes in a joint enterprise of "research-by-objectives", while in certain well-defined circumstances, special mission-oriented research institutes are being built to do the job, either on a national scale, or at the level of multinational economic unions.

Government bodies for scientific and technological policy in the industrialized countries are fully developed, though they often undergo spectacular reforms at the apex of the governmental decision-making structures. There is a great deal of scientific preparation of policy decisions in this field and permanent contact is maintained with educational, industrial, agricultural, health, environmental and foreign policies, as well as with the organization of overall socio-economic planning and the State budget. Parliamentary control over governmental policies for science and technology is often exercised through specialized committees.

The promotion and co-ordination of research is generally the responsibility of sectoral bodies such as research councils, academies of science and science foundations which help to unite in one national R and D and STS system a scattered network comprising thousands of research units and laboratories. The scientific and technological public services (STS) of industrialized countries are a major part of government operations which, together with a minimum higher educational level of 30% of the population, contribute to the spread of science and technology throughout the whole society. Approximately twenty-five countries belong to this group.

(iv) About twelve advanced industrialized countries are now approaching the era of post-industrial society. In these cases, there is a gradual shift in emphasis from economic to social considerations in which the balance between the two becomes a major problem. There is much more conscious decision-making about the complex systems that govern the life of society, with more deliberate choices and more conspicuous decision-centres, all of which is likely to intensify political activity. Scientists, engineers and economists participate more directly in the political process as decisions become increasingly technical. Considerably strengthened, the role of science and technology becomes a basic institutional necessity and this raises crucial questions about relations between juridical and political structures, and those which are scientific and technical. The co-existence and co-operation of the "two cultures" develops into a key issue. Meanwhile, traditionally small and autonomous, the scientific community grows ever larger and becomes increasingly government-dependent, both in regard to its research funds and the services it performs.

The deployment of the scientific and technological potential of post-industrial societies is already apparent in the contemporary evolution of the highly developed countries which face conspicuous problems relating to their quality of life. Their major preoccupations include environmental control, urban technology, genetic manipulation, control of birth and death, and the space and marine sciences.

Science-based industry and agriculture obviously remain at the basis of man's productive activities in post-industrial societies. They are increasingly supported by fundamental research in the basic sciences, while technological innovation depends to an ever-greater extent on close co-operation between governments and industry. As the products of science-based industries have a short commercial life, much of the labour force are involved in the preparation for future production in activities such as research and experimental development, technological innovation, commercial marketing and the training of users of new products or processes. Furthermore, since factory work is geared to the prospect of full automation, staff are increasingly employed in machine-servicing and maintenance. This produces a steady decline in the manufacturing labour force, similar to the decline of the agricultural labour force during the early phases of industrialization.

In post-industrial societies, theoretical knowledge is of central importance in regard to the development of new technology, economic growth and social stratification. National scientific and technological potential gradually replaces energy consumption or steel production as a comparative measure of strength.

In conclusion, the key problems of post-industrial societies will undoubtedly be the organization of science and technology, as well as the creation, dissemination and application of new knowledge. Hence, government policies for science and technology will have to participate increasingly in shaping the future of nations and of mankind.

4. Science and technology policy as a part of overall national development policy

A central aim of modern societies is steady growth in the capacity for endogenous and self-reliant development which is at present recognized as the prime factor in controlling security and living conditions. In pursuing this goal, the application of science and technology is generally considered in an overall long-term and global perspective, in keeping with cultural values. Furthermore, it is generally acknowledged that development should be directed towards maximum national autonomy[1] in the sphere of science and technology.

Development is nowadays viewed as a process in which a national community changes from its present state (cultural, political, economic and social) towards a more advanced one. Involving economic growth, social evolution and technological change, this process is generally governed by a combination of planning for specific goals and a strategy geared to maximizing the efficiency of governmental resources in order to overcome obstacles to development arising from competitive challenges liable to affect community welfare and survival.

In this respect, the science and technology policy of a government consists of principles and methods, together with the legislative and executive provisions required to stimulate, mobilize and organize the country's scientific and technological potential, so as to implement the national development plan and/or strategy. In operational terms, this policy is the business of politicians, managers and specialists in the field, who are dealing with the institutions and processes which determine, first, priority areas for research and, secondly, the functions of science and technology applied for practical purposes.

In both normative and indicative centrally planned economies planning and budgeting of science and technology (R and D and STS) are a part of the overall national planning and budgeting. As such, they can either be integrated as a first rank function or budgeting category in the overall national plans and budgets, or they can appear as a second-rank function or budgetary category in programmes such as those in economic, educational, health and industrial fields. In either case, policies in science and technology are only really profitable in so far as they are capable of guiding R and D and STS activities and international scientific and technological transfer towards the general goals and/or strategy of national development. In so doing, a first step is to express both the latter in terms of concrete and specific objectives for national scientific and technological activities. In the highly complex conditions of modern societies, these numerous "scientific objectives" are widely distributed throughout different economic and social sectors. One primary function therefore, of science and technology policy is to establish the relative priorities of programmes generating new knowledge. It must be borne in mind that the parts of programmes relating to fundamental research are not subject to any plans except those for the allocation of resources, since the likelihood and moment of discovery cannot be forecast. However, policies must also fix priorities for the application of science and technology to development. Choices have to be made and guidelines laid down with regard to scientific and technological services, the transfer of science and technology, the modernization of production infrastructures, the introduction of modern techniques into key sectors, the development of techniques appropriate to national needs and the use of new techniques better adapted to the natural or social environment. This second aspect of science and technology policy is closely related to development, land management, urban development, trade and employment policy, etc.

Policy-making in science and technology presents certain specific difficulties not present to the same degree in other aspects of national development policy. First, it must plan well into the future, since the results of scientific and technological activity will only become apparent over a long period. It is difficult to devise a policy without assumptions about future trends in a national production system or, at least, a preconceived model of the economic and social structures one hopes to achieve. Secondly, policy-making is almost inevitably selective in the majority of countries; it is indeed practically impossible for all nations to pioneer across the whole scientific and technological field because

1. The term is used here in its etymological sense of "self-government", which in no way implies a self-centred and nationalistic attitude.

of limitations imposed by the vast scale on which national scientific communities and infrastructures for research and experimental development work have to be established.

Of course, it would be pretentious to suggest that the advance of science and technology can be centrally directed by arbitrary selection of national scientific objectives and the subsequent commitment of national resources. Over-concentration of research planning, particularly of basic research, can lead to stultification. However, if one is familiar with the scientific and technological principles required to tackle specific socio-economic problems, then there is every reason for mounting concerted mission-oriented attacks on such problems, based on a centrally derived consensus. However significant it may be, the contribution of science and technology to development and change is limited and of little use without concomitant socio-economic inputs and appropriate political drive. Further, it is mainly the motivation for growth and change which prompts technological innovation and not the reverse (although the arrival of new technologies has often stimulated it). In lesser-developed countries, this is very significant in constructing a national scientific and technological policy, for short-fall in development is frequently caused by socio-economic inhibitions rather than insufficient science and technology. A shortage of scientists and technicians in production as well as poor management and inadequate quality in goods and services are often more significant than any lack of governmental research establishments or scientific and technological services.

There is, therefore, a limit to what should be expected of science and technology in relation to socio-economic development. Unfortunately, there is a growing tendency to expect researchers to overcome all obstacles to development, or show how to avoid situations which are solely the product of political beliefs and ideologies, or of social attitudes. When pressures to achieve objectives or to overcome difficulties override the realities of life, consciously or otherwise, then science or technology cannot help. They are most useful in discovering how things work as causal systems and applying the knowledge acquired for the benefit of mankind; they achieve their full potential on hard-centred subjects[1]. The application of science and technology to soft-centred subjects must be treated with care. It is dangerous and can threaten the position of scientists as well as leading to confusion at policy-making level. This does not mean that political and social considerations are not valid constraints in policy-making for science and technology, but it does imply that scientific attacks on problems to which the solutions lie elsewhere, should be avoided.

5. Scope of science and technology policies

Owing to its contribution to development policy and its key role in the productive sectors of the economy, science and technology policy has to remain attentive to changes likely to affect sectoral policies.

Because it must also be made effective and purposeful in supporting national development plans and strategies, high priority should be given to its formulation and implementation. Defined and adopted only after careful analysis of the national economic and social situation, it should aim at self-sustained autonomous scientific and technological growth as well as the organization and planning of relevant activities in support of economic and social development.[2]

The practical consequences of all scientific and technological activities lie in the innovative changes which they encourage within society and which are expected to contribute to national welfare and development.

In modern times, especially over the last few decades, scientific and technological activities have been promoted for their contribution to progress in medicine, agriculture, and industrial technology which, in turn, has represented a factor in economic growth.[3] It is however likely that in the future, the role of science as a basis for new or more appropriate technology will be more subtle and complicated. As well as maintaining the equilibrium of the man-environment system, this will also ensure more equitable use of available natural resources and energy. Science and technology will have to determine selection criteria and evaluate the implications of alternative technological choices in terms of their societal value. Furthermore, an effective policy for science and technology must always be sensitive to unforeseen and unpredictable changes (discontinuities) in the global environmental situation which are often outside the boundaries of normal extrapolation.

It follows that policy-makers in science and technology should be responsible for all matters where science and technology meet with government concern. While the concept "science policy" (sometimes used as an abbreviation for science and technology policies) is generally taken to cover all areas of knowledge including technology, some authors have used the expression "technology policy" in the sense of technological choices for industry, which in fact constitutes a part of industrial policy. Unesco consistently refers to

1. The term is used here in the sense of "hard-sciences" which are nomothetic and mainly characterized by a high degree of causal predictiveness, whether determinate or probabilistic.
2. See Third Report of UNACAST, Supplement No. 12, ECOSOC, 41st session, United Nations, E/4178, 1966, p. 9, para. 28(a).
3. Also because of their decisive role in the armaments race, as has been mentioned in section 2.

science and technology policy-making as pertaining to all research and experimental development (R and D) operations, including scientific and technological services (STS), as well as to the transfer and innovation process which ensures effective use of discoveries and inventions in the national economy. It makes no difference whether the discipline concerned is biology, sociology,[1] technology or any other of the numerous areas covered by modern knowledge or expertise.[2]

The aims of the overall mission of governmental policy-making in the field of science and technology should, therefore, be as follows:

(i) to determine and select scientific/technological objectives consistent with national plans and/or strategies;

(ii) to justify these choices and evaluate the consequences;

(iii) to exercise judgement in setting the norms that should govern the ways and means in which science and technology are developed, transferred and applied;

(iv) to gather, organize and deploy the resources required to pursue the selected objectives;

(v) to monitor and evaluate the results obtained in applying the policy.

The following are therefore among the most important questions to be dealt with by policy-makers in the field of science and technology:

(a) Establishing and strengthening governmental structures and mechanisms for the planning, budgeting, co-ordination, management and promotion of national scientific and technological activities;

(b) Gathering, processing and analysing basic data concerning national scientific and technological potential (STP), including data on ongoing research; monitoring national scientific and technological development; and ensuring the smooth growth of the institutional infrastructure for science and technology;

(c) Preparing the scientific and technological (R and D and STS) section of the national development plan and/or of the State budget; in doing so, policy-makers should:

- identify development opportunities and needs which call for the application of science and technology (including forecasting, to be dealt with separately below);

- identify existing scientific and technological knowledge relevant to the socio-economic development of the country;

- select the major tasks for the national R and D and the related scientific and technological services;

- maintain a proper balance between the various types of research (fundamental, applied, experimental development);

- support the development of a creative national scientific community and set standards for the status of scientific researchers in conformity with their responsibilities and rights;[3]

- select the areas in which technological transfer and adaptive research will be preferred to indigenous R and D;

- optimize the human, financial, institutional and informational resources for achieving the objectives established for national R and D, STS and technological transfer operations;

- promote and organize national participation in the planning and execution of international undertakings (research, exploration, monitoring, legislation, information, technical assistance, etc.)

(d) Assessing and promoting the productivity, relevance, quality and effectiveness of national R and D and STS in various sectors of performance (higher education, government institutions, industrial enterprises); removing organizational and managerial difficulties encountered in the execution of R and D and STS.

(e) Promoting the process of innovation as a driving force in development as well as the propagation of innovations throughout the national economy;

(f) Forecasting the implantation rate and the socio-cultural impact of new technologies in the national economy (technology assessment);

(g) Initiating legislative action called for by changes brought about in the human individual, in society, or in man's natural environment as a result of the application of discoveries and inventions; evaluating their economic profitability and social utility (or harmful effects);

Although the above list is not exhaustive, it indicates the most important areas for which governmental policy-makers are primarily responsible. Of special significance are the long-term scientific perspectives and technological forecasts, which will play an important part in policy-making for many years to come. Indeed, in identifying and stimulating new opportunities for R and D as well as for the application of science and technology modern forecasting techniques have become important instruments for both planners and policy-makers.

In recent years various methods and approaches to technological forecasting have been proposed. In attempting to rationalize and classify them, four basic elements have been identified - qualitative, quantitative, time and

1. It is worth noting in this connexion that the General Conference of Unesco at its 19th Session decided (c.f. Resolution 19 C/2.121) that the Organization's programme in science and technology policy would encompass appropriate segments of the social and human sciences, thus confirming the Executive Board's decision taken at its 83rd Session in October 1969 which specifically stated (para. 25 of Document 83 EX Decisions) that the Organization's programme in science policy would also cover the social and human sciences.
2. See, in this regard, the "Proposed international nomenclature for fields of science and technology", Document Unesco/NS/ROU/257 rev. 1.
3. See the Unesco "Recommendation to Member States on the Status of Scientific Researchers", loc. cit.

probability - each of which must be taken into consideration in an effective technological forecast. Since there is practically no method that includes all four, it will be necessary to use a combination of two or more complementary methods.

The four basic elements of technological forecasting are briefly described below:

(i) qualitative methods involve the description of a technological concept or phenomenon (such as intuitive thinking, analogies, relevance-trees and morphological analyses). This element is essential to any technological forecast;

(ii) quantitative methods measure the level of activity of a future technological concept in well-defined terms or units, and preferably in terms of efficiency and performance, or in economic values like cost and market share;

(iii) time methods allow for a statement of the time in years ahead when the technological concept or phenomenon will materialize. Examples are time series analyses, learning curves, input, output and relevance matrices;

(iv) probability assessments provide a statement of the probability that the forecast will materialize (as in Delphi, cross impact assessment, and the games method).

Carried out in this form, technological forecasting is likely to provide a reliable basis for decision-making, and should be regarded as an essential question to be faced by policy-makers in science and technology.

In broad terms, the functions of a science and technology policy-making body can hence be summarized as follows:

(a) the planning and budgeting function. The first aspect of this function is to look ahead, so it is, therefore, long term in character. It consists mainly in defining broad "scientific/technological objectives" and in deciding between options and results in periodic statements determining the ranges of resource allocation for national scientific and technological activities.

The second aspect of this function is short term, and therefore more tangible. It focuses on problems such as budget allocations, the share of the national R and D effort to be dedicated to competing requirements and the preparation of decisions on major R and D programmes. Both aspects rely heavily on complete and accurate information, particularly in regard to national scientific and technological potential.

(b) The co-ordination function. This function aims at coherence and consistency among the activities of mission-oriented government departments (and the private sector, if any) which have operational responsibility for the R and D programmes and related services.

(c) The management and promotional function. This function is action-oriented creating the conditions needed to achieve "scientific/technological objectives". Action is initiated by granting the resources, while evaluation ensures that their use produces the expected results.

(d) The execution function. The practical implementation of programme objectives is related to this function, the main problem being bench-level optimization of resources and effectiveness of operations. For R and D operations, the principal agents are the Directors of all relevant institutions and the Heads of Research Units, while the instruments are the various research management techniques.

(e) The function of general policy advice. This includes participation in the preparation of the National Development Plan, advice on crucial issues like the use of the sea, outer space, and the natural environment, the creation of alternative civilization blue prints to reduce societal or international tensions, the use of science and technology for national security purposes and the shaping of national ethics and laws on the use of discoveries and inventions.

(f) The function of advocacy for science and technology. This function comprises organized support for scientific and technological activities as such and especially for fundamental research which, because it is long-term, tends to suffer by comparison with applied research. It also includes the protection of the legitimate interests of the scientific community, and of the responsibilities and rights of its individual members. Experience shows that science or technology in themselves are rather weak competitors in the race for government allocation of resources. They need authorized spokesmen to assess their present performance and to take steps to strengthen them.

* * *

According to their structure and organization within the government, some of the responsibilities of science and technology policy-making bodies have been specifically highlighted by Ministerial (or government expert) meetings held under the auspices of Unesco since 1965. These meetings have attempted

(a) to integrate national policy in science and technology with policies in other fields such as education, finance, manpower development, industry and the environment;

(b) to ensure effective liaison and co-ordination of efforts between national research organization and those who use the research results;

(c) to secure and distribute funds for the support of basic research and to determine how government and other development funds should be allocated to research geared to national objectives;

(d) to create or maintain strong governmental structures for policy-making in science and technology, as well as for co-ordinating, financing and monitoring the performance of national activities in this field;

(e) to identify and remedy any breakdown in the supply of human, financial, information and institutional resources needed to implement scientific and technological projects;

(f) to maintain close contact with appropriate international organizations so as:

(i) to increase international and regional activities in regard to development applications of science and technology and to prepare suitable national plans;

(ii) to make comparative assessments as between the national scientific and technological potential, and that of other countries;

(iii) to make international comparative studies of national science and technology policies;

(iv) to survey, at international level, those policy-makers in the field who have a comprehensive understanding of science and technology as an economic, social and political force, as well as a subject in its own right.

6. Basic options in the field of science and technology policies

A set of principles of action regarding policies in science and technology has gradually crystallized, over the last decade, from decisions and resolutions adopted by various United Nations bodies, by the General Conference and Executive Board of Unesco, and by ministerial conferences on the application of science and technology convened by the Organization.

Subsequently, the following basic options for the formulation and application of policies in the field have been identified:

(a) Scientific and technological autonomy of nations. The welfare of a country depends heavily on its capacity to identify and resolve scientific and technological problems whose priority is related to national development objectives. Consequently, States should be committed to a process of sustained self-reliant and endogenous development based on their own autonomous scientific and technological capacity.

(b) Research in the field of science and technology is not neutral in its impact on society; its pursuits are very closely related to the goals of human existence. The way in which scientific research and experimental development (R and D) perform the essential task of supporting the structure of society is crucial because, once they are operational, science and technology are immensely powerful forces for good or evil. Studies on policy-making, planning and budgeting techniques should therefore be fully encouraged in order to help governments link scientific and technological activities both positively and practically to national social, economic and cultural development goals.

(c) The integrated but dual aspect of science and technology policy. It is increasingly recognized that policy governing research and experimental development (R and D), and the scientific and technological services (STS) as well as the corresponding transfers and the innovation processes affecting productive sectors of the economy, should for planning purposes be considered as integrated. Naturally, this does not mean that promotional activities and the performance of the work should be centralized. Indeed, all advanced countries have been careful to make sure that decision-making occurs as near as possible to the centres where the resulting activity takes place. However, it is also recognized that scientific and technological policy has a dual aspect: the development of the national scientific and technological potential (including the promotion of discipline-oriented research aimed at furthering advancement of knowledge per se) should be set against the use of creative and assimilative forces inherent in this potential in order to achieve general development objectives; this includes the so-called mission-oriented research.

Both aspects sometimes conflict and their successful co-ordination is one of the major purposes of good policy-making.

(d) Science and technology for peaceful ends. Military research and experimental development have been rightly described as the driving motor of the armaments race. They endanger the future of humanity, hinder progress through their excessive secrecy, and account for some 40% of the world's total R and D expenditure. In accordance with United Nations principles for peace and security, an attempt should be made to redirect this massive R and D effort towards peaceful objectives by, for example, focusing at least some attention on the specific development problems of the Third World.

(e) Scientific and technological interdependence of nations. While fully exercising their right to self-government in scientific and technological affairs, nations have not failed to recognize that both science and technology are international in character. In this respect, all countries are mutually interdependent and attempts to strengthen their relationships will inevitably lead to increased international co-operation.

(f) Mutual benefit and fair returns for partners in international scientific and technological co-operation. The need for each country to have a consistent policy in science and technology is particularly apparent in international decision-making. Co-operative undertakings in the field should respect principles of mutual benefit and fair returns for all participants, and countries should be entitled to receive the results of exploration and research concerning territories and coastal areas under their jurisdiction.

(g) Free circulation and equitable distribution of scientific and technological information. Scientific knowledge and, to a lesser degree, technological know-how are mankind's common heritage, the results of which should be internationally shared, since the free flow of this information is an essential prerequisite for global long-term progress.

(h) Status of scientific researchers. Both national and international policies in science and technology should respect the provisions of the "Recommendation to Member States on the Status of Scientific Researchers"(1) and particularly those regarding these workers' moral and material responsibilities and rights.

Although foregoing principles of action are by no means exhaustive, they do constitute a set of basic options which will gradually be improved and developed in the future.

1. Adopted by the General Conference of Unesco at its 18th session, in November 1974.

7. Interaction of science and technology policy with other governmental policies

Policy-making in science and technology obviously interacts with other governmental policy areas since it is directly related to socio-economic, educational, cultural and foreign affairs. The diagram below shows how it overlaps with other aspects of national life.

It is now appropriate to discuss two important areas of national activity, closely related to science and technology policy: education and culture.[1]

(a) The link with educational policy

Viewed in terms of science and technology policy, the educational system fulfils the dual purpose of satisfying the demand for qualified scientists, engineers and technicians and making the general public more familiar with scientific thought. It does this through general (or vocational) education, enabling people to confront science and technology rationally in their daily lives.

Effective policies in the field obviously depend upon the quantity and quality of human resources, and since these are essential factors in innovation, the educational system has to be developed and updated in order to supply them. Furthermore, educational level and the capacity for innovation are interdependent, so that, in any given instance, an increase in qualified manpower encourages innovation, which in turn generates a demand for new qualifications. This explains why the problems of mass education at higher level are now so crucial. Although they involve forecasting the future needs of qualified manpower for production, research and administration, qualitative problems, such as the content of education, may be even more important, since the need to control progress demands increasing knowledge and a fresh outlook.

In regard to the general public, more emphasis is now attached to education in individual and social attitudes rather than to passing on previously acquired knowledge. Indeed, the success of every individual or collective enterprise depends on the ability to assess changes occurring in the economic and social organization, and to interpret them with scientific open-mindedness instead of resorting to past conceptual frameworks.

A society wishing to exploit its scientific and technological resources in order to achieve its development objectives must, first, educate its citizens in observational fact-finding, adaptation to change and rational decision-making. Secondly, man must increasingly learn to question previously acquired knowledge (because new assumptions may be immediately challenged) and to make decisions (because the factors on which these will be based are rapidly becoming more numerous and complex). Both conditions are vital in carrying out the planning and administration imposed by scientific and technological progress, and in ensuring a smooth mobility of human resources, now an important factor in the dynamics of economic activity.

A country considering its policy for science, has to achieve a balance between the supply of graduates with advanced degrees, and the R and D jobs to be created following an increase in research expenditure. The expansion of university output must be rapid enough to maintain a steady supply of staff to centres of research which, in turn, must absorb these university-qualified research scientists in order to discourage their emigration.

In a development policy based on science and technology, higher educational planning has greater scope because it has to provide the highly qualified manpower required for operative technology and research. As well as being available at the appropriate time, this educational supply must correspond in quality and quantity to the jobs being offered by the national economy. Instead of being based on present requirements, therefore, the educational system should be adjusted in accordance with the needs of an economy whose structure and organization will change while its future managers are still at school.

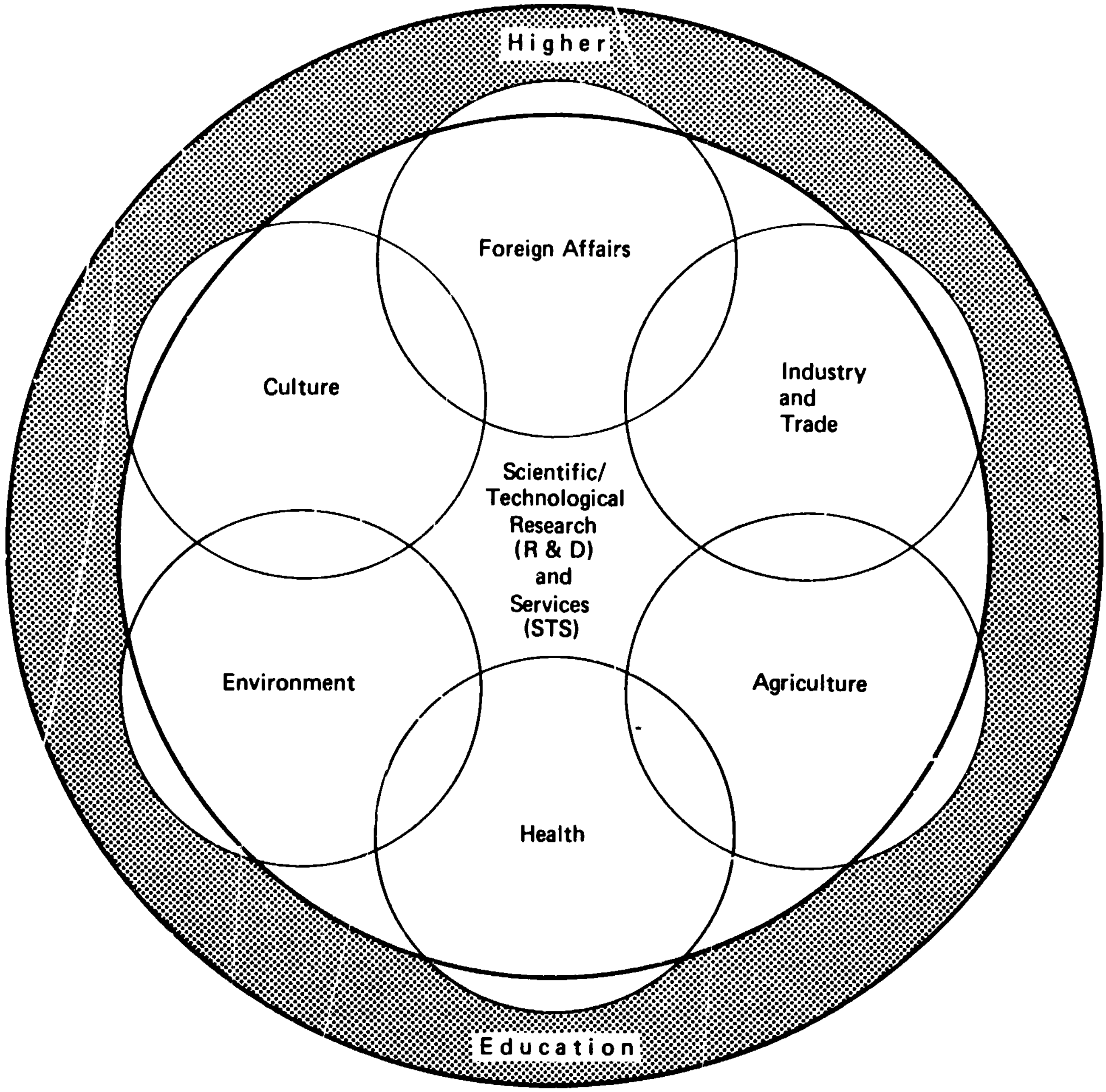
The education of highly qualified managers generally lasts ten years (equivalent to two five-year plans) starting at the end of the first stage of secondary education, when they are 15, and continuing until they are aged 25. The education of qualified technicians lasts five years (the usual length of one economic plan) from the ages of 15 to 20. Higher educational planning therefore is normally concerned with the numbers of suitably-qualified graduates, likely to be required at some date at least ten years into the future. Consequently, it relies on long-term options selected in accordance with overall national objectives, in the choice of which scientific and technological policy fulfils its key function. Policy-makers in this field should accordingly pay considerable attention to the higher educational development plan, since this is of immediate concern to them.

In contrast to the influence of education on scientific and technological development, let us now examine how policy in science and technology affects the educational system. Broadly speaking, there are feedback effects in the following areas:

- educational objectives, or the relative importance attached to the needs of society, and individual demands, as well as the mechanisms established to balance the two;
- the content of education, involving decisions as to where and at what age levels science and technology should be incorporated into educational programmes as specific subjects or fields for learning experiences;
- the approach to education, implying the use of activity or "discovery" methods rather than traditional rote learning;
- the structure of the educational system, and particularly the extent to which it is compatible with the fundamental aspects of a modern highly mobile scientific and technological society;

1. The relationship with economic policy will be referred to in sections 10 and 11 below.

Science and technology policy: its principal interconnections



Note: There are many other links not represented in the two-dimensional structure of the above diagram. These include the services responsible for pharmaceutical and food control (Health-Industry), and for the monitoring of industrial pollution (Industry-Environment-Health). Their form is naturally dictated by the conditions of the country in which they are to be found.

- the spread of education, or the choice between educating a limited number at the highest possible level, or mass education at a more modest level;
- educational guidance, with special emphasis on the functions and structures of the systems required to attract suitable students into science and technology at the appropriate levels;
- the social significance of education, or the extent to which social values constitute a rewards system for specific branches of education, such as engineering, liberal arts, medicine or law.

Clearly, the interaction between policies for science and technology and for education is not limited to universities, and takes in all levels of education. However, its implications for universities will remain particularly significant since, in many countries, these institutions provide a meeting ground for educational and R and D functions, as well as training leaders who may or may not be responsive to national scientific and technological requirements.

From an operational standpoint, national bodies in charge of educational planning and of science and technology policy-making should co-ordinate their work in at least the following major areas:

- the content and financial support of scientific and technological education;
- anticipating the supply of, and demand for qualified scientists, engineers and technicians;
- training in science and technology teaching;
- the establishment, support, finance and staffing of research units in universities and polytechnics;
- the establishment of new university science faculties (including medicine) and polytechnics.

Evaluation of achievements in education, and in science and technology would have to be periodically exchanged in order to realign estimates and projections. Revisions of either plan or strategy would have to take into account restrictions imposed by the operational requirements of the other.

Finally, presentation of unified proposals in drawing up plans and/or budgets required in areas were educational policy overlaps with S and T policy; such as research in the universities, greatly encourages speedy implementation of the proposed actions.

(b) The link with cultural policy

The concept of a comprehensive cultural policy integrated with a country's overall development plan and/or strategy is of fairly recent origin. It is opposed to and replaces the notion of "cultural affairs", which is limited almost exclusively to art, and which usually represents a series of sectoral activities of marginal value for major national functions.

Nowadays, a more significant concept defines cultural policy as the sum of efforts mobilizing the most profound aspirations of a nation in order to improve the quality of life. Any truly cultural policy will be pluralistic in principle as well as in its various practical fields of activity. Culture in these terms is no longer exclusively limited to art but is also applicable to other forms of invention such as pure science, sports, handicraft and industrial arts, and the conservation of nature. Cultural policy and science policy become jointly committed to increasing both individual and collective creative potentialities.

It should be recognized that the reciprocal relationships between science and cultural policy have not yet received all the attention they deserve, either at national or international level. However, in some cases, preservation of the cultural heritage and conservation of nature and its resources are being increasingly recognized as important cultural factors which unify action throughout a country in fixing the objectives and standards for its quality of life. This is particularly important when there is considerable dependence on foreign technology, in order to avoid too rapid a break with tradition.

Moreover, cultural activities increasingly employ scientific and technological methods and equipment so that any policy for science and technology may well be required to emphasize further its links with cultural policy.

8. Governmental structures and mechanisms for policy-making in science and technology

In a number of advanced and developing countries, several new ministries have appeared in recent years in fields such as energy, environment, and culture. Among them, one often finds a Ministry for Science and Technology, or an equivalent governmental body directly responsible to the Prime Minister, as the case may be. In countries where science and technology and daily politics are separate, the corresponding governmental policy-making body is not headed by a cabinet rank minister. Instead, matters are referred to a special Statutory Body, a system thought to encourage continuity in policy when frequent changes in personnel occur at top political level.

There are many reasons for creating such horizontally integrated policy-making bodies in the field of science and technology, some of which are mentioned below.

The first is the obvious inability of "vertical" ministries responsible for a well-defined sector of the economy such as agriculture, health, or industry, to deal adequately with the application of science and technology to development either across the board, or in terms of objectives assigned and resources devoted to research, experimental development and scientific/technological services. One major drawback is that no single governmental office is responsible for "inter-sectoral" questions, or for developing new fields which are not the concern of traditional ministries. Under these circumstances, research and innovation is bound to generate "more of the same" instead of pioneering in fields like space, nuclear energy, the environment, the quality of life, urban decay, rural development, and unemployment. Another frequent inadequacy is the absence of any governmental authority responsible for post-graduate training, status, working conditions and employment of scientific researchers and similar personnel in the governmental, academic and productive enterprise sectors. The resulting "brain drain" or emigration of talent, now a well-known phenomenon, has crippled or at least impoverished the scientific communities of many developing countries in recent years.

A second reason is the acute "vulnerability" of research and scientific service budgets in all traditional ministries. These activities are of vital importance for the long-term future of any nation and for the development of human knowledge. However, they often undergo severe budgetary cuts or are badly hit by inflation if there is no one at top governmental level to support them, to ensure adequate promotion of science and technology through successive national development plans or state budgets, and to hold the key to a "double lock" on budgets relating to science and technology (R and D + STS) in all ministries. It is well known that the lead-time between the establishment of research teams and the yield of applicable results is on average seven years throughout which continuous effort is required. Any discontinuation in budgetary support for these research units leads to their breakdown and total waste of initial investment.

Thirdly, in many countries, horizontally-integrated policy-making bodies are a consequence of the autonomy of higher educational institutions. While, in these cases, universities and polytechnics often account for most of the national research potential, it is difficult to harness this innovative force into activity oriented towards national requirements, so that university-research remains exclusively "discipline-oriented". The results are published in international science journals, and primarily serve the advanced countries which can exploit them immediately, while the less developed countries foot the bill - paradoxical situation indeed! A governmental science and technology policy-making body, with a related budgeting or funding system for "mission-oriented" research supporting long-term development policy enables considerable academic resources to be mobilized in order to solve national problems.

Fourthly, there is a universal and growing need to double-check and invigorate (by means of competitive research teams) the often inflexible and somewhat "crystallized" autonomous organizations created by governments for the study of demographic, economic, social, and development or public health programmes.

Finally, one should not forget the various tasks to be carried out at national level in regard to technological transfer, commercialization, forecasting and assessment.

What then are the various government organs needed to perform the above-mentioned functions and activities? International comparative studies carried out by Unesco have shown that it is useful to distinguish four functional levels in governmental science and technology policy-making:

(i) Functional level 1: planning, budgeting, decision-making, interministerial co-ordination and assessment of results.

The responsibility for the formulation of policy generally rests with a special Government Department or Statutory Body assisted by a "National Council for Science and Technology". Policy formulation normally includes the preparation of the National Development Plan or Strategy relating to science and technology; it also includes the preparation, on an annual basis, of the functional State Budget for science and technology (mainly R and D and STS); and it includes the assessment function (sometimes called evaluation, monitoring or "control") which consists in a continuing survey of a country's scientific and technological potential at the level of R and D or STS units, including ongoing research, results obtained, and their practical application.

The decision-making function usually belongs to the Government, or to a Committee of Ministers more specifically concerned with science and technology; it mainly involves the approval of the National Science and Technology Plan (or Strategy) as well as the annual State Budget for Science and Technology.

Interministerial co-ordination takes place, first, during the preparation of the plans and budgets, and then at the various stages of implementation of these policy-documents as approved by the Government.

(ii) Functional level 2: promotion, financing and scientific co-ordination of research, experimental development (R and D) and scientific/technological services (STS) in the various "sectors" of the economy.

The functions performed at this level are intimately related to "interministerial co-ordination" and they normally represent the first steps in the implementation of the policy decisions taken by the government.

They can be carried out either by various government departments or ministries through traditional budgetary procedures along "administrative" budget lines or through "programme-budget" procedures as applied in so-called "management by objectives".

Most countries apply a combination of these two financing procedures, and have set up one central body (or several sectoral bodies) often called the National Research Council(s) to handle the financing of R and D according to well-defined programmes. The latter can be achieved either by responding to requests for the funding of specific projects submitted by outside institutions, laboratories, research units and individual research scientists (responsive method), or by selectively entrusting them with the execution of specific projects called for by certain development objectives according to the National Science and Technology Plan or Strategy (normative method). For this latter purpose, the National Research Councils sometimes support or create their own National Research Centres in various branches of science and technology. (See Functional level 3 below). However, apart from funding projects in support of national development objectives, the National Research Councils often promote scientific and technological research for the advancement of science or technology as such, with a view to improving the level and quality of research in the country or to building up its scientific and technological potential, particularly through support for post-graduate education and research at universities and polytechnics.

(iii) Functional levels 3 and 4 concern the actual performance of research and experimental development (R and D) and of scientific and technological services (STS). Since they constitute the operational levels of national policy for science and technology, they are not dealt with in this section.

* * *

In general, it may be said that the governmental structures and mechanisms for science and technology policy (first and second levels), are established in such a way that:

(a) the design is to suit the administrative traditions as well as the socio-economic and cultural conditions of a particular country;

(b) the responsibility for policy formulation lies with an organization at the highest level of the Government and/or strongly linked with the highest planning authority for overall national development;

(c) the policy-making can be subjected to constant review and adapted to changing circumstances;

(d) active and broad participation of scientists and technologists, as well as specialists in the social and human sciences, is ensured during the policy-formulation process.

(e) the organization in charge of policy formulation receives an adequate budget, with a view to ensuring the quality and continuity of its work, and is offered reasonable autonomy and stability in carrying out its functions notwithstanding any periodic political and administrative reorganization within the government.

9. The national R and D and STS system(1)

The national R and D and STS system can be defined as a set of scientific and technological resources and organized activities aimed at discovering, inventing, transferring and promoting the application of new knowledge, with a view to achieving national objectives. Here, the national scientific and technological public services (STS) represent the whole range of activities which are crucial to the progress of research and the practical application of science and technology. (2)

National R and D and STS systems constitute the "hard core" of activities and institutions to which national policies in science and technology apply, as indicated in the diagram in section 7 showing the interaction of various sectors of human activity with science and technology policy.

The machinery and structures for policy formulation, as described in section 8, can be dynamically linked to institutions implementing this policy by using a cybernetic model described in terms of "black boxes" and "interconnexions". This is illustrated in the diagram below.

Within Zone I of the diagram, the means intended for national scientific and technological institutions which arise from the National Development Plan and/or the State Budget are fed into the R and D and STS systems as "energy", commonly expressed in financial form. The general objectives of the R and D and STS efforts are also fed into the system as directives and norms in the form of instructions or recommendations addressed to the authorities responsible for making resources available to:

- the institutions responsible for sectoral promotion of R and D;
- the institutions performing R and D and providing scientific and technological services (STS).

The meeting point of objectives and means is represented by a "valve" in the cybernetic diagram. If the valve fails to operate as it should, the whole science and technology policy operation is meaningless. This is exactly what happens in certain countries when the ministry of finance (or the bureau of the budget) reserves the right, on "technical grounds", to block the implementation of governmental policy decisions by freezing or suppressing the budgetary resources earmarked for S and T activities.

Zone II covers both the work of national research institutions and units, and of scientific and technological public services. Also included in this zone is the publication, storage and dissemination of research results, including their "packaging" in a form ready for immediate practical application.

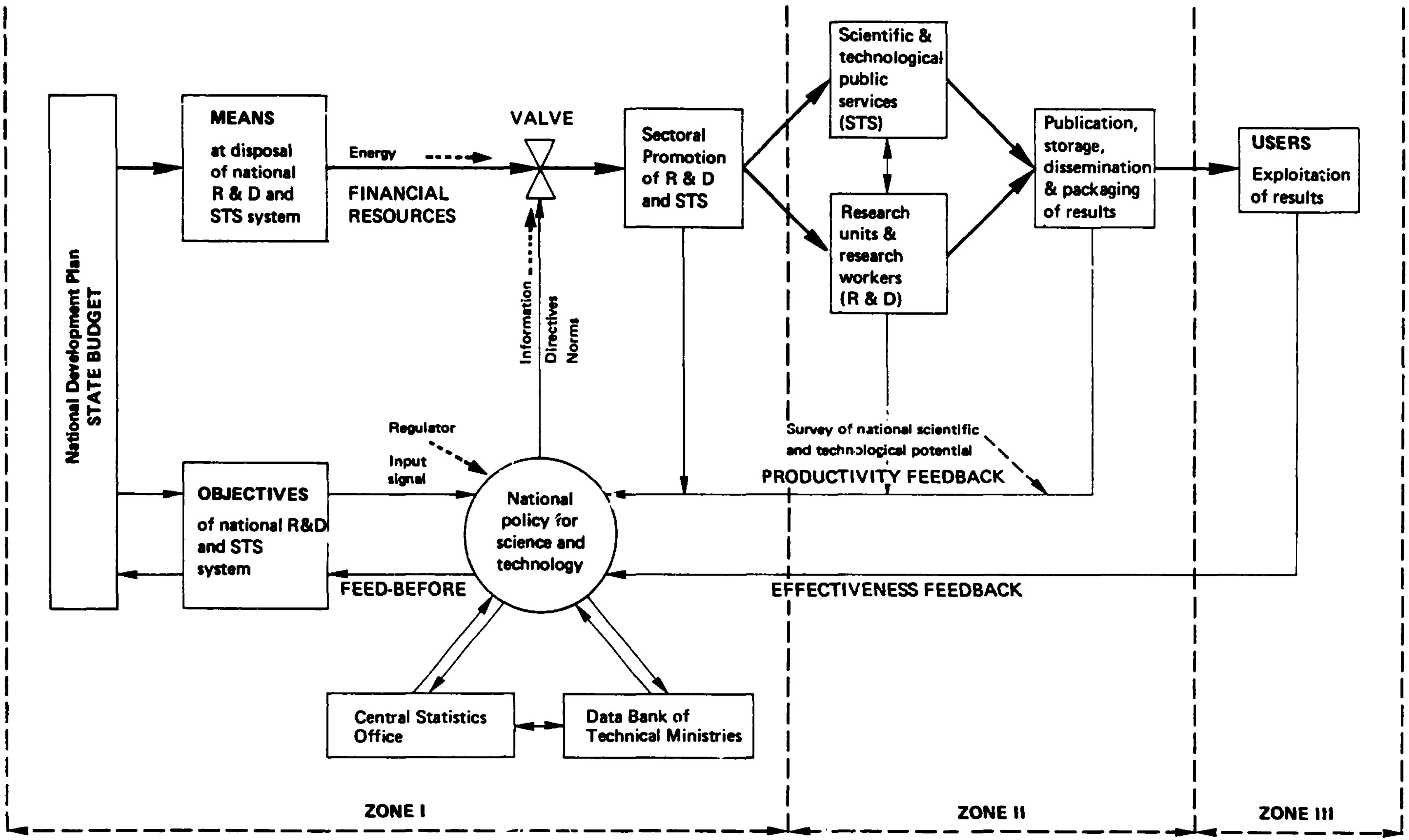
Zone III comprises the users of scientific and technological knowledge; this is where practical application takes place and where the socio-economic impact of the national R and D and STS activities can be gauged.

Efficiency and Effectiveness of the National R and D and STS system

These concepts are particularly relevant in countries where the government, responding to the demands of "public accountability", wants to ensure that its limited resources are being properly used. Whatever stage of development has been reached, the importance of maximizing the benefits of available scientific and technological resources naturally remains a valid objective. This explains the growing interest in approaches to the management of R and D and STS based on evaluation of their efficiency and effectiveness. However, since research results are naturally subject to

1. See footnote No. 2, page 12.
2. An illustrative list of these services is given in section 10 below, derived from the World Plan of Action for the Application of Science and Technology to Development, United Nations, New York, 1971 (pages 90 and 91).

Cybernetic model of national R & D and STS systems



the uncertainty inherent in exploration of the unknown, considerable discrimination is necessary in applying the notions of efficiency and effectiveness to R and D. For example, research activities do not lend themselves to an assessment of input/output ratios, whether qualitative or quantitative. Input can be measured easily enough but measurement of R and D output is likely to defy econometric calculations for some time.

Efficiency is a concept intrinsic to S and T measuring how far resources invested in R and D have been productive within reasonable time limits; it may be considered as the ratio of the new scientific or technical knowledge actually produced to that which might have been expected in theory using the given resources. Although it does not take into account the users of this newly-acquired knowledge, it is by far the most interesting concept for the scientific researcher at the bench. Effectiveness on the other hand, is a concept extrinsic to S and T which gauges the output of R and D both qualitatively and quantitatively against the socio-economic objectives pursued; it is mainly user-oriented and, as such, is concerned with the socio-economic "benefits" which may be expected from investment in national R and D. These two concepts can be applied to individual organizations within R and D systems, as well as to the systems themselves.

Attention is currently being focused on three main criteria concerning R and D evaluation:

(a) the cost of research work as compared to the benefits gained from the successful application of its results;

(b) the benefits for society (including security and quality of life) derived from successful application of R and D results;

(c) the scientific and technological value of R and D results, which can be estimated by the award of international prizes, the citation index of publications, and the granting of patents and licences.

According to a Unesco study in six European countries, the quality of research planning seems to be a key issue in the effectiveness of mission-oriented R and D at the research unit level. Indeed it appears that research unit leaders tend to be exclusively science-oriented and hence show a limited awareness of socio-economic factors, such as price/quality/market relationships, affecting the sponsors they are meant to serve. Under these circumstances research programming can be rather arbitrary. Without attempting to curb the intellectual independence of research unit leaders, it is useful to development management systems in which senior research personnel have to undergo thoroughly the discipline of defining their objectives, justifying their requests for budget allocations and accounting for their subsequent performance. It may also be advisable to bring research staff into closer personal contact with their sponsors or potential clients. In many ways this question can be regarded as a special case of a more general management problem.

10. The influence of economic development strategies

The impact of economic development(1) policies on national applied research policies is increasingly influencing scientific and technological activities throughout the world.

In the last decade, controversial and sometimes conflicting tendencies have emerged in regard to economic development strategies in many countries, some of which relate directly to national policies for science and technology. The following five types of strategy are particularly relevant to the construction of a New International Economic Order:

(i) promoting the domestic economy through investment or demand;
(ii) limiting "dependency" on foreign resources;
(iii) reinforcing the country's position on foreign markets;
(iv) developing a new type of society;
(v) strengthening - or withdrawing from - international co-operation.

As well as affecting international relations, the probable short- and long-term effects of different R and D approaches regarding these economic development strategies affect inflation, employment, equilibrium in the domestic sector, external equilibrium, interventionism, and the type of society involved. Furthermore, it has often been emphasized that situations are never clear-cut; the strategies mentioned above for the purpose of analysis usually exist in a specific combination.

The strengthening of domestic economies normally depends on investment in the productive sectors and can be reinforced by innovations resulting from successful research and experimental development. In the highly industrialized countries, the growth of new labour-saving types of capital goods is, at present, generally welcomed by firms anxious to increase productivity and minimize social conflicts, since they can then increase wages in line with recorded increases in productivity. Although a development policy centred on more capital-oriented production conforms to the wish of governments to reduce inflationary pressures it is liable to increase underemployment unless it also allows for the creation of new firms. A "stagflation" situation makes it particularly difficult to choose a reflationary policy involving investment in capital goods. Fighting unemployment means sacrificing the usual labour-saving trend of technical progress in favour of a

1. The term "economic development" here covers projects that are no longer steady-state projects, aimed merely at maintaining a production flow of a given type. Instead, they become transformational, based on a prior representation of possible kinds of production, and capable of meeting latent needs which can be made explicit (taken from J. Ladrière, "The Challenge presented to Cultures by Science and Technology", Unesco, 1977).

search for new forms of work organization such as job enrichment. However, assuming this happens, the multiplier effect of the investment would most probably be lower than that assumed in the case of the heavy investment of recent years. However, domestic economies can also be strengthened by increasing the demand for consumer goods. This involves activating the traditional incentive provided by the attraction of "new" products which are really no more than adapted or improved versions of former commodities, manufactured chiefly in the traditional sectors. However, the effects of innovation in the consumer goods sector often conflict with other governmental concerns, as the following points indicate:

(i) a policy of this kind means upholding the traditional consumer society model,, while "consumerism" is nowadays under attack on several counts, as will be seen below;

(ii) such a policy may hinder attempts to fight inflation, insofar as the arrival on the market of new products to replace previously manufactured goods is usually accompanied by price increases unless there are special controls. These increases are justified only by an objective improvement in the services offered;

(iii) finally, priority for innovation in the production of consumer goods is liable to direct R and D towards experimental development or more product differentiation rather than more fundamental research of greater long-term value. This would apply in the case of firms, R and D institutions, working for industry, and government R and D contracts and subsidies.

This is why many advanced countries are trying to encourage consumption of goods and services produced by sectors using advanced technology since this entails the marketing of entirely new products, particularly in data-processing and electronics, pharmaceuticals and medicine, the aerospace industry, and nuclear energy for peaceful purposes. The approach is optimistic in that it conforms to the idea of a new industrial revolution for the highly developed countries. New energy forms would replace fossil fuels; vehicles would be electrically-propelled or run on hydrogen; rockets and supersonic aircraft would supersede conventional planes; automatic data-processing would make it easier to centralize or decentralize corporate management; and the dependency of sick people under medical care would be reduced by developing new drugs and individual appliances. These current trends may be little more than the very early stages of new forms of consumption resulting from science-based industries. Approaching a new age of industrial civilization naturally creates difficulties for S and T policies, and it is debatable whether national economies will be ready to bear the very high costs entailed. Self-financing companies would have to be convinced that the probability of increased consumption would justify the enormous investment required to satisfy the demand, since the existence of new products does not in itself guarantee a profitable market. Furthermore, certain technological innovations are geared more to collective consumer requirements outside the market. Although governments or the banks would have to be ready to underwrite the necessary investment, directly or indirectly, the concept of a transition towards a new model of society (as outlined below) might provide further legitimate grounds for doing so. With regard to S and T policy, increased priority would probably be given to fundamental research since technical progress is already running out of radically new ideas. However, this would not eliminate the risk that programmes too closely tied to the economic situation could cause substantial R and D effort to be switched to purely commercial objectives, a trend further exacerbated by the growing intensity of international competition.

Within the strategy for limiting dependence on external sources, two alternatives or simultaneous approaches can be adopted: imports of primary products can be reduced and/or limits can be placed on the purchase of patents and licences from abroad.

Countries opting for a reduced import of raw materials generally adopt the following complementary S and T policy decisions:

- the encouragement of research aimed at manufacturing substitute products. Often synthetic, these are designed to replace products containing primary commodities which have to be imported because sufficient quantities are not available at home;
- the encouragement of research aimed at the development of manufacturing processes enabling the consumption of imported primary products used in capital or consumer goods to be reduced;
- increased support for research leading to the discovery of new energy sources as a substitute for oil, and their exploitation on an industrial scale (wind, geothermal, hydroelectric, nuclear - both fission and fusion - solar energy, etc.).

However, these policies may conflict with other constraints dictated by socio-economic conditions in industrialized countries. Indeed, research and the subsequent widespread introduction of processes and products to replace oil and other imported primary products require enormous public and private resources, which, in current economic circumstances, may prove difficult to obtain. In any event, the manufacture of substitute goods and the adaptation of existing goods to stricter standards for the saving of energy and raw materails inevitably entails a rise in both costs and prices, which usually makes the products of countries deficient in raw materials temporarily less competitive on the international market. Furthermore, an S and T programme aimed at self-sufficiency in energy and a reduction in the inflow of raw materials would be accompanied, to some extent, by a policy of semi-autarky or neo-protectionism among the highly industrialized countries. This would run counter to the internationalization process (described below) and to the establishment of a New International Economic Order (NIEO), not to mention the possible negative effect which the systematic use of energy-saving processes or the entry into circulation of substitutes (ersatz) might have on sectors, such as the car industry, which fuel the growth of industrial economies. Finally, it should be emphasized that the development of new energy sources may clash with ecological concerns. The curb on nuclear construction programmes in some countries of Western Europe and North America as a result of general public protest provides a significant example.

The countries which opt for the second alternative, of limiting purchases of patents and licences from abroad, are pursuing one or more of the following objectives:

(i) strengthening of links between basic and applied research and experimental development in order to take advantage of ideas which can produce processes and products suitable for patenting (vertical technology transfer);

(ii) the encouragement of research aimed at adapting domestically-produced processes used in one sector for use in another (horizontal technology transfer within a country); and

(iii) to enhance the value of domestic and foreign R and D findings by means of a science and technology information policy integrated with S and T policy.

There can be no doubt about the long-term effectiveness of this approach provided it is not affected by fluctuations in the world economic situation. However, it disregards both the implications of internationalization, which is expected to reduce the technology gap between countries, and the trend towards international division of the production of knowledge which arises from the frequent specialization of national Scientific and Technical Potentials (STPs).

In regard to the strategy for strengthening positions on foreign markets, countries can adopt two alternative or simultaneous approaches: markets can be developed by making the most of technological advantages, and production can be redeployed by the take-over of production plant or service facilities in other countries which would serve as a channel for technology transfer.

In terms of S and T policy, making the most of technological advantages likely to open up foreign markets for locally-manufactured products entails providing support for R and D in sectors in which the country has gained at least slight technological superiority in international competition. In addition, firms capable of withstanding competition on the world market have to be helped to launch new products and to extract the maximum commercial spin-off from the applied research and experimental development devoted to them.

It should be emphasized that the growing rôle of international competition in the relationships between the developed economies tends to work more in favour of technological innovation than of scientific discovery. Although some countries may be reluctant to finance basic research whose findings may subsequently be exploited by more enterprising foreign competitors, it must be remembered that, the maintenance of a basic research capability is a prerequisite of a technological innovation policy. If efforts are over-concentrated on technological research and development to the detriment of fundamental research, public and private decision-makers are in the long run liable to prejudice irreversibly the success of their initial objectives. If, in the middle term, the R and D effort aims at a level as close as possible to that of commercialization so that technological advance can be created and exploited, it may turn out to be incompatible with the neo-mercantilist principle, proclaimed at the outset, of retaining an absolute technological advantage. In fact, the product cycle theory states that the manufacture of a new product is bound to become standardized as it is made more widespread. If this theory is applied to international trade, it implies, sooner or later, the growth of foreign competition. Recent examples show that it is difficult for a country to maintain its technological advantage indefinitely in a particular sector, and this may prompt it to replace its traditional export strategy by one of production redeployment.

Indeed, several of these factors underlie the phenomenon of production redeployment, e.g., the ownership and control of overseas plants and service facilities through direct investment by national companies which, as a result, become transnational. These transnational companies (TNCs) are undoubtedly having an immense influence on R and D and on the international transfer of knowledge throughout the world. The following is a summary of some of the trends that have developed since the early sixties.

- Centralized accumulation of R and D resources: as a general rule, the R and D laboratories are located in the TNC home country, near the parent company. TNCs comprise most of the bigger industrial companies, in which a considerable proportion of the R and D carried out in each domestic industrial sector of the market economy countries is concentrated.
- International transfers of knowledge take place on an intensive scale but they are "internalized" which means that they are confined to the self-contained world of the TNCs. The fact that little or no R and D is undertaken by subsidiaries, or only carried out piecemeal, usually makes them highly dependent on the head office laboratories. Furthermore, knowledge and know-how circulate strictly within the constituent units of the TNCs and are not propagated to the economy of the host country, although internationalization of production appears to be accompanied by an increase in technology flows between countries;
- Generally, governmental scope for directing or controlling the R and D activities of the TNCs is very limited. The strategy and organizational structures adopted by them are largely immune from the influence of government R and D decision-makers in both host and market-economy home countries.

As a general rule, the redeployment of production and the accompanying transnationalization of firms increase industrial control of R and D activities. In this connexion, it may be necessary to examine the assumption that, as a result of this, decision-making centres normally located in the general public sector (the State and the government) which determine and implement national policies in science and technology policies are thereby being displaced towards the enterprise sector.

Many countries are seriously considering the adoption of a strategy for developing a new type of society. In so doing, the first approach consists of redefining the objectives of R and D policy in view of attempts to achieve both economic growth and a more competitive domestic economy, as discussed above. It should be supplemented by the encouragement of socio-cultural research into the problems of social inequality which are faced by all countries, including the most highly industrialized, as a result of inequitable distribution of goods and services and unsatisfactory patterns of socio-cultural behaviour.

More radical and challenging are the efforts of some of the more advanced industrialized countries to create a "post-industrial" type of economy. This trend is being reinforced by:

- sociological concerns, conservation of the environment and the return to nature;
- criticism of everyday life: urbanization, transport, the role of the media, work organization, and the inhuman aspect of some technologies;
- the uninhibited expression of desires in concepts such as increased leisure, lifelong education, flexible working hours, the permissive society, rejection of organizations, "imagination rules", and the refusal of dogma.

Ecological concerns, like environmental conservation and the depletion of resources may well lead to a realignment of R and D on a radically different value system. Although inspired, since the eighteenth century, by the idea that it is the key to technical progress and of man's control over nature, its disciplines and areas of investigation in the new value systems would have to be defined in accordance with new aspirations. Refusal to accept the restrictions imposed by industrial work and mass urbanization should foster the development of automated forms of production, with an extension of individual communications networks as the media become universally accessible. Electronics, computers and telecommunications already belong to the age of mass-production, but they are sectors requiring very substantial investment and a highly skilled labour force not readily available in large numbers. The study of new forms of social organization, from the family and the shop-floor to the world economic system, would provide S and T with a potentially rewarding area of investigation. There would be more "time to breathe" as well as more space to breathe in. The factors involved in the internationalization of production, communications, consumption and culture would create irresistible pressure for much closer links between national organizations, at least in the regions occupied by societies already belonging to the post-industrial age.

The resulting links between R and D centres would make it possible to set up programmes on an international scale and to mobilize the increasing volume of resources needed. The scale of R and D in advanced technology sectors (such as the aero-space, computer and nuclear engineering industries) and the profitable application of its results are now already beyond the scope of medium-sized nations. But equal participation by all countries in worldwide R and D is still wishful thinking. Although a substantial degree of internationalization already exists, it is mainly confined to what is, at present, an exclusive group of highly industrialized nations. Nevertheless, the role of R and D geared to economic development will sooner or later have to be considered in terms of such an internationalist outlook.

Most of the strategies examined above have one problem in common: the choice of a future international orientation for S and T policy now lies between the two extremes of co-operation or withdrawal. The first offers the prospect of tangible achievement, while the second as yet, only foreshadows decline, although, under present circumstances, it cannot be automatically dismissed. Organized international scientific co-operation between States and between industrial firms is the subject of PART IV below and will not, therefore, be discussed here. However, it should be noted that the co-operation between industrial concerns from different countries in joint ventures or "Kompleksnye problemy" is barely able to withstand the pressure for the transnationalization of industrial firms which has already been mentioned. This is true particularly of the advanced-technology sectors with examples in the computer, aeronautical and nuclear-engineering industries. Very briefly, these attempts at co-operation display a number of features which should be examined more thoroughly and most probably corrected:

- the predominant position occupied by some of the partners, which is a reflection of their scientific and technological capability;
- the appearance of a new trend in which technological co-operation is not tied to equity participation, so that each partner remains legally independent.

The main reasons for this closer co-operation between industrial concerns are probably related to the complexity of the problems involved and the considerable volume of financial and technical resources required. As a result, international co-operation in S and T among industrial enterprises probably reflects the pattern of change already observed in the advanced-technology sectors.

Finally, mention should be made of the temptation to withdraw from international S and T co-operation. The restrictions of international competition, the effects of the geographical redeployment of production and the bleak economic outlook have prompted some to advocate that the increasing internationalization of economies should be reduced or reversed. This attitude is based on two main sets of arguments, the first of which is strategic. The development, in foreign countries, of plants employing advanced technology (especially in firms taking equity participations and delivering turnkey factories) would lead to "excessive" circulation of advanced scientific and technical knowledge. This might weaken the technological pre-eminence of some industrialized nations, and particularly of their armed forces, a situation which could upset international military balance. The second set of arguments is related to the neo-merchantilist approach. Given that the geographical redeployment of production through transnational corporations (TNCs) would tend to deprive home countries of their technological advantage, it would be preferable to curb the establishment of overseas plants and to use traditional export channels to take advantage of the rents created by a science and technology based monopoly situation. This would imply ending the propagation of innovation involved in the internationalized approach to production.

11. National S and T policies in the context of a New International Economic Order (NIEO)

A national S and T policy which can be integrated with economic development policy, and simultaneously adapted to world-wide needs in a New International Economic Order (NIEO), requires a radical change in outlook by both advanced and developing countries.

The definition of an S and T policy designed to establish a NIEO consistent with the aims and aspirations of the developing countries must be based on an analysis of the current situation, the main features of which is a considerable science and technology gap between the highly industrialized countries and the remainder, and the tendency for technology to become standardized.

The quantum gap between the S and T resources of the countries in the European and North American region and those of the developing countries can easily be observed in statistics on:

- the absolute volume of funds earmarked for R and D;
- their volume as a percentage of GNP,
- the absolute and relative number of R and D researchers and centres, and the average size of such centres;
- the balance of patents and licences;
- the geographical location of technological innovations.

In addition to this quantum gap, there is a quality gap. The concentration of R and D effort in the most developed economies corresponds to the channelling of substantial resources in a given developmental direction. S and T policies are influenced by the specific problems of these economies, and the relationship between the objectives of R and D and the socio-economic context means that contemporary proposals are overwhelmingly geared to the problems of the industrialized countries, whose economic, social and cultural structures, differ radically from those found in less developed nations. The latter, therefore, have to purchase, imitate and use S and T which has originally been devised, developed and applied in the more developed economies. This is the problem underlying the issue, so keenly debated in recent years, of the "unsuitability" of the operative technology transferred from North to South. However, an attempt has to be made to understand the logic underlying the problems in order to encourage the emergence of a New International Economic Order (NIEO).

It must also be recognized that world market exports give impetus to the development model advocated or followed (implicitly or explicitly) by the industrialized countries, so that export sectors assume strategic importance. One effect of the widespread introduction of this model is the marked tendency for technologies to become standardized.

The growth of a uniform technology is more than the unintentional outcome of the transfer of operative technologies developed and used by the highly industrialized economies. The growing internationalization of economies, heralds the introduction of development models apparently jointly adopted by North and South. Since, in this case, the finished or intermediate products manufactured by the developing nations will be offered on the markets of the highly industrialized countries they will have to conform to overseas technical specifications, as well as being favourably comparable in price and quality to those of their competitors. In short, the world market mechanism requires products to be standardized, regardless of their origin.

Although the subsidiaries of transnational companies (TNCs) are of considerable significance in semi-industrialized countries or those in which the industrial areas are confined to free-zone type enclaves, the technological independence of the production units involved is very limited. When finished products are manufactured - as in the case of "relay" subsidiaries - their product range is wholly or partially the same as in the parent company. Products are adapted very slightly to account for differences both in local conditions (such as climate, consumer habits or the infrastructure) and in the size of the production units. These differences become less marked and may disappear altogether when the finished products manufactured by overseas TNCs are intended for export to the markets of the industrialized countries. If the subsidiaries manufacture components or spare parts (as in the case of "workshop" subsidiaries), then regardless of the origin of these components, their technical specifications have to be identical, because they are intended for goods that must conform to uniform standards. No matter how skilled village craftsmen may be, they are generally incapable of meeting the specifications laid down by the TNCs for the manufacture of components forming part of a complex assembly.

In conclusion the concept of NIEO or of the international integration of economies has made the controversy about appropriate technology somewhat irrelevant. However the developing countries still have to decide whether to create an export-based development model or at least one in which exports provide the main impetus - a problem which goes beyond the scope of the present analysis.

From international technology transfers to endogenous development

National science and technology policies, whether in the industrialized or would-be industrialized countries, do not appear to have been sufficiently investigated from the standpoint of a NIEO. In defining their future S and T policy, the highly industrialized countries will probably have to take into account the growing competition from promising industries in the developing ones as well as their own limitations. Manufactured goods produced in the Third World seldom possess advanced technological features. As has already been observed, the geographical redeployment of certain branches of industry frequently involves the components of a complex finished product which may be subsequently assembled elsewhere while built to specific manufacturing standards (as in the case of electronics and optics). Management of the S and T needed in industries using advanced technology remains under the control of the big industrial enterprises and the public or private laboratories of the developed countries. Moreover, not surprisingly perhaps, attitudes in these countries are already hardening, bearing in mind: (i) increasingly keen international competition, particularly in regard to traditional products from the developing nations; (ii) the growing negotiating strength of these nations; (iii) the rise in raw material prices. In any plans for a NIEO, the industrialized countries may therefore be tempted to direct their S and T policies towards strengthening their technological lead, for example by concentrating on basic and applied research. This approach would entail a break with the past when priority was given to the development of innovation primarily geared to promoting sales.

As far as S and T and a NIEO are concerned, it has to be established whether there will very soon be a new form of international specialization with a gulf no longer between manufactured goods and raw materials, but between new products developed principally through advanced science and technology, and standardized manufactured goods.

As far as the developing countries are concerned, the present international context is posing new problems regarding the transfer and the management of technology. The problem of the transfer of operative technology is still largely presented in terms of the bargain that has to be struck between those making the demand or, in other words, between the scientific and technological haves and have-nots. The issue is seemingly one of a contract with frequently very one-sided provisions between two very distinct partners, often Nation States.[1]

However, the growing volume of transfers over the past fifteen years, has to be considered in very different terms:

(i) First, the partners cannot be confined to the dyad formed by the developed and the developing State. An increasing number of transfers take place through TNCs based in the developed countries. Moreover, as already pointed out, although the TNCs are officially international, knowledge and know-how circulate in the virtually closed world of the network which they form. In other words, the flow is internalized.

(ii) Generally speaking, technology transfers through the geographical redeployment of production have not taken the form of agreements between nations. The practice has been for industrial enterprises to provide their subsidiaries with the knowledge they needed for their production activities. In short, the transfers have largely been motivated by those who already possessed operative technology rather than on the basis of negotiations between suppliers and clients.

(iii) Local managerial control over S and T is severely limited in this type of internalized transfer. Local managers can scarcely control the spin-off, since this depends on the strength of relations between the TNC subsidiaries and local industrial enterprises. Furthermore, they can have little impact on innovation and even less on fundamental and applied research, because subsidiaries engage in hardly any R and D and their links with the local scientific community are not therefore very close.

Naturally, all this is very generalized and a comprehensive analysis would have to allow for the specific conditions of the host country, the industrial sectors involved, and the policies followed by individual TNCs. However, these typical features are based on a sufficiently large number of empirical studies for their general validity to be recognized, and this alone ought to justify a new approach to the problem.

Development of local science and technology capability

The prospect of the international transfer of operative technology is not sufficient in itself to enable the receiving countries to construct their own S and T policy. It has to be supplemented by an approach involving endogenous economic development based on an expanded local scientific and technical capability. Achieving this capability will require deliberate governmental effort, as it will not be automatically generated by the establishment of a NIEO; neither can it be obtained by means of a stricter, more equitable regulation of the operations controlled by the TNCs.

If a NIEO based on the international transfer of operative technology is not rooted in the creation of an appropriate Science and Technology Potential (STP) in all countries, it is liable to lead to an international order more than ever based on unequal development but of which S and T would then be the cornerstone.

It should be added that there can be no clear view of the role of R and D in national development or of its adaptation to meet world needs in a NIEO, unless the spirit of competition still uppermost in national and international relations is replaced by a new spirit of co-operation. This must be based on the recognition of the interdependence of all in areas of knowledge relating to S and T, which should be increasingly regarded as the collective property of the international community.

1. This is one of the reasons which prompted UNCTAD to draw up an "International Code of Conduct for the Transfer of Technology".

CHRONOLOGICAL LIST OF REFERENCES FOR PART I

1. Final Report of the Lagos Conference (August 1964), Unesco, Paris, 1964.
2. Final Report on the CASTALA Conference (September 1965, Document Unesco/NS/ROU/202), Unesco, Paris, 1965.
3. Third Report of the Advisory Committee on the Application of Science and Technology to Development, Supplement No. 12, Economic and Social Council, E/4178, United Nations, New York, 1966 (paras. 28(d), e.)
4. "Principles and Problems of National Science Policies", Unesco Science Policy Studies and Documents, No. 5, Unesco, Paris, 1967.
5. "Science and Technology in Asian Development", Final Report on the CASTASIA Conference (August 1968), Unesco, Paris, 1970.
6. "Science for Development" by J. Spaey et. al., Unesco, Paris, 1971.
7. "World Plan of Action for the Application of Science and Technology to Development", United Nations, New York, 1971.
8. "Science Policy and European States", Final Report on the MINESPOL I Conference (June 1970), Unesco Science Policy Studies and Documents No. 25, Unesco, Paris, 1971.
9. Final Report on the MINESLA Conference (December 1971), Unesco, Paris, 1972.
10. "Science and Technology in African Development", Final Report on the CASTAFRICA Conference (January 1974), Unesco Science Policy Studies and Documents No. 35, Unesco, Paris, 1974.
11. "Recommendation to Member States on the Status of Scientific Researchers", adopted by the General Conference of Unesco at its 18th session in November 1974.
12. "Science and Technology in the Development of Arab States", Final Report on the CASTARAB Conference (August 1976), Unesco Science Policy Studies and Documents No. 41, Unesco, Paris, 1977.
13. "Unesco Medium-Term Plan (1977-1982)", Document 19 C/4, Unesco, Paris, 1977.
14. "Science, technology and governmental policy", Final Report on the MINESPOL II Conference (September 1978), Science Policy Studies and Documents No. 44, Unesco, Paris, 1979.
15. "Scientific Productivity: The Effectiveness of Research Groups in Six Countries". Co-publication of Unesco and Cambridge University Press, 1979.

PART II

The Scientific and Technological Potential of Nations

National scientific and technological potential (STP) can be regarded as an interactive complex of human, financial, material, informational and managerial factors. As such, it covers all the organized resources that a country has at its sovereign disposal for the purposes of discovery, invention and technological innovation, and for the study of national and international problems involved in the application of science and technology. This is a key operational concept in policy-making in the field and an increasing national priority[1] since one of the principal policy objectives is to rationalize growth of the national STP and to optimize the effectiveness of its impact on socio-economic development.

Among the various classifications of the components of national STP, the following has proved particularly convenient as a framework for representing scientific and technological activities in institutional terms. It has been developed by UNACAST[2] with the co-operation of Specialized Agencies of the United Nations system, in order to identify the institutional needs of developing countries in the field:

1. National policy-making bodies in science and technology
   - 1.1 Central policy-making body
   - 1.2 R and D promoting and co-ordinating bodies in various sectors or fields (exact, natural and social sciences; agricultural, industrial, medical, nuclear and space sciences).
2. Higher education institutions in science and technology ("third level")
   - 2.1 Science faculties in universities
   - 2.2 Polytechnic schools and schools of engineering
   - 2.3 Schools of agriculture
   - 2.4 Schools or university faculties of medicine
3. Technician-training institutions ("second level")
   - 3.1 Technological training institutions
   - 3.2 Agricultural training institutions
   - 3.3 Medical training institutions
4. Research and experimental development (R and D) institutions
5. Scientific and technological public services (STS)

This classification, which could, of course, be made more detailed,[3] illustrates the complexity of the institutional framework of a nation's scientific and technological potential. All countries, except perhaps the very small, need to have a minimum institutional capacity in each of the five major categories, the exact distribution of which should normally reflect their individual needs.

Policy-making in science and technology, as in any other field of public concern, depends on comprehensive quantitative and qualitative information, for purposes of both analysis and decision-making. Much of this can be provided by a comprehensive survey of the national scientific and technological potential (STP) which involves collecting, updating and analysing data relating to ongoing activities and the resources at their disposal. The information gathered may be administrative, substantive, operational, structural, statistical and numerical, and it should relate to all R and D and STS units in the country.

However, the STP survey provides only some of the information required for science and technology policy-making. Other categories, including socio-economic and international data, also have to be taken into consideration.

Meanwhile, the collection of numerical data known as "science and technology statistics" have encountered numerous specific conceptual and operational difficulties ever since the details

1. See "Manual for surveying national scientific and technological potential", Science Policy Studies and Documents, No. 15, Unesco, Paris, 1970.
2. See "World Plan of Action for the application of science and technology to development", United Nations, 1971, pp. 71-72 and 89-91.
3. See detail under Section 4 below dealing with Institutional resources.

required were defined in the early sixties. At present, the statistics are still fragmentary, often inaccurate, and not really suitable for international comparison.

For example, they only cover activities relating to the input of resources and even these are incomplete. Although information is available on manpower, finance and (to a lesser extent) institutional input, material and informational resources, as well as organizational data, are disregarded despite their comparative importance in systems analysis. In some cases, the data coverage does not relate to national aggregates, but corresponds only to certain areas of the economy or sectors of performance; and in others, the social sciences and humanities are totally ignored.

The inaccuracy of the statistics arises from difficulties which countries encounter in identifying the R and D and STS components in the "vertical" or "sectoralized" state budgets devoted to areas like education, industry, agriculture and health. Governments are only slowly beginning to prepare functional budgets for science and technology which provide for the measurement of expenditure at source level; they are also slow in collecting expenditure statistics at the R and D and STS unit level.

Comparisons of R and D expenditures in different countries are also made unreliable due to changes in currency exchange rates, either among themselves or with respect to a standard currency of comparison, such as the US dollar. These rates either fluctuate substantially over a short period or, as a result of economic or political conditions, may have different values at the same time. International comparisons are also limited because the sources of information and the year of reference vary between countries, or because the available time series do not cover the same periods; yet a further reason is that national statistical practices and concepts are not necessarily designed for international comparisons.

In matters relating to manpower statistics for science and technology (R and D and STS), difficulties arise in head-counting when scientific researchers are only working part-time. Few countries have been able to express these statistics in numbers representing "full-time equivalent" scientific workers.

Furthermore, the value of the statistics is compromised when inputs have to be classified according to research objectives whether discipline- or mission-oriented. For example, although an educational field or discipline is only taught when it has gained a certain recognized status, research activities often concentrate on overlapping disciplines or the creation of altogether new fields of knowledge which the statistics, clearly, do not record immediately.

Finally, relatively few Member States have established a programme of exhaustive continuous data collection in the field so that, for the great majority, only fragmentary information is available.

Bearing in mind the above limitations of the data[1], the statistics on science and technology set out in the two tables in the Annex, which present comprehensive regional distributions of the development of R and D activities, are intended for illustrative purposes rather than as a basis for comparisons. Although, in view of these limitations, it has not been possible to present meaningful regional totals, the figures do provide evidence as to the level of scientific and technological activity, with particular reference to R and D in major countries throughout the world. The first table of the Annex relates to scientific and technological manpower, showing the stock of scientists and engineers, the number of those engaged in R and D activities and their support ratio (the number of technicians per scientist or engineer). The second table is concerned with the financial resources for R and D activities and sets out, both in national currency and in US dollars, the total and per capita expenditure on R and D and the total R and D expenditure as a percentage of the G. N. P.

1. Human resources

One of the fundamental objectives of any development plan is to manage human resources, through education and training, in the best interests of a country or community. It is generally realized that the planning of these resources for science and technology is a complex task calling for simultaneous consideration of interrelated economic, administrative and technical matters; it is also recognized that it can only be realistically approached as one aspect of manpower planning, taking into account the estimated relative cost and effectiveness of alternative ways of reaching national goals.

Without adequate data on the total stock of qualified personnel in all categories (scientists, engineers, technicians, scientific researchers, research and development managers, teachers in higher education, postgraduate workers, and scientific planners) and projections of the trends observed, no meaningful manpower planning for science and technology is possible. As a result, countries often attempt to maintain a register of statistical information on personnel working in the field, with particular emphasis on scientific researchers, classified by levels of education and by specialization.

A brief analysis of the data contained in Annex (Table I) leads to the following conclusions:

- in the mid-seventies, more than 90% of the world's total of economically active scientists and engineers were at work in the industrialized countries.
- the ratio of scientists and engineers per 10, 000 of population varies roughly between 150 and 400 in industrialized countries, whereas it is

1. Attempts are being made by Unesco to improve the reliability, coverage and international comparability of statistics in the field of science and technology. See in this respect the "Recommendation concerning the International Standardization of Statistics on Science and Technology" adopted by the 20th session of the General Conference of Unesco.

well below 70 in the vast majority of the developing nations in most of which it does not even reach 25. Although it is difficult to make regional comparisons of the density of manpower on the basis of the scattered data available, it appears that the ratio of scientists and engineers per 10,000 of population is lowest in inter tropical Africa (10 or below in many cases), and Asia[1] whereas in most of the Latin American countries, it is above 50 and in Argentina, as high as 155. A similarly distorted distribution at world and regional levels is to be observed for scientists and engineers engaged in R and D.

- over the last ten years or so, the ratio of R and D scientists and engineers per 10,000 of population in the developing countries (approx. 5.7) grew a little faster than in the developed countries (approx. 25.6); but, in spite of the increase, the former still account for too small a share of the world's R and D scientists and engineers if they are to overcome rapidly some of their most pressing development problems.

Supply, demand and employment of scientific and technological personnel

An adequate supply of technically qualified personnel is an essential prerequisite for the promotion of a country's scientific and technological activities. Hence, close co-operation between scientific and technological manpower development and economic planning has to be established so that an equilibrium (or near equilibrium) between supply and demand of manpower in the productive sectors of the economy can be achieved.

In many developing countries, it has become necessary to study the problem of the "Brain Drain",[2] including what is known as the "Internal Brain Drain" or misuse of personnel within these countries. Such studies should include the international movement of qualified scientists and engineers, whose aim is to gain further experience and training abroad.

The development of policies and institutions in the field of science and technology is generally designed to eliminate or at least alleviate the paradoxical phenomenon of the unemployed, under-employed or misemployed qualified scientists and engineers whose talents and capabilities are not used to full advantage in the service of their countries.

In general, a high degree of scientific creativity in a community coupled with the prospects of permanent self re-education, career development, satisfactory conditions of employment and improved social status is likely to lead to a better utilization of qualified scientific and technological staff.

While the employment issue is gradually becoming vital in all countries, its consequences for socio-economic development are certainly worse when unemployment hits highly qualified and creative people like scientific researchers. It implies that terms and conditions of employment should be framed and interpreted with maximum precision and flexibility, in order to meet the requirements of creative activities in science and technology, thereby recognizing their highly significant contribution to the well-being and prosperity of contemporary society.[3]

Access of women to scientific and technological careers

Policy-makers should not overlook the important need for women to have access to scientific and technological careers and subsequent career development prospects. Aside from the principle of individual equality of opportunity, the value of attracting women, as well as men, into careers as scientists, engineers and technicians is obvious, and all social barriers which prevent this stifle a great deal of human potential in science and technology. As regards the possibility of careers for women in this field at higher level, a number of studies conducted in different countries seem to indicate that the nature of the work they are given to do is usually at the lower technical levels.

General education and training of scientific and technological personnel

Education and training programmes aimed at supplying qualified personnel are costly in terms of investment, particularly since the economic benefits are generally long-term and the results often intangible. It is, therefore vital that these programmes be adapted to national development needs, which is now fortunately possible because of the strong relationship which can be established between educational and scientific/technological policies, as indicated in Part I, section 7. These close links are essential if endogenous scientific and technological development is to be achieved and tailored to the specific economic and social conditions of a given country. As a result, the curricular content of higher education in science and technology has attracted considerable attention in recent years, so that it is now generally accepted that the reappraisal of these curricula should be consistent with local needs and practical problems.

At the same time, lifelong education is being encouraged with adequate opportunities for scientists and technologists to revise and update their knowledge through, inter alia, sabbatical years and refresher courses. Considerable attention is also now being paid to the in-plant and in-service training of technicians and technologists,

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1. Except, of course, the industrialized countries of Asia, such as Japan, Hong Kong, Rep. of Korea.
2. See in this connexion, the study prepared by Unesco for the United Nations Advisory Committee on Science and Technology for Development, entitled: "The problem of emigration of scientists and technologists" (Doc. Unesco/NS/ROU/158).
3. See the Unesco "Recommendation on the Status of scientific research workers", loc. cit. paras. 14-19, 39, 41.

in which universities, technical institutions and industry generally agree to participate on a cost-sharing basis.

Furthermore, there is no doubt that universities will continue to play an important part in the training of scientific researchers. It is therefore essential that they receive maximum possible support, while co-operating closely in national mission-oriented R and D programmes.

Postgraduate education in the field of science and technology

The expansion and strengthening of postgraduate education has always been one of the major responsibilities of universities. Nowadays, however, it has become a principal area of interest to science and technology policy-makers because of the justifiable importance of the R and D component in postgraduate studies. In recent years, some countries have tended to create postgraduate institutes of advanced studies and centres of excellence, where national or regional resources are pooled to update and extend scientific or technological knowledge. However, this trend has created fresh problems regarding selection criteria for elite groups and the separation of those which are disintegrating.

2. Financial resources

In devising a policy in science and technology which is integrated to development planning, the scale of the national effort in this field should first be compared to that devoted to other activities like production, education and defence. Although, it is not easy to assess optimum proportional values for these activities, it is at least clear they are best expressed in terms of manpower and funds. However, the subject of financial allocation will usually be uppermost in discussions on science and technology policy, with special reference to sectoral allocation and detailed breakdowns.

For planning and budgeting purposes, most countries have tended to separate the financial aspects of resource allocation to research (R and D) and the scientific and technological services (STS) on the one hand, and to higher education, on the other. There is nothing wrong with this, provided one remembers that the availability of skilled scientific workers is an absolute prerequisite. Furthermore, it is recognized that it is easier to take and evaluate policy decisions in regard to financial flows, with relatively little delay in response, than in the case of manpower flows in which the time required to train highly qualified research scientists precludes anything but long-range planning of from 10 to 15 years. Accordingly, society has to establish criteria in deciding what proportion of its financial resources be earmarked for activities in science and technology (R and D and STS) as opposed to those in competing areas such as education, social security and foreign aid.

In most cases allocations will depend on political as well as scientific, economic and social choices inherent in the national development plan or the State budget. The chief political factor is the extent to which a country wishes to be self-reliant in its production of research results instead of depending on imported resources and expertise. Decisions will be based on the general political trend of the country as well as on the importance it attaches to scientific self-reliance, due consideration being given to relative costs of various alternatives. National prestige is yet another factor which may enter into political choices; in developing countries, particularly, such considerations are usually treated with caution. In any event, the political factors have to be introduced at an early stage of this decision-making process, since they affect both the allocation of indigenous resources and foreign policy (particularly in regard to overseas aid), as well as the overall outlook of the policy in science and technology.

Science and technology budgeting[1]

Conveniently defined as policy-in-action, the budget is the complement of planning and programming whose operational elements it presents in the form of annual expenditure and financial structure; it shows the share of financial responsibility which the government accepts in implementing the plan in a given year.

Accordingly, it is easy to understand the key function of budgeting as a particularly powerful instrument of national policy in science and technology, especially if one bears in mind certain important characteristics of activities in this field. These include their contribution to identification of long-term development options, and of short and medium-term development objectives (which they often also help to achieve), as well as their great reliance on government financial support. Yet an examination of national budgets for S and T - in countries where they exist - reveals that they are rarely suited to the purposes for which they ought to be intended. Moreover, scientific and technological activities are not, in the budgets of many countries, visible components. In fact, traditional budgets show the total appropriations, by ministry, in administrative rather than functional terms, which do not allow individual activities and their components to be identified. However, long before the question of budgeting in science and technology arose, the inadequacy of the traditional budget concept had become a matter of concern for developed as well as developing countries. The old type of budget is in fact a very inappropriate link with the national development plan and this partly explains why a small but growing number of countries now prepare an annual functional budget (programme-budget), in addition to the traditional administrative one.

1. See in this connexion document UNESCO/NS/ROU/438 presented as Reference Document No. 8 at the MINESPOL II Conference (Belgrade, September 1978).

The concept of functional budgeting, with science and technology singled out as a separate function of first or second category, not only makes the national budget more lucid; it also helps to avoid arbitrary budgetary decisions. While in the traditional administrative type of budget, cuts or increases are usually made only at the level of the ministries concerned, these decisions can be rationalized if they are related to ongoing functions and programmes which may also be ranked in priority order. All too often, arbitrary general budgetary decisions have adversely affected R and D activities, which are particularly vulnerable to abrupt fluctuations in annual financial appropriations because their results only become available at the end of a project invariably several years in length. In this kind of situation, all previous budgetary inputs may be lost if financial support for a R and D project is curtailed or ended before the date set for its completion.

The production of a comprehensive budgetary balance sheet for activities in science and technology considered as a single item with references to financial flows and distribution of funds, has constituted a landmark in the development of national science and technology policies in many developed countries, as well as a growing number of developing ones. However, it should be stressed that this does not mean that the implementation of activities foreseen in the consolidated science and technology budget should be entrusted to one ministry only. The principal requirement is the consolidated presentation of R and D, STS and related activities of the various ministries in terms of contributions to national objectives, or, in other words, in the form of programme-budgets.

A national budget for science and technology prepared in functional terms not only allows for the co-ordination of scientific and technological activities carried out in various branches of government and the economy; it also provides a rational basis for governmental decision-making in relation to its own optimal size.

The content of the area to be integrated in the Science and Technology Budget

The content of the S and T function which has to be integrated in the functional budget of the State is usually broken down into four subcategories or subfunctions:

(i) The planning and general administration of S and T which comprises all management activities connected with the efficient working of the national science and technology infrastructure;

(ii) R and D training of scientists and technologists representing the transition, at the upper level of the postgraduate stage, between systematic and formal education, and the point where R and D and STS activities constitute a professional occupation;

(iii) Research and experimental development (R and D) consisting of creative activities designed to add to knowledge or discover new applications;

(iv) Science and technology services (STS) which cover supporting activities (metrology, standardization, quality control, general-interest scientific data compilation, scientific collections) and the circulation of knowledge (information, extension and technical consultancy services) forming the link between S and T and the production of goods and services.

Types of functional budget documents for science and technology

(i) The composite budget

When there is no homogeneous functional classification applicable to the entire national budget, the existence of a specific budgetary analysis system for S and T enables one to draw up a "composite budget for S and T". However, this is not so much a budget as a consolidation of all funds allocated to S and T as they appear in the annual budgets of the different ministries. A compendium of this kind takes the form either of a report attached to the budget law providing a comprehensive view of ministerial S and T expenditure (often restricted to R and D alone), or of a compilation prepared by the national science and technology policy-making body or statistical office. Unfortunately, such composite budgets do not enable comparisons to be made between funds earmarked for S and T (as a function for developing creative and innovative capability) and those for other government functions.

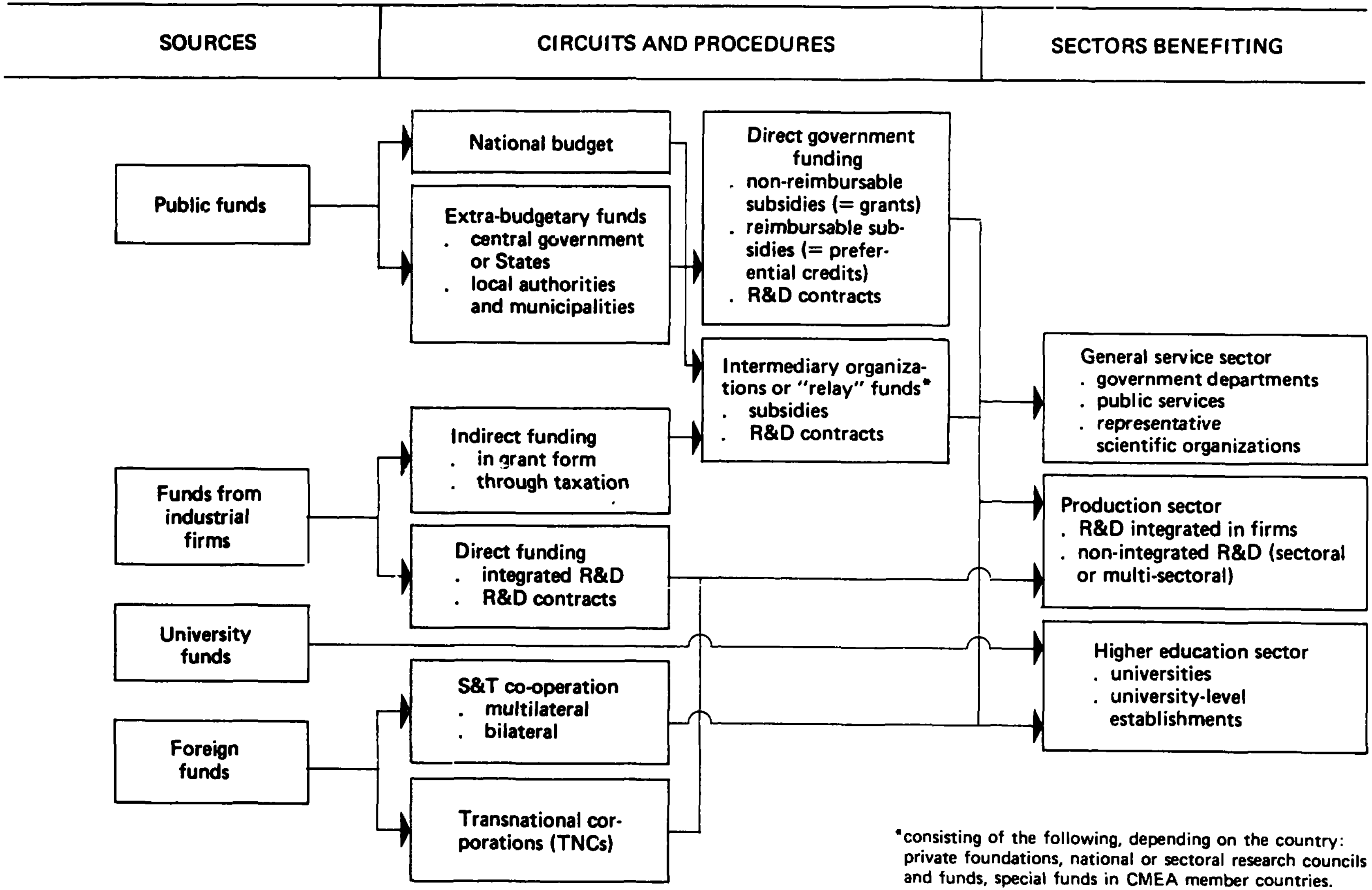
(ii) The functional budget

The first type of functional approach is to use a homogeneous budgetary classification for all government expenditures, embodying S and T as a subcategory or, in other words, as a heading appearing under each of the functional categories in that classification. This approach, in which S and T is treated as a subfunction, makes it difficult to classify the increasingly large number of multipurpose or multifunction R and D programmes. Moreover, it does not allow the institutional distribution and total of the budget funds allocated to S and T to be read off directly, since the subfunction level is seldom used in comprehensive analysis tables.

The second type of functional approach consists in introducing a first level category specific to S and T into the functional classification of government expenditures. This makes it possible to include in the national budget document a two-dimensional comprehensive analysis table of the total of the budget lines, in which the distribution of all budget funds, including those for S and T, is indicated in terms of institutions and functions.

The requirements that have to be met prior to such functional integration include (i) budgetary conditions: a homogeneous functional classification has to be used in the national budget, and the total funds earmarked for S and T should exceed a certain threshold, and be distributed among a sufficiently large number of S and T institutions; (ii) institutional conditions: there should be a national body responsible for S and T policy, and

Main forms of R&D funding



*consisting of the following, depending on the country: private foundations, national or sectoral research councils and funds, special funds in CMEA member countries.

(iii) co-ordinating conditions: there should be close collaboration between that body and the bodies responsible for the plan and the budget.

It is important to note that the explicit integration of S and T in national budget procedures does not require any additional financial effort or any change in the legal budget structure, since it is merely a political decision aimed at:

(a) introducing a specific category for S and T into the functional budget classification;

(b) providing for the budgeting of S and T activities;

(c) gradually directing the funds earmarked for S and T in accordance with the criteria laid down in government decisions and official documents such as national development plans.

The funding of R and D

Financial resources for research and experimental development are generally not confined to public funds only; whenever applicable, financing of research from private funds is also being encouraged, and governments usually attempt to create an economic climate conducive to this as part of the national development plan.

The above table illustrates the main forms of R and D funding encountered in the Member States of Unesco.

(i) Funding of R and D through the national budget

Over the past twenty years or so, the tendency has generally been for government responsibility for R and D to grow, mainly as a result of two factors:

- the recognition that R and D has a fundamental role to play in economic and social development;
- the shortcomings of private R and D funding structures and mechanisms in areas where:
  - the return on investment is long-term and cannot be readily identified
  - problems are too wide-ranging or are of a multisectoral nature
  - costs are too high for the financing capacities of firms and other bodies.

However, regardless of the nature of government responsibility for R and D, the authorities will always have to assume the co-ordinating role which they alone can exercise and which consists primarily in the preparation and implementation of the national budget.

Government budget funding may be direct, in which case public funds are allocated directly to R and D executing agencies in the form of contracts and of subsidies, which may or may not be reimbursable. Alternatively, it may be indirect with funds channelled through intermediate organizations responsible for distributing them to the executing agencies, as will be seen in the next section.

(ii) R and D funding through promotional or speical funds

(a) the private foundations: in the past, private foundations promoting R and D were a relatively important source of funding for scientific research. They were particularly effective in responding to applications by researchers owing to their prompt action, their independence, an often bold and innovating outlook and the fact that they were not bound by the constraints of annual budgeting.

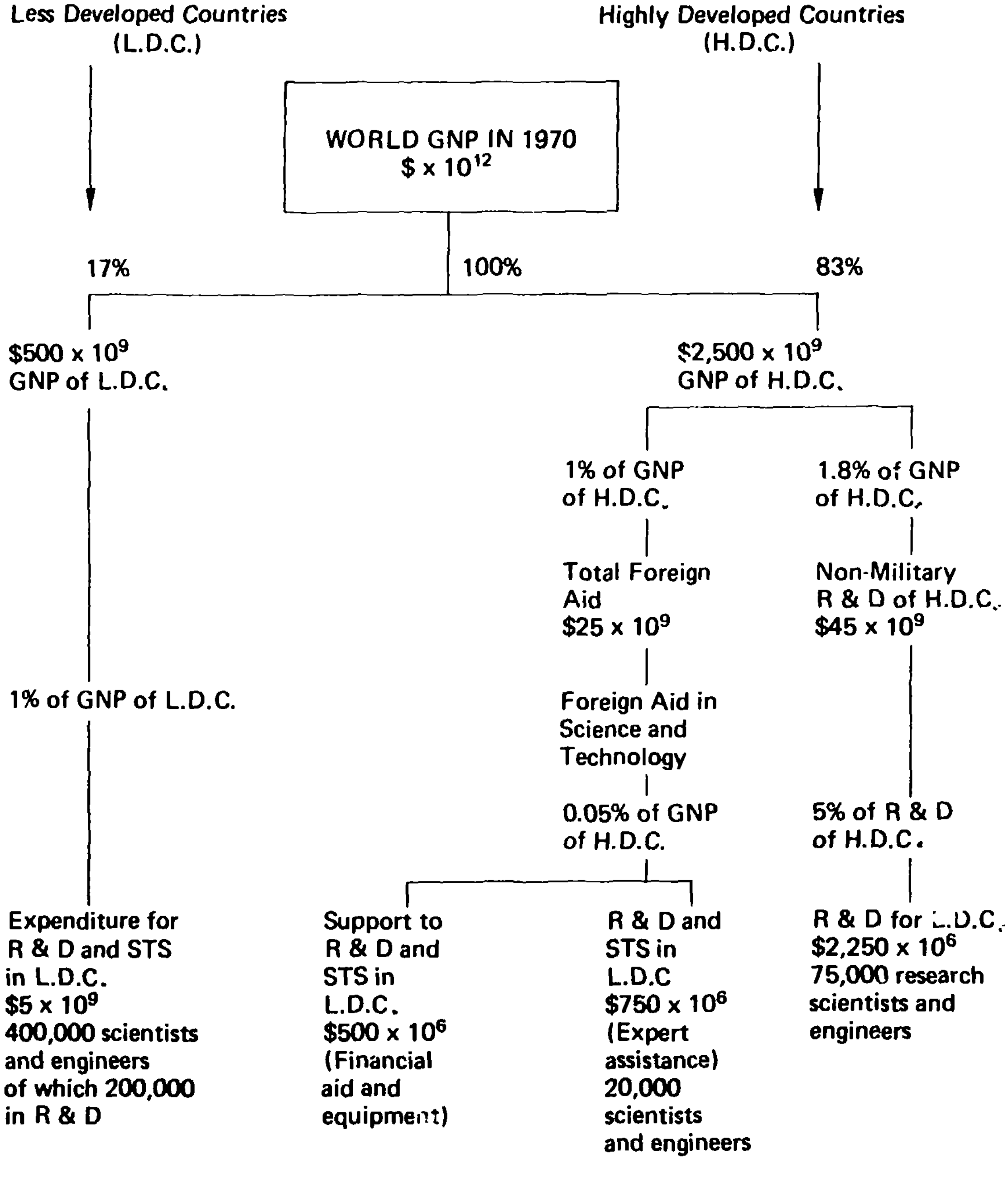
(b) National or sectoral research councils and funds: in view of the magnitude of the new needs generated by the increase in public funding of R and D, governments have decided - depending on the country - either to set up a new type of public funding agency, or else to resort to existing private institutions whose funding they have gradually taken over. Both solutions have, in fact, led to the same result. The distribution of the funds which governments allocate to research has been entrusted to largely autonomous central promotional bodies managed by committees of scientific researchers and responsible for translating practical problems into questions scientifically posed in the form of research projects.

This form of intervention deprives the national budget of some of its decision-making and control powers. However, it still has a trend-setting and guiding function first, when the subsidies granted by the private foundations have to be supplemented by funds from the national budget and secondly, when governments provide funds only on condition that the partners involved themselves finance at least 50 per cent of their approved proposed research programme, as is the case in several market economy countries.

(c) Special funds in CMEA member countries. This refers primarily to the financial resources provided by funds such as the technical and economic development funds in the socialist countries. These special resources are usually formed from the proceeds of an industrial turnover tax and the sums involved are then allocated by the various ministries concerned to joint R and D programmes of common social significance for a particular sector of national activity.

In concluding this brief account of the forms of R and D funding, it is fair to say that when handled by governments, it may make the return on research credible enough for it to attract capital from industry and sometimes even from foreign funds. This clearly shows that the power of governments to indicate the direction which R and D should take goes far beyond the funding for which they are directly responsible. In regard to this, it is worth recalling the controversial question of apportioning R and D funding among fundamental research, applied research and experimental development, in relation to their real or assumed relative importance in national development. In any event it is recognized that fundamental research must continue to enjoy a high degree of independence, characterized by unfettered support. At the same time, however, it is felt that there is a need to develop a national consensus on the criteria to be applied in selecting research projects and on the place and level at which such selection should be made - and rightly so - bearing in mind that fundamental research may lead to investigation of scientific problems far removed from immediate practical applications or national requirements.

Science and technology targets for the second UN development decade applied to 1970 GNPs and prices



GNP = Gross National Product
H.D.C. = Highly Developed Countries
L.D.C. = Less Developed Countries
R & D = Research and experimental Development
STS = Scientific and Technological public Services

Note : The average costs of maintaining a research scientist or engineer was assumed to be as follows in 1970, in L.D.C. : $12,500; as "technical assistance experts" : $37,500; in H.D.C. : $30,000.

Financial Targets for the application of science and technology for the 1970-1980 decade

The World Plan of Action for the Application of science and technology to development[1] has specified three targets for expenditures in this field[2].

(a) Target I recommends that developing countries should attain, by 1980, a minimum level equal to 1 per cent of their GNP on the sums allotted to science and technology (research, experimental development, scientific and technological services); of this, at least 0.5 per cent of the GNP should be for R and D. Countries below this level should aim at increasing the financial resources devoted to science and technology at a rate of about 15 per cent each year. Obviously, the suggested target is an average, which has to be computed by adding the GNP's of developing countries and comparing this total with their consolidated scientific and technological expenditure. Some countries which were spending less than 0.1 per cent of their GNP on R and D in 1970 can hardly be expected to reach the 0.5 per cent target by 1980; others, which were already spending 0.5 per cent of their GNP on R and D in the mid-seventies will certainly exceed it. The limitation or Target I is based on the experience of advanced countries, which suggests that a doubling time of five years for national expenditures on R and D should not be exceeded in countries that have reached or overtaken a proportion of 0.2 per cent of the GNP devoted to science and technology (R and D and STS). This five-year doubling time corresponds to an annual growth rate of 15 per cent (at constant prices) which, if exceeded, leads to waste since manpower and R and D institutional infrastructures cannot keep pace with requirements.

(b) Target II relates to international aid, and recommends that highly developed countries should increase their direct support of science and technology (R and D and STS) to reach, by 1980, an average level equivalent to 0.05 per cent of their GNP. This corresponds to 5 per cent of the total foreign aid if the latter is calculated at 1 per cent of the GNP of the highly developed countries. At 1970 prices, this would have amounted to $1,250 million for which two subsidiary targets were proposed:

(i) to pay $750 million for scientists and engineers working in developing countries, which would account for some 20,000 specialists at an average annual cost of $37,500 (at 1970 prices);

(ii) to cover direct financial assistance amounting to $500 million in scientific and technological equipment.

(c) Target III recommends that each of the highly developed countries should, by 1980, devote at least 5 per cent of their own internal non-military R and D expenditure to research on problems of specific importance to developing nations. (In 1970, this total was less than 12.5 per cent of the total military research and development expenditure of the former). Target III amounts to approximately 75,000 scientific researchers at work if the unit average cost (at 1970 prices) is taken to be an annual $30,000 in highly developed countries.

The Table above summarizes these three targets in financial terms with the numbers of scientists and engineers concerned.

Financial effort devoted nationally to research and experimental development (R and D)

Table II in the Annex shows the intensity of the financial effort devoted, by several Member States in each region, to research and experimental development. For reasons explained above, as well as the rapid pace of inflation in many countries in recent years, the absolute value of R and D expenditures cannot really be compared between the late sixties and the late seventies. Furthermore, comparisons are not meaningful between countries using different principles and methods of national accountancy such as the System of National Accounts (SNA), which is the basis for evaluating the Gross National Product (GNP), and the Material Product System (MPS), which is used to calculate the Net Material Product (NMP).

When considering the world-wide financial effort devoted to research and experimental development, the disparity between developed and developing countries seems even more pronounced, since the available statistics, while less reliable than those relating to human resources, show that probably more than 95 per cent of world expenditure on R and D around 1975 had been incurred by the industrialized countries. There is evidence that the situation was similar in 1965-1967, as the developing countries have not been able to increase significantly their financial share of the world's R and D effort in the last decade.

A comparison of national per capita expenditure on R and D further emphasizes the prevalent low level of public and private spending for it in the developing countries. Whereas industrialized countries spend annually between US$ 50 and 150 and in some cases (such as the United States and Switzerland in 1975) up to some US$185 per capita on R and D, there is practically no country in the developing world where this ratio exceeds US$ 5.

This situation is also exemplified by the low GNP percentages that developing countries devote to R and D. Generally speaking human and financial resources devoted to science and technology in the industrialized nations in the years

1. Cf. Ibid. pages 56 to 58.
2. Target I has been approved by the U.N. General Assembly in its Resolution 2626(XXV) on the International Development Strategy for the Second Development Decade; while Targets II and III have been the subject of subsequent resolutions from (a) the U.N.General Assembly: 3179 (XXVIII); and (b) ECOSOC: 1718 (LIII); 1822 (LV), 1901 (LVII) and 2029 (LXI).

1940 to 1960, followed an exponential growth curve which has, however, since been slackening with a slight upsurge in the last two or three years in some of the most advanced countries.

Since 1960, the developing countries have decisively moved towards the same exponential growth rate because they are coming within the sphere of influence of highly developed modern science and technology.

It is encouraging to note that, in proportion to their economic strength, the developing countries are reacting more vigorously to the impact of scientific knowledge than did the developed ones forty years ago. It is clearly essential for them to achieve rates of growth of human and financial resources devoted to R and D higher than those of the industrialized countries. Otherwise, the world will pursue its present fatal disruptive course largely caused by the increasing scientific and technological "gap" between rich and poor nations and the resulting "technological colonialism".

There is a final point of considerable significance. The tremendous increase in world outlay for R and D in recent years and the subsequent scientific and technological progress have often led to international tension and power struggles, both economic and military. No less than an estimated annual US$ 25 billion were being spent on military research in the early seventies[1], a sum which represented 30 to 40 per cent of the total world expenditure on R and D, and exceeded by a factor of three total official aid to Third World countries.

3. Information resources

Information resources in science and technology constitute a key element in its potential. They comprise not merely the information itself but also all arrangements, however informal, enabling one to collect, store, and evaluate it before transferring it to its eventual users, regardless of their geographical location. Furthermore, the need to ensure this flow requires personal contact (through meetings, for instance) just as much as the establishment of institutional components of the information transfer chain (institutions, transmission means and organized programmes).

In turn, this demands a systematic way of organizing the flow of information within a country and abroad. A science and technology policy-making body can function effectively only if such links are fully operational. Thus, a national policy for scientific and technological information should be formulated and considered as an integral part of the policy for science and technology itself, and the responsibility for it should clearly rest with the government.

In building up information resources, the principle requirement is the development of national infrastructures leading to the establishment of systems for collecting and organizing information in order to facilitate its retrieval, availability, transfer and exchange. This includes the study of techniques, processing of information, and its conversion into forms comprehensible to the principal group of users.

The major tasks are as follows:

(a) Formulation of national policies to promote systematic development of the S and T informational infrastructure;
(b) Carrying out national surveys of existing S and T information facilities and needs;
(c) Planning, design and establishment of national S and T information services and systems;
(d) Evaluation of operational projects aimed at developing the national S and T informational infrastructure;
(e) Organization of experimental and pilot projects for the transfer of information.

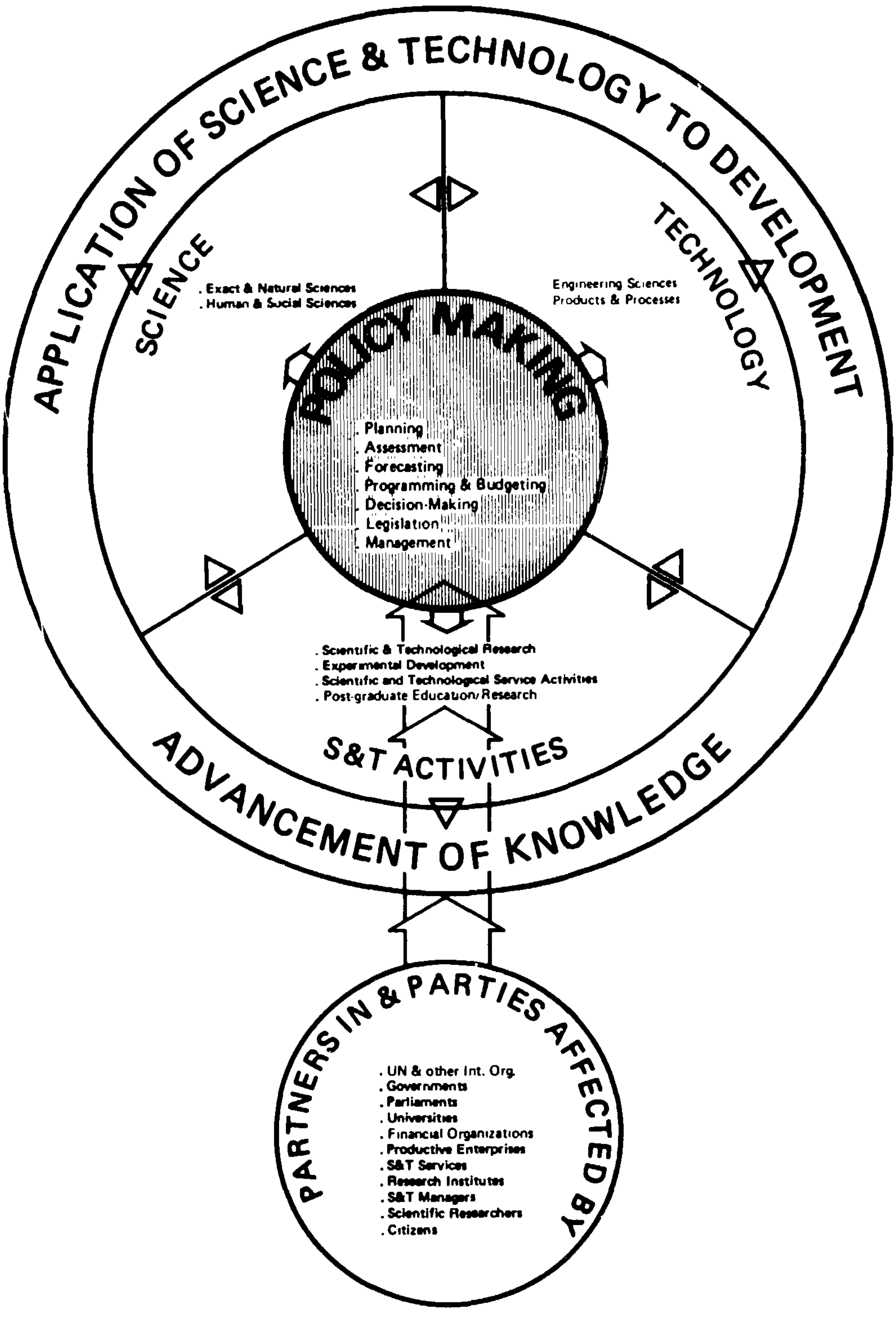
The World Plan of Action for the Application of Science and Technology to Development states that "the Second Development Decade should provide for a systematic and adequately supported effort to improve the facilities and arrangements for the transfer of existing knowledge and technology from the developed countries to the less-developed ones. Developing countries require scientific and technical information systems of their own, suited to the type, capacities and location of the producers and users of such information, and giving emphasis to the type of knowledge most needed for economic and social development".[2]

Such information systems should be effectively connected with the information networks of other developed countries, a task which requires compatibility and co-operation between national and international information systems, both within and outside the United Nations. This explains the UNISIST programme launched by Unesco in 1972 which aims at co-ordinating scientific and technological information activities at national and international levels, in particular by promoting systems interconnexion and facilitating access to the world's information resources. The ultimate goal is the establishment of a flexible and loosely connected network of national and international information services, based on voluntary co-operation. UNISIST was concerned initially with basic and applied sciences and technology; it has since been extended to social sciences and will later be directed to other fields of knowledge.

In emphasizing the type of scientific and technological knowledge most needed for economic and social development, Unesco has also proposed launching the SPINES system. This is based on the principle that Member States and international organizations should be assisted in the sharing of the literature and basic data which they produce on policy-making, in the field and on the management, transfer and assessment of science and technology, and their application to development. The developing countries in particular must enjoy a greater flow of information, allowing for the

1. This sum represented about 10 per cent of the world's expenditure on armament.
2. The World Plan of Action for the Application of Science and Technology to Development, United Nations, New York, 1971, p. 45.

Conceptual coverage of the SPINES System



Main Documentary Categories of the SPINES system

AOO FOUNDATIONS OF SCIENCE AND TECHNOLOGY POLICY-MAKING

- AO1 Theory and systematization of science and technology
- AO2 Philosophy and ethics of science and technology
- AO3 History of science and technology since the nineteenth century
- AO4 Sociology of science and technology
- AO5 Economics of science and technology
- AO6 Politics of science and technology
- AO7 Creativity and psycho-sociology of scientific researchers

BOO SCIENCE AND TECHNOLOGY RESOURCES

- BO1 Human resources for science and technology
- BO2 Financial resources for science and technology
- BO3 Scientific and technological information
- BO4 Scientific and technological facilities and equipment
- BO5 Institutional resources for science and technology
- BO6 Other resources and constraints influencing the trends of S and T policy

COO PRACTICE OF SCIENCE AND TECHNOLOGY POLICY-MAKING

- CO1 Elaboration, implementation and monitoring of national science and technology policies
- CO2 Science and technology forecasting and assessment
- CO3 Transfer, diffusion and implantation of technologies
- CO4 Organization and management of scientific and technological activities at the performer's level
- CO5 Legislation in science and technology
- CO6 International co-operation in the field of science and technology

DOO GENERAL CONTENTS AND SOCIETAL RESULTS OF SCIENCE AND TECHNOLOGY PLANS, PROGRAMMES AND PROJECTS

- DO1 Fundamental research and sciences
- DO2 Agricultural R and D
- DO3 Industrial R and D
- DO4 Transport and communication R and D
- DO5 Health R and D
- DO6 Environmental R and D
- DO7 Civil Space R and D
- DO8 Energy R and D
- DO9 Defence and Peace R and D
- D10 Socio-economic and cultural R and D
- D11 Multisectoral R and D and other scientific and technological activities

selection of scientific advances and new technologies suited to their specific needs, and the calculated likelihood of adapting them to local conditions.(1)

The proposed SPINES system is based on a feasibility study conducted by an international team of consulting specialists in the field of computerized information systems.(2) Its main characteristic is its high degree of decentralization. Member States (or groups of Member States) will be responsible for collecting and disseminating the information through national (or regional) SPINES units, which could conveniently be located in the documentation departments of national science and technology policy-making bodies. The computerized processing and merging of the input information would be done by a small "Central Processing Group", whereupon all Member States and their national (or regional) SPINES units, would receive a periodic world coverage of relevant information in the form of magnetic tapes and a SPINES index and abstract bulletin (SPINIA). The above diagram and table illustrate the coverage of the system and the description of its main documentary categories.

The indexing of the SPINES input literature and the retrieval of documents by users will be based on the SPINES Thesaurus(3) which lists some 10,000 terms interlinked through approximately 70,000 relations. The Thesaurus, originally compiled in English - is being or will be - adapted to other official languages of Unesco such as French, Spanish, Arabic and Russian. Other linguistic versions are also being contemplated as part of Unesco's effort towards unification and semantic equivalence of scientific and technological terms, with a view to promoting their use in the local languages. Furthermore, it must be stressed that S and T information flows depend to a large extent on information specialists. They should receive an appropriate training in organization of methods and operational management of information centres and systems, including library facilities and user-oriented information services, the importance of which has been steadily growing in the process of transfer and adaptation of science and technology.

4. Institutional resources

In addition to the provision of human, financial and informational resources, there is a need for an adequate "material base" comprising an operational network of institutions in which scientists and technologists can work productively, provided they are given adequate support to ensure continuity of operations.

The concept of an "operational network of scientific and technological institutions" is an important one in the sense that it implies the co-ordinated functioning of its various components so as to ensure overall high productivity and adequate effectiveness of the whole, especially in terms of purposeful application of scientific and technological knowledge to problems directly relevant to the achievement of national development goals.

If such an institutional network is to operate in a co-ordinated manner, the existence of a governmental policy-making mechanism for science and technology is essential, at least in those countries where policies in this field create institutions and not the reverse. Hence, the effective functioning of this policy-making machinery, within the framework of an overall national plan or strategy for development, is of special importance(4) when governments contemplate creating or strengthening institutions specifically designed to increase national scientific and technological potential and its absorptive capacity.

As mentioned in Part I, section 8, it has been found useful to distinguish the following functional levels of operations in a country's institutional infrastructure for science and technology:

- the first and second functional levels, which include the institutions responsible for planning, budgeting, decision-making, co-ordination, promotion, monitoring and assessment of scientific and technological activities (these are discussed in Part I, sections 8 and 9);
- the third and fourth functional levels, which comprise the institutions in charge of performing research and experimental development (R and D) and of carrying out scientific and technological service (STS) activities, including those relating to science and technology transfer (see Part I, section 11).

Of vital importance in this infrastructure is the concept of "network" referred to above, implying that each institution operates as part of an integrated system, in which the functional components are co-ordinated in order to ensure satisfactory effectiveness "across-the-board".

Unesco and other Specialized Agencies of the United Nations system have contributed significantly during the past 15 years, thanks to the financial support of the United Nations Development Programme (UNDP) to building up the institutional infrastructure of science and technology of many developing countries. Nevertheless, much remains to be done in regard to institutions actually performing scientific and technological activities

1. In this connexion, reference is made to the following resolutions adopted by the United Nations General Assembly: 3201 (S-VI) of 1 May 1974; 3362 (S-VII) of 19 September 1975; 3442 (XXX) of 9 December 1975 and 3507 (XXX) of 5 December 1975. Attention is also called to resolution 1902 (SVII) adopted by ECOSOC on 1 August 1974.
2. See the Feasibility study on the establishment of a science and technology policies information exchange system published in the Unesco series "Science policy studies and documents" No. 33 (1), Paris, 1974 and Document UNESCO/NS/ROU/387.
3. SPINES Thesaurus, published by the Unesco Press, Paris 1976.
4. Cf. World Plan of Action for the application of science and technology to development, United Nations, New York, 1971, p. 68.

(third and fourth levels). For this reason, the UN Advisory Committee on the Application of science and technology to development has asked Unesco to proceed on a country-by-country basis, with detailed surveys of institutional needs in the field of developing Member States. A methodology has since been developed(1) for supporting such surveys and has already been successfully applied in a number of countries including Colombia, Indonesia, Ghana, Jordan and Morocco.

Two categories of institutions are of special importance among those carrying out scientific and technological activities:

(a) the institutions performing R and D which comprise university research departments and research centres of various kinds operating outside the universities though normally in close liaison with them. The extent of this operational network usually increases with continued national economic development. However, in developing countries, most of the work is still conducted at the universities, while some R and D is also undertaken at the schools of medicine, engineering and agriculture. Meanwhile, the creation of "centres of advanced study and research" has often been recognized as an effective means for improving the national research atmosphere and capacity, and for raising the already high standards of the work itself.

There are also R and D institutions, both public and private, which carry out their functions within the ambit of various productive sectors of the national economy. Their work has a direct bearing on the activities and responsibilities of the relevant government departments which support them either directly or indirectly through special fiscal measures, for example;

(b) the scientific and technological services (STS) represent a mixed group which includes the institutions in charge of:(2)

(i) S and T Information and Documentation (STID) comprising all S and T information and documentation activities incorporating the storage, recording, filing and dissemination of data and information on S and T activities, not intended exclusively for specific users. The group therefore covers services provided by libraries, archives, information and documentation centres, referral services, scientific congress centres, data banks and information-processing services.

(ii) Museums of science and/or technology, botanical and zoological gardens and other S and T collections (anthropological, archaeological, geological, etc.).

(iii) General-purpose data collection: all activities comprising the routine systematic collection of data in all fields of science and technology. The group covers:

- topographical, geological and hydrological surveying; routine astronomical, meteorological and seismological observations; surveying of soils and of plants, fish and wildlife resources; routine soil, atmosphere and water testing; the routine checking and monitoring of radioactivity levels.

- prospecting and related activities designed to locate and identify oil and mineral resources (excluding prospection by productive enterprises for purposes of exploitation)

- the gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics, such as population censure, production, distribution and consumption statistics, market studies, social and cultural statistics, and so on. However, market studies as well as the production and sales statistics (at the enterprise level) are excluded from this group.

(iv) Testing, standardization, metrology and quality control: regular routine work on the analysis, checking and testing by recognized methods of materials, products, devices and processes, together with the setting up and maintenance of scientific standards of quality and standards of measurement. However, this excludes work of this type carried out by productive enterprises directly related to their economic activity.

(v) Regular routine work on the counselling of clients of other sections of an organization and of independent users. The purpose of this activity is to help them to handle scientific, technological and management information, and it also includes extension and advisory services organized by the State for industry; however it does not cover the normal activities of project planning or engineering offices.(3)

(vi) Activities relating to patents and licences involving systematic work of a scientific, legal and administrative nature carried out by public bodies.

(vii) Systematic work on the translation and editing of S and T books and periodicals (with the exception of textbooks for school and university courses).

Within the scientific and technological services (STS), those institutions specifically devoted to the transfer of operative technologies deserve special attention from policy-makers. Indeed, whilst there is widespread agreement on the need for transferring operative technologies across frontiers and on the options available to the developing countries for doing so, the same is not

1. See "A method for priority determination in science and technology" published as No. 40 in the Unesco series "Science policy studies and documents", Paris 1977.
2. See the "Recommendation concerning the international standardization of statistics on science and technology" adopted at the 20th General Conference of Unesco.
3. Medical practice and clinical activities carried out in universities, hospitals and clinics that are performing R and D are sometimes included in the STS.

true for policies[1] and institutions explicitly relating to this activity. However, the broadening and deepening understanding of the transfer process over the last decade has focused recent interest on institutions specifically concerned with the transfer of operative technologies, on their specific functions and on the assessment of their impact on socio-economic development. Here, institutional needs seem to stem from national policy for operative technology transfer in regard to both use of these technologies and the interrelated aspects of the import of technology, including foreign investment, licensing arrangements and patents. In this respect, there is a wide variation in the institutional arrangements amongst different countries, and it is also recognized that the institutions responsible for education and training, R and D and scientific/technological service activities (STS) are all, to some extent, contributing to the transfer process. Therefore, the activities of the institutions specifically devoted to the transfer of operative technology must be closely co-ordinated with all other S and T institutions which also have a significant role to play in that process.

Although much experience has been obtained on the question of technology transfer, the general conclusion is that no universal model of a "technology transfer centre" exists, because of the great differences amongst the socio-economic and political systems of the countries concerned. The establishment and maintenance of a centre or a system of special institutions or agencies for the transfer of operative technologies clearly involves a national decision in which level of economic activity, technical sophistication, market potential, natural resources and financial capacity must all be taken into account.

It is generally believed that the effective application of operative technologies appropriate to individual developing countries calls for two types of services:

(a) a government-sponsored centre or system from which prospective users (governmental, academic and industrial) can gain information as to where operative technologies may be obtained and can secure direct access to them;

(b) government-sponsored services which will assist prospective users in determining the type of operative technology they should seek, advising them as to how they may select and adapt it, and training personnel to use it.

These governmental services should play an important part in helping investment institutions and industrial development companies such as:

(a) investment and development banks,
(b) financial holdings,
(c) other private and public enterprises,
(d) transnational companies.

The purpose of this assistance should be to transform their knowledge, entrepreneurship, managerial skill and capital into effective capacity for the production of goods and services.[2]

CHRONOLOGICAL LIST OF REFERENCES FOR PART II

1. "Principles and Problems of National Science Policies", Unesco Science Policy Studies and Documents, No. 5, Unesco, Paris, 1967.
2. Unesco Statistical Yearbook, Paris, (Annual since 1968).
3. "Science and Technology in Asian Development", Final Report on the CASTASIA Conference (August 1968), Unesco, Paris, 1970.
4. "World Plan of Action for the Application of Science and Technology to Development", United Nations, New York, 1971.
5. "Science Policy and European States", Final Report on the MINESPOL I Conference (June 1970), Unesco Science Policy Studies and Documents, No. 25, Unesco, Paris, 1971.
6. Final Report on MINESLA Conference (December 1971), Unesco, Paris, 1972.
7. "Science and Technology in African Development". Final Report on the CASTAFRICA Conference (January 1974), Unesco Science Policy Studies and Documents, No. 35, Unesco, Paris, 1974.
8. United Nations. Demographic Yearbook, 1975, New York.
9. World Bank. Bank Atlas and Computer printouts, Washington, 1976.
10. "Science and Technology in the Development of Arab States", Final Report on the CAST-ARAB Conference (August 1976), Unesco Science Policy Studies and Documents, No. 41, Unesco, Paris, 1977.
11. "Medium-Term Plan (1977-1982)", Document 19 C/4, Unesco, Paris, 1977.
12. Unesco. Statistical surveys of scientific and technological activities, Paris (Annual or Biennial since 1968).
13. Fifth meeting of the Standing Conference of the Directors of National Councils for Science Policy and Research of the Latin American and Caribbean Member States, Final Report, Quito, March, 1978.
14. "Science, technology and governmental policy", Final Report on the MINESPOL II Conference (September 1978), Science Policy Studies and Documents No. 44, Unesco, Paris, 1979.

1. Policies regarding the transfer of technology will be dealt with in the next part because of their special importance to the overall development policies of governments. See also "Major Issues arising from the transfer of technology to developing countries", UNCTAD Report 7D/B/AC. 22/20/Rev. 1, Intergovernmental Group on Transfer of Technology, Geneva, 1977, paras. 106, 129, 130.
2. See Third Report of UNACAST, Supplement No. 12, ECOSOC 41st Session, United Nations E/4178, New York, 1966, paras. 99-102.

PART III

Transfer and Assessment of Technology

The history of societal evolution shows that the level and scope of a country's operative technologies is a determining factor in its economic growth and its survival as a politically independent unit. In some cases, the choice of an operative technology and its suitability for meeting socio-economic needs may constitute a determining factor for the survival of a community in the face of the most pressing human problems.

Development of operative technologies in the productive sectors of the economy includes the introduction, first, of genuinely innovative processes or products through "vertical" transfer from the research laboratories into production, and, secondly, of existing processes transferred "horizontally" from one country or industry to another through commercial or other channels. Science based operative technologies have such a significant part to play in the economic development of all countries that their choice assessment and the decisions made for their transfer and implantation become vital aspects of most governmental policies, whatever their field or scope of application.

There is a large body of literature on the subject of the transfer and assessment of operative technology which has, in recent years, attracted the attention of the governments of many developing countries and of certain international organizations. Special emphasis is laid on such transfer in relation to the establishment of a New International Economic Order which focuses, in particular on the setting-up of an International Code of Conduct on the Transfer of Technology.[1]

As well as influencing the production factors and socio-cultural characteristics of the importing countries, transferred technology also has a strong effect on their scientific and technological potential. These influences can be advantageous or detrimental, depending on the conditions under which the transfer takes place.

The following points are intended to underline some of the key issues regarding the transfer of operative technologies[2] which are particularly relevant to national policy-making in science and technology:

1. Influence of technology transfer on the overall scientific and technological development of a nation

Emphasis on the transfer of operative technologies at the enterprise level, characteristically in the form of specific projects and programmes based on imported proprietary technology, has obscured the impact of these transfers on overall national scientific and technological development.

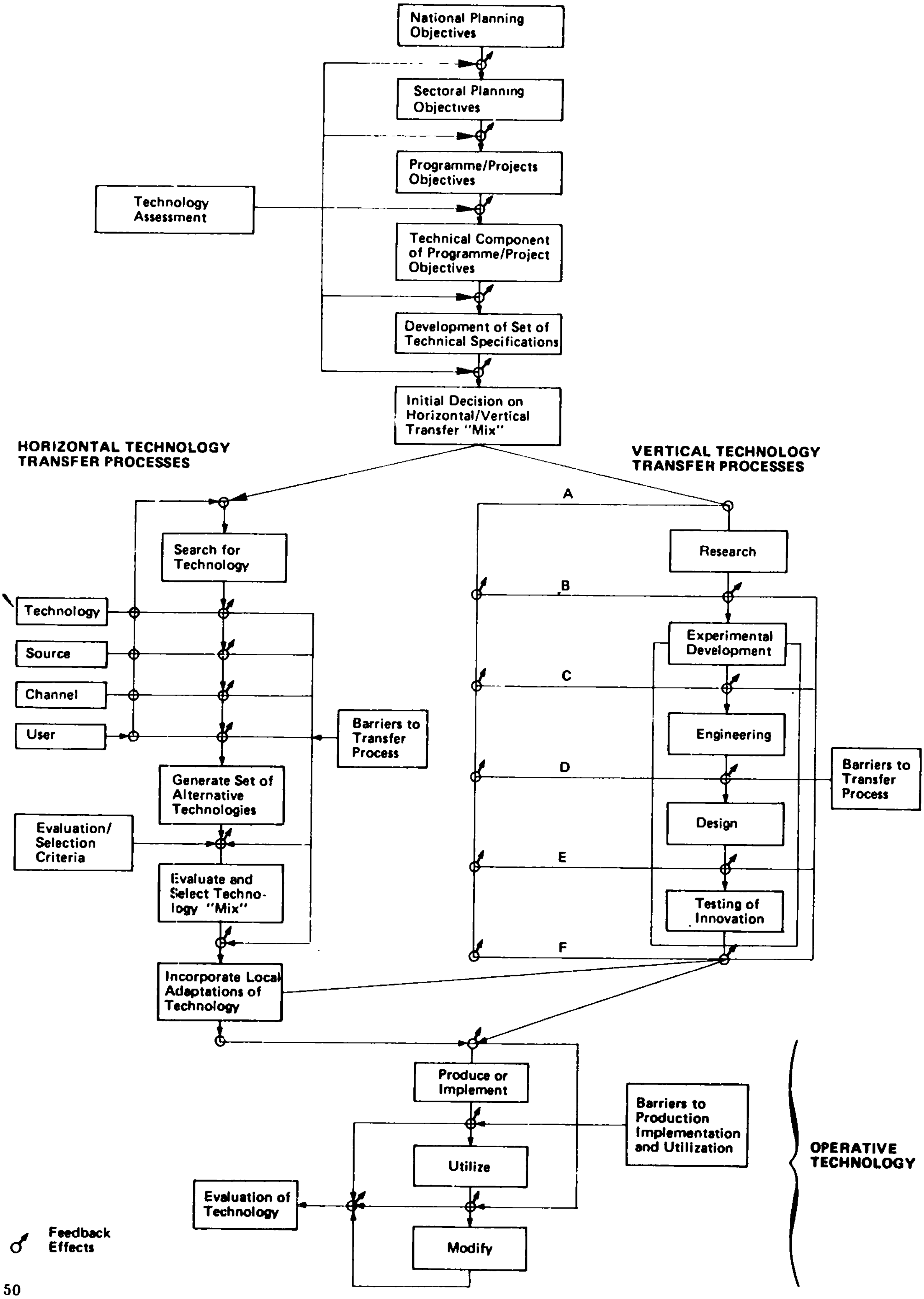
As a result, there is a danger that countries heavily dependent on the import of foreign operative technology will restrict their R and D activities such that these remain separate from the mainstream of the development planning process; in this case, the transfers themselves appear to relate solely to isolated development projects whose impact on the economy as a whole (for example in terms of social costs) is neither appreciated nor assessed. This is most unfortunate since it may often have far-reaching long-term effects far beyond those first anticipated for a given development project.

A fragmented unco-ordinated approach of this kind leads to an artificial dichotomy between policy in science and policy in technology; it also encourages a depreciation of effort in creating an indigenous R and D capability, and may result in conflicting and even chaotic patterns in a country's scientific and technological development. Indeed, if greater importance is constantly attached to imported operative technologies believed to have a more immediate impact on the development process, local R and D soon becomes an academic costly exercise which developing countries can ill afford.

This erroneous short-sighted approach is so harmful that efforts to avoid it should be of prime

1. Ref. UN General Assembly Res. 3201 (S-VI) and 3202 (S-VI) of 1 MAY 1977 and UNCTAD document 1D/8/C.6/AC.1/2/Supp. 1/Rev.1.
2. In this connexion, reference is made to Resolution 39(III) of UNCTAD 3rd session, para. 21 and the preamble to Trade and Development Board resolution 74(X) concerning the role of UNCTAD in the transfer of operative technology.

Interrelationships between horizontal and vertical technology transfers and the national planning process



concern to countries embarking on rapid self-sustained development. Many countries have erred in the past by not considering science and technology as inseparable components in one integrated planning effort, and by overlooking their joint interaction and impact on national growth. If we are to capitalize on former mistakes, now is the time to do so. In seeking a more effective approach to the problem, the fundamental objectives of the developing countries should be as follows:

(i) to identify and select imports relating to operative technologies - which generally account for an overwhelming proportion of technological applications in the productive sectors of the economy - in co-operation with local specialists in charge of the national policy for science and technology;

(ii) to regard indigenous R and D as a complement to the import of technology and where possible to give it preference;

(iii) to regard the decision on the relative importance of local R and D and the import of operative technology as a crucial aspect of development planning and the formulation of national scientific and technological policy.

Programmes concerning the transfer of operative technology which are consistent with this policy should accordingly be prepared by the government. Indeed, imported operative technology should sometimes be considered as giving effective support to the development of indigenous science and technology in selected areas.

2. A framework for analysing technology transfer processes

It was pointed out earlier that technology transfer basically takes place in two ways. Vertically, knowledge nowadays tends to flow from its origin in basic research, through applied research, to an invention which is developed, produced and marketed. At any level of this chain, knowledge or "know-how" may transfer horizontally to or from other vertical chains(1) as can be seen from the above diagram.

The main link between vertical and horizontal technology transfers is based on the fact that technologies must often be adapted or even radically altered, when they are transferred. The two processes are likely to be interdependent.

It must be admitted that the complex mechanisms involved in international technology transfer are not yet entirely understood. This last remark relates particularly to:

(i) transfers through local subsidiaries of transnational companies;(2)

(ii) transfers between developing countries, both of which should be given special attention in the coming years.

As "technology" is primarily a matter of "know-how" (education, training, information and patents), its international transfer is basically a human process. Of course, this does not mean that machines are less important, but simply that the human contribution is predominant, since there can be no transfer unless man himself is capable of accomplishing it. This is yet another reason why countries should have enough qualified scientists, engineers and technicians, for the strength and calibre of these specialists largely determine a nation's absorptive capacity of foreign operative technology.

This being so, it is clear that the economic, scientific and technological policies of developing countries should be planned so as to maximize the benefits obtained from a wise blend of horizontal and vertical transfer processes, combining imported know-how with a drive towards national technological innovation; furthermore, capabilities should be developed continuously both in vertical and horizontal transfers.

As well as assessing the technical and economic feasibility of research findings prior to their application, national bodies should be capable of selecting imported technologies, monitoring and negotiating transfer contracts and closely studying their implementation. The usefulness of national or regional centres to accelerate technology transfer, or the establishment of data banks for the storage, analysis and dissemination of information on various imported and local technologies, should be carefully examined.

It is quite clear that countries wishing to master the process of horizontal transfer of operational technologies must learn:

- to make an independent choice from among several technological possibilities;
- to adapt imported operative technologies to local conditions;
- to participate in the world production of original technological innovations in order to gain more benefit from the favourable transfer conditions linked to bartering as opposed to mere purchase of operative technology;
- to ensure the satisfactory establishment and efficient management of imported operative technologies by the local productive and service industries.

3. Use and assessment of technology

Indiscriminate transfer of operative technologies on a case by case and purely ad hoc basis is gradually being replaced by a policy of creation, selective assimilation and balanced transfer of technology within an overall strategy of national development. This implies careful surveys to assess the social and economic costs of alternative transfers of operative technologies, including the special and sometimes unfair restrictive practices imposed on them. The assessment is best performed by specialized scientific groups entrusted with the monitoring of major transfer

1. World Plan of Action for the application of science and technology to development. United Nations, New York, 1971, p. 70, para. 1.
2. In this context reference is made to the work of the ECOSOC Commission on Transnational Corporations, which held its first session in March 1975 (see "Report of the First Session", New York 1975, doc. E/5655-E/C.10/6).

processes, thereby assimilating and developing the transferred technologies through close operational involvement.

In the last few years, a number of developed countries have created evaluative mechanisms,[1] and procedures which will enable them to establish more explicit policies for the regulation of technological development so as to ensure, as far as possible, that the positive effect of technology can be maximized and the negative one identified and avoided.

Basically, therefore, technology assessment is an institutionalized attempt to develop objective, comprehensive, evaluative and forecasting information, using techniques allowing a multidimensional appraisal of societal impact with which technological decisions are associated. It is less concerned with the design or technical specifications of technology itself than with the impact of its development and application on the life and objectives of society.

The assessment process uses a variety of methodologies and techniques in performing its evaluative functions. Some are already familiar, including cost-benefit analysis, systems analysis, technological forecasting, risk and probability theory, and computer simulation and modelling, while others are relatively new such as the "delphi technique" (organized group consultation of experts), "cross-impact" matrices and analyses, and the development of "relevance trees".

There is no reason to believe that assessment should concern industrialized societies only. On the contrary, developing countries in the early stages of industrialization are more urgently in need of evaluative skills in selecting optimal technologies to meet their economic and social needs. While the approaches and methodologies of assessment still need to be perfected, in some respects they are already operative. Methods and approaches to technological forecasting have been discussed in Part I, section 5.

4. The international patent system and its role in the transfer of technology

Governments have been repeatedly informed by UNCTAD[2] about limitations on access to technology in developing countries, a situation which is partly due to the inadequacy (or non-existence) of national patent systems. Where this applies, the use of the international system becomes an important and effective instrument of national development policy in general, and of science and technology policy in particular.

The main purpose of patents and similar rights is to protect new technological and industrial inventions. Representing significant progress, these inventions can be used either to manufacture a product or as a process which makes manufacture possible; as such, they constitute new operative technologies.

Governments are interested in gaining access to foreign operative technologies and, at the same time, in protecting their own. Patents are a source of information as well as a key constituent of technological and industrial property in the transfer of operative technologies to developing countries; unfortunately they often contain descriptions of techniques written with legal rather than technological considerations in mind. In most cases, their industrial use cannot be undertaken on the basis of the technical details they contain, because other crucial information, for example, in regard to the "know-how", has to be obtained from the owner[3].

One reason for this is that the know-how, especially in certain industries, is secret; another is that even totally frank disclosure thereof cannot provide the integrated operative experience needed to ensure effective economical adaptation and use of a given technology.[4]

UNCTAD has undertaken extensive work on this complex process of transfer, by developing an International Code of Conduct on Transfer of Technology[5] and restructuring the industrial property system, with particular emphasis on those economic, commercial and development aspects which relate to the effectiveness of the transfer of operative technologies to developing countries.

With this as a basis, a revision of international conventions on patents and trademarks has been urged, in order to make these agreements more effective in aiding developing countries in the technological transfer and development process of operative technology. This, in turn requires national patent systems consistent with the revised Paris Convention for the Protection of Industrial Property, proposed by the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations.[6]

Broadly speaking, it seems that:

(i) Patents encourage the development of technology and industry, so long as care is taken to adapt the regulations governing their use to the special needs of each country or group of countries, in order to avoid imposing unduly severe restrictions on industrial freedom to introduce technological innovations.

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1. See for example the "Office of Technology Assessment" established by the Congress of the United States (Cf. Technology Assessment Act of 1972, Public Law 92-484, October 13, 1972).
2. See "Major issues arising from the transfer of technology to developing countries". UNCTAD document N° TD/B/AC.11/10 Rev.1, Ch. II.
3. See "Transfer of operative technology at the enterprise level", Report of an Interregional Expert Group, ST/ECA/151, United Nations, New York, 1972, Paras. 90-91.
4. See "Third Report of UNACAST," Supplement N°12, ECOSOC, 41st session, E/4178, United Nations, New York, 1966, para. 113.
5. UNCTAD document 7D/B/C.6/ACS/2 Supp. 1/Rev. 1, and subsequent modifications.
6. See UN General Assembly resolution 3362 (S-VII), para. 3, Section III.

(ii) While protection should cover as broad an area as possible to encourage inventive spirit in a wide range of different sectors, all inventions should not receive the same kinds of safeguards. The patent itself should be granted only for reasonably significant inventions, after very thorough examination. Those which have a lesser impact, or are not clearly technological should be given limited protection, through the utility model, the certificate of authorship, or a system of rewards not involving a grant of title.

(iii) An industrial property office has several functions to perform, including the issue of patents, documentary research and the training of staff able to conduct technical and economic negotiations, and the work of a "technological data bank". It must accordingly be powerful enough to perform these tasks efficiently.

In regard to the last point, European experience has proved conclusively that patent offices operating solely at national level are very inefficient. The same invention is investigated in several countries, and largely as a result of this duplication of effort, the period between the filing of an application and the award of a patent is far too long. This inefficiency would be even more marked if offices were to serve also as technological data banks, which seems likely in the future. A joint patents office, serving groups of countries sharing certain common characteristics, is therefore probably an essential prerequisite both for the issue of patents and for the establishment of a technical data centre. However, the experience of the European Patent Office suggests that such bodies can be created and brought into operation only very gradually, even when the necessary resources are available. Moreover, the establishment of an easily accessible computer-operated "Data Bank" is a costly business and the training of its staff inevitably takes time. For this reason, it is better to concentrate initially on those areas of technology of most immediate use to the national economies concerned, gradually extending such data banks to other sectors, as needs and opportunities dictate.

5. The transfer of operative technologies in relation to the development process

As far as the developing countries are concerned, there are now strong arguments for the organization, co-ordination and comprehensive control of the processes involved in the transfer of operative technologies with a view to achieving the objectives of their development plans. These arguments include the need for the following:

(i) an assessment of the impact of technological innovations on the national culture, the social system and the economy;

(ii) the provision of mechanisms for the co-ordination of technology-intensive development projects and the elimination of conflicting transfer operations;

(iii) an increase in the national capacity to monitor the transfer process, to diagnose problems arising from it and to organize means of solving them;

(iv) the provision of more opportunities and communication channels for developing countries to exchange their experience in regard to technology transfer;

(v) a reduction in the cost of acquiring operative technologies through the "unbundling" of technological packages offered on the international market.

Strategies for the use of technologies are being developed in some countries to suit their socio-economic and cultural conditions. For example, legislation regulating the import of operative technologies is particularly geared to the rational management of natural resources, protection of the environment, creation of employment and favourable economic terms for technology transfer, a matter discussed further in the following section. It follows, therefore, that preliminary studies are required to identify those operative technologies which, as well as being socially beneficial, contribute most effectively to national developmental objectives and the general goals outlined in the World Plan of Action[1] for the application of science and technology to development.

6. Links between operative technologies and economic issues

In recent years, ideological and semantic differences have given rise to endless debate based on terms such as "appropriate technology", "intermediate technology", "low-cost technology", and "labour" or "capital-intensive technology". All these have a common origin in the fundamental relationship between economics and operative technologies since the latter cannot exist aside from the production of goods or services. Without the growth of such technologies the division of labour cannot take place, a fact which explains their economic significance to development.

This significance relates to the labour factor in the production of wealth, or the working contribution of man using his hands or the tools he has constructed. The level of technology associated to the labour factor reflects its productivity, and when the technological intensity of production is low, "labour" and "employment" (simple manpower) are virtually interchangeable in any equation for the production of wealth. As it rises, however, this is no longer the case, since there is a conspicuous growth in both quantitative and qualitative employment problems which, for unenlightened social or political reasons, can easily block technological advance, thus defeating the development objective which is to increase wealth. If the adjusting factor could be optimized simply by balancing employment against

1. See World Plan of Action for the application of science and technology to development, United Nations, New York, 1971, p. 75.

operative technology (meaning the use of socially or economically "appropriate technology") the problem would not be serious. However, the most significant aspect of modern operative technology is that it enables man to extend enormously the capability of human labour beyond that which man can achieve unassisted by machines. Consequently, the suitability of operative technologies is largely an economic rather than a technical issue, of relatively little concern to the technologist who can define opportunities in his field but not their socio-economic value. Similarly, both technological innovation and transfer of operative technologies are affected primarily by economic policies, or trade and commercial practices.

Furthermore, associated technical manpower problems may inhibit transfer or innovation; these include inadequate basic skills and discipline in the labour force meant to absorb and handle the new technology. But this, of course, is mainly a training issue.

Finally, it is vital to recognize that international trade and import restraints are inevitably inhibiting the implantation of appropriate operative technologies in a given country. Any attempt, therefore, to separate the study of these two questions is unlikely to yield workable solutions; this is particularly so with regard to developing nations.

7. Policies for the introduction of new technologies

The effective introduction of new operative technologies is not a spontaneous process to be left to the interplay of uncontrolled forces; on the contrary, it requires deliberate action and policy-making by both governments and industry.

In the case of vertical technology transfer (the progression of technology from a science to the finished product), the trend is towards the organization of domestic R and D by "vertical integration"; in other words, all research relevant to the transfer (whether it be fundamental, applied, or experimental development) is brought together in a "mission-oriented" institution.

This contrasts with the "horizontal integration" of research according to scientific disciplines or technologies, which is found chiefly in traditional universities and polytechnics and described as "discipline-oriented".

Naturally, this classification is a vast oversimplification, since no R and D establishment belongs exclusively to one or other category. For example, faculties of medicine and agronomy in many universities display a high degree of vertical organization, and both universities and polytechnics can provide common ground for useful contact between numerous development "missions" because of their ability to create very flexible ad hoc combinations among their discipline-oriented research units.

Governments in partnership are particularly well-placed to facilitate horizontal technology transfer.

For example, the government of the receiving country can:

(a) Grant low interest loans to the domestic industry undertaking innovation, in accordance with the guidelines of the national development plan;

(b) Grant special tax exemption to this new industry;

(c) Give high priority to training abroad for qualified staff who will later work in it;

(d) Give preferential treatment to foreign experts specializing in this industry.

Measures which the government of the developed country can introduce to facilitate the transfer of its national technologies include the following:

(a) Selective tax relief for firms which agree to set up plants overseas in order to assist the economic development of less privileged countries;

(b) Complete takeover of the training of qualified staff from the receiving country to work in these newly-established industries (with or without multinational assistance);

(c) A commitment to total or partial responsibility for the risks to which its industries are exposed when undertaking operations abroad;

(d) Payment of at least part of the direct costs[1] of the transfer.

It would be unrealistic not to mention here the ever-increasing significance of "transnational" corporations (sometimes called multinational companies), which are estimated to have been responsible, in 1970, for approximately one quarter of the world's production.[2]

These organizations are heavily committed to horizontal technology transfer to developing countries and, as such, are often supported by the governments of the developed countries to which they belong, even when the transfer remains completely "international" in the sense that it exercises no influence in the host country outside the premises of the subsidiary company.

Although the presence of these companies in developing countries is consistent with their need to increase their control of the market and maximize profit margins, host governments[3] have recently taken exception to some of their practices.

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1. Direct costs, referring to those included in the contractual agreement generally comprise (i) purchase costs of patents, licences, know-how and trademarks, and (ii) expenses incurred in acquiring the necessary technical knowledge and know-how at pre-investment, investment and operational stages.
2. The added value of all transnational corporations was estimated at one-fifth of world gross national product in 1971, a figure which does not, however, include the centrally planned economies (see "Multinational Corporations in World Development". Department of Economic and Social Affairs, No. ST/ECA/190, United Nations, New York, 1973, p. 13).
3. Special reference is made to Resolution Nos. 4.5, 4.6 and 4.10 taken at the CAST-ARAB Conference, 1976.

Stages in which a newly introduced technology implants itself	Criteria of Assessment
1	Use of machinery and imported products
2	Maintenance, check-up and quality control services
3	Repair workshops
4	Local assembly line production
5	Local production of individual parts, geared to on-site assembly
6	Local production of major components, geared to on-site assembly
7	Manufacturing engineering (fitting up of machinery and organization of production)
8	Design engineering (machinery and products)
9	Experimental development of prototypes and pilot factories

Among these are the following:

(a) The attempt to obtain a monopoly and then a monopsony on the national market;

(b) The concentration of all genuinely creative work (including R and D) in the parent company, which is nearly always situated in a highly industrialized country;

(c) Scattering component parts manufacture among several countries in order to avoid the threat of nationalization;

(d) The practice of "internalized transfer" (also known as "closed door" manufacture), in order to ensure that their very advanced technologies cannot be used by the host country.

In matters of technology transfer, national manufacturing establishments should participate in finalizing contracts with transnational corporation so as to encourage a favourable balance between imported and local technologies. The importing countries naturally wish to secure the best possible terms in contractual agreements between governments and transnational corporations, and any policy concerned with the introduction of technology through the use of patents, licences, know-how and trademarks has to take this into account.

Once introduced into the receiving country, a new technology usually passes through several stages of "establishment" before being totally assimilated. These stages indicating the degree of assimilation in a given case, are shown in the table above.

Similarly, in the case of horizontal transfer, one has to determine the stage of which technology will be imported, and to plan its development (up to stage 9) in accordance with a pre-established schedule.

Next comes the stage of feedback from the user to the supplier, which is generally based on an evaluation of the technological, economic, socio-cultural and political effects of the transfer.

(a) The technological effects include the increase in national productive capacity and the improvement in the general standard of technological competence;

(b) Economic effects will be measured chiefly in terms of the per capita increase in the GNP, the creation of new jobs, the fall in prices of products and services, and the freedom of access to new products;

(c) Among the socio-cultural effects are the general improvement in the standard of living, the drift of the rural population into the towns (sometimes with detrimental consequences) as well as the change in outlook following industrialization, which in turn increases the national capacity for technological assimilation.

(d) Political effects are closely linked to the technological independence of a country and its international power and prestige.

CHRONOLOGICAL LIST OF REFERENCES FOR PART III

1. "World Plan of Action for the application of science and technology to development", United Nations, New York, 1971.
2. "Major issues arising from the transfer of technology to developing countries", UNCTAD document TD/B/AC. 11/10/Rev. 1, International Group on Transfer of Technology, 3rd session, 1974.
3. "Science and Technology in African Development", Unesco science policy studies and documents No. 35, Final Report on the CAST-AFRICA Conference, Unesco, Paris, 1974.

4. "An International Code of conduct on transfer of technology", UNCTAD document No. TD/B/C. 6/AC. 1/2/Supp. 1/Rev. 1, United Nations, 1975.

5. Final Report on the CASTARAB Conference, Unesco SPS No. 41, Unesco, Paris, 1977 - Especially Recommendation No. 4.

PART IV

International Co-operation in Science and Technology[1]

1. The international character of science and technology

The twentieth century has undoubtedly recognized, both in theory and in practice, that scientific knowledge is universal and that it constitutes an important part of mankind's common heritage. Technology is similarly capable of transcending national boundaries, although its freedom is often limited by barriers created in exercising patent rights and by the secrecy inherent in military or industrial competition.

Although these observations are not recent, the growing tendency towards transnational co-operative development of scientific and technological knowledge is a relatively modern trend whose implications outstrip the simple international sharing of discoveries and inventions. For while sharing involves transfer and dissemination of information, co-operation comprises collaborative planning, organization and performance of research, experimental development, data collection, surveying and monitoring, and other activities. The present chapter discusses this concept in more detail.

2. The need for international co-operation in the field of science and technology

First, in regard to necessities, the following arguments are among those most frequently cited by governments in favour of increasing international co-operation in science and technology:

(a) the rapidly increasing cost of R and D for each unit of knowledge acquired,

(b) the generally slower growth-rate of national expenditure now devoted to R and D by the highly developed countries, as compared with expenditure in the 1960s. This is partly due to the "saturation" effect which affects the exponential growth of all human phenomena from a given point onwards,

(c) the need for world-wide extension of the scientific study of global phenomena concerning the earth as a whole, including meteorology, seismology and tectonics, water balance and oceanography,

(d) the need for easier co-ordination of the legislation of different countries in regard to the homeostatic balance of human societies (for example, in the field of pollution),

(e) the rapid development of essential international legislation based on a better understanding of fundamental scientific issues such as in ocean resources, nuclear energy and space.

This list is not exhaustive and there will doubtless be more compelling arguments for increasing international co-operation in S and T in the future.

With regard to the advantages of scientific and technological co-operation for governments, the following arguments are among the most common:

(i) from the economic point of view, co-operation generally secures the greatest value from expenditure through the pooling of human and material resources, information and R and D facilities. It also reduces unnecessary duplication of work and a shortening of the lead-times preceding the operational stage of research;

(ii) from the scientific standpoint, international co-operation has beneficial multiplier effects on the acquisition of new knowledge which are frequently discussed in terms of well-known analogies including spin-off and fall-out. Other important scientific advantages are increased international credibility of research findings, greater concentration of scientific and technological publications, and the possibility of tapping skills not always available in a given country;

(iii) in regard to the political advantages to governments, the list is somewhat longer and includes the following:

- the reduction of international tension caused by the secrecy sometimes surrounding R and D confined to a strictly national context;
- a greater awareness at regional and world level of physico-chemical, biological, demographical,

1. The activities referred to in this part under the term "science and technology", are those defined in Part I, section 1.

and other restrictions, which determine both the limits of growth and the conditions of human survival;
- clearer definition, by governments, of the objectives and tasks which should be assigned to national R and D;
- an extension of the basis for evaluating the results of national R and D and their application in the productive sectors of the economy;
- an increase in opportunity for small countries to train specialists in certain disciplines which are not the subject of advanced research at national level, as well as increased capacity for the local absorption and adaptation of new technologies developed abroad;
- the developmental effect for the scientific and technological potential of the least advanced countries in all regions of the world.

The Unesco Conference of Ministers in charge of national science and technology policies have consistently added to this brief summary of the advantages to governments in strengthening international scientific and technological co-operation. However, they have not ignored the difficulties and occasional disadvantages which such co-operation may create in the preparation or implementation of relevant national policies.

The resources allocated by the community of nations to international co-operation in science and technology has been steadily increasing now for many years. Policy-makers in governments are therefore understandably selective in the direct or indirect support which they grant to these co-operative activities. The essential motivation, when they decide to offer it, is the belief that a given activity will contribute to a specific national objective.

One major difficulty stems from the different national terminologies and patterns used to express the categories of these objectives and to rank them. In some countries, this is done in a highly specific and structured way; in others, with a more pragmatic approach, there is less direct reference to objectives, so that if planning is used, it tends to be more restricted in scope, less explicit in its terms, often less extensive in its time-scales, and occasional in character. Moreover, there may, in a given country, be variations in the degree to which planning for different national objectives is structured.

Allowing for this lack of uniformity, general principles have gradually been established in regard to the types, levels and modalities of international scientific and technological co-operation, and the principal factors conditioning its effectiveness.

3. Some prerequisites and barriers affecting the effectiveness of co-operation

Experience gained over a long period indicates that there are several key prerequisites for effective multilaterial S and T co-operation. These are as follows:

(a) mutual provision of information on the partners' national (and international) policies in science and technology;

(b) an accurate assessment by each partner of the individual potential of the others in this field (including relevant ongoing S and T projects);

(c) a common political will for multilateral co operation, with full agreement to free and immediate exchange of information about results, progress and failures in ongoing research in the S and T field chosen;

(d) a sound grasp by partners of the basic objectives of their co-operative effort. These objectives may be intrinsic to science and technology as in the case of fundamental research, the aim of which is to advance science (and sometimes technology), by means of R and D, post-graduate education, or improved scientific public services.[1] Alternatively, objectives may be extrinsic to science and technology as, for example, improved mutual understanding peaceful coexistence and international security, the enrichment of industrial innovation, or the satisfaction of societal needs and aspirations;

(e) the joint definition of long-term objectives for the proposed multilateral co-operation programmes, as well as joint agreement on the scientific and technological projects to be chosen; it is recognized that sharing of similar objectives by different countries increases the likelihood that R and D projects will be suitable for co-operative ventures.

(f) an agreement between the partners as to their respective rights and duties, especially in regard to:
- a just return of benefits to each and all of them,
- the sharing of the resource-costs involved (S and T manpower, finances, facilities and equipment, and information);

(g) consensus among the partners as to the juridical and other forms of co-operation most in keeping with the chosen objectives;

(h) a firm decision as to where S and T activities will be performed, which clearly means specifying: the site for these activities (in the case of institutionalized co-operation), as well as the denomination and location of the scientific organizations, departments and research units taking part in the co-operative venture;

(i) finally, a decision as to what phase of a project (feasibility study, implementation, dissemination of results, practical application in production, or evaluation of effectiveness) lends itself best to international co-operation; this is particularly important in choosing an appropriate form for the multilateral effort.

There are also barriers to be overcome within countries which are likely co-operative partners in multilateral S and T co-operation. Among these are the following:

1. The practice is widespread, among governments, of deciding what percentage of their total investment in R and D should be allocated to fundamental research. Where this occurs, it is important for a country to decide what proportion of this percentage should be reserved for international ventures.

(i) the sensitivity of potential partner States to the possible impact of co-operation on particular aspects of national policy or objectives;

(ii) the potential negative impact of the proposed co-operative action upon the national innovation process;

(iii) an awareness of internal weaknesses as, for example, in technological fields, management, national regulations regarding the mobility of scientists, the organization of R and D, and the use of foreign languages.

Overcoming these barriers requires a courageous approach, which involves spelling out in a constructive way the internal problems and difficulties that international S and T co-operation can help solve. At the same time, highly advanced countries can demonstrate a genuinely co-operative attitude towards those countries which need strengthening in a given area by locating, for example, the headquarters of new multilateral co-operation projects in less developed countries, or by internationalizing national scientific or technological centres with a high reputation.

4. Characteristic features of international co-operation schemes in science and technology

Modern organized schemes of this kind can be analysed according to several important criteria which are indicated below:

Classification according to the nature of the co-operation

Under this heading one may distinguish:

(a) Institutionalized co-operation characterized by a common S and T programme of action, and a common budget fed by national contributions. This falls into two categories:

(i) Intramuros: the S and T activities are carried out in a central institution bringing together scientific workers from all the participant countries. The category includes: (1) international S and T organizations created by a special international agreement, and (2) national S and T organizations with an international vocation.

(ii) Extramuros: S and T activities are shared between branches operating in the various participating countries.

(b) concerted co-operation characterized by the co-ordination of national action according to a commonly planned working programme; the heads of national teams meet at intervals to exchange and compare the results of their work which often requires a standardization of methods. Under this arrangement each participating country (or laboratory) pays its own expenses, but the costs incurred by the collaboration are usually borne by an international organization.

(c) catalytic co-operation in which efforts are made by an international organization to promote free spontaneous exchange of information about ongoing S and T activities and their results between partners in different countries. Generally, this kind of exchange does not mean that, before starting work, participants should first agree on a joint plan of action. Instead, co-operation tends to be ex post facto and its intensity depends on the scheme adopted for making information available among participating countries (meetings, exchange of specialists, newsletters, computerized information systems, and so on). "Catalytic" co-operation sometimes also involves promotional action by the executing agency in the form of unconditional subsidies (as opposed to contracts).

Classification according to the legal status and membership of the agency responsible for organizing the co-operation

Several directories[1] published by Unesco, the Organisation for Economic Co-operation and Development (OECD), and the Union of International Associations have shown that it is very difficult to draw up a complete catalogue of international organizations whose statutes refer in one way or another to science and technology. In some organizations, S and T activities are dominant while, in others, these activities arise from assignments of a more general nature, concerned with subjects such as agriculture, health or culture, or with an economic or social bias.

It is however useful - from a juridical point of view - to distinguish between:

(a) intergovernmental S and T organizations (IGO) which are established by an agreement between governments, with State or government membership and

(b) non-governmental S and T organizations (NGO) which are generally formed as a result of non-governmental initiatives often originating in the international scientific research community; membership of these does not include States or governments.

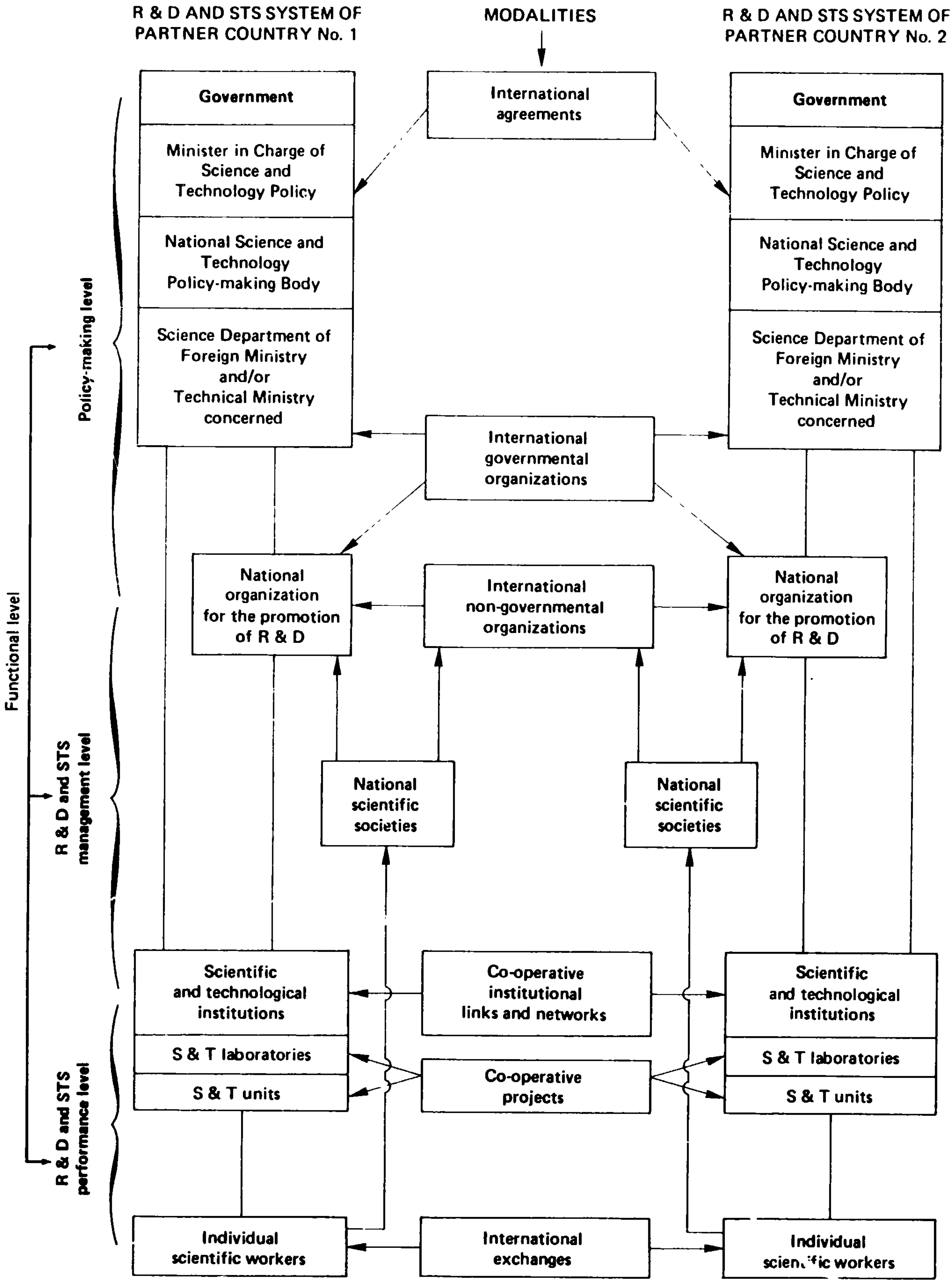
The classification according to legal status of the agency responsible for organizing the co-operation is, however, of little operational value if it is not considered in conjunction with the type of international instrument or contractual modality by which co-operation is governed, as described below.

Classification according to the type of international instrument or contractual modality governing the co-operation

Depending on the functional purpose of the planned multilateral co-operation belongs, the type of international instrument or contractual

1. Cf. "Directory of international scientific organizations", published by Unesco, Paris, 2nd edition, 1952; "Organisations scientifiques internationales", published by the Organisation for Economic Cooperation and Development (OECD), Paris, 1965; "Yearbook of International Organizations", published by the Union of International Associations, Brussels, 1977.

A schematic representation of possible levels and modalities of international S & T co-operation (bilateral and multilateral)



modalities governing it may vary widely. Typical arrangements include:

(a) special intergovernmental agreements which are usually employed when creating new intergovernmental organizations enjoying an independent international status;

(b) adoption of programmes and budgets specifically devoted to co-operative S and T ventures by the governing organ(s) of existing intergovernmental organizations;

(c) contractual agreements between the executing international organization in charge of a co-operative S and T project, and the partners in the co-operating countries;

(d) legal incorporation of a non-governmental international organization in a host country whose legislation includes provisions for such formalities.

Classification according to the geopolitical area in which co-operation takes place

A rough distinction can be made between:

(a) world-wide international co-operation which, theoretically, could involve all sovereign States, whether or not they are members of the United Nations system;

(b) regional co-operation involving countries belonging to a well-defined geographical or cultural area;

(c) interregional co-operation involving countries belonging to different regions;

(d) subregional co-operation restricted to groups of nations such as those which have entered into formal economic integration agreements, as well as those which share common ecological conditions or border on the same river, lake or sea;

(e) bilateral co-operation, which is restricted to two partner countries.

Classification according to the degree of vertical integration of the co-operative projects

Scientific management conveniently distinguishes between a number of phases in S and T projects (mission oriented activities which must be carried out in a limited time-span). These are as follows:

(a) the feasibility study phase (identification, selection and planning);

(b) the implementation phase (the accomplishment of R and D or scientific service activities);

(c) the phase of sharing and dissemination of results;

(d) the phase of application in the form of productive activities;

(e) the phase of effectiveness evaluation.

Multilateral co-operation projects in S and T can accordingly be grouped into categories according to their degree of "vertical integration" (incorporating one or more of the five phases described above).

In the past, partners sometimes selected projects independently before subsequently deciding to co-ordinate them and make joint use of the results. In other cases, they agreed to limit co-operation to the initial selection of projects and the final task of disseminating, applying and evaluating results, in order to retain maximum freedom of action with individual responsibility for carrying out S and T activities. This pattern has also been used by some transnational companies, and by certain intergovernmental organizations like Unesco and FAO.

Examination of existing schemes for international co-operation shows that complete "vertical integration" (covering all five phases indicated above) is very rare except in the case of the "institutionalized" patterns already described.

5. Operative levels and modalities of international scientific and technological co-operation

The widely differing patterns of co-operation which have emerged in recent years depend on the choice made by partner countries from among the possibilities offered by each of the classifications discussed above.

The above diagram illustrates the most frequently adopted modalities of international co-operation, together with the policy-making and managerial levels involved. It relates to bilateral co-operation when no more than two partner countries are concerned, but can also apply to multilateral co-operation involving n + 2 partners. Because the diagram is ascending, it recognizes that scientific/technological work is performed by individuals employed by institutions belonging to organizational entities - of increasing scope whether inside or outside the governmental hierarchy.

The degree of political and managerial complexity which characterizes international co-operation in science and technology obviously tends to grow with the number of national partners involved, thereby reducing the effectiveness of operations. This is perhaps the main reason for enlisting the services of international organizations, which can be divided into the following main categories:

(a) the intergovernmental organizations belonging to the U.N. system. Some of these have a general vocation for international co-operation like the United Nations Organization itself and its regional economic commissions, while others like Unesco have an "across-the-board" responsibility in the field of science and technology. A third group consists of those oriented towards specific disciplines or missions such as the International Atomic Energy Agency, the World Meteorological Organization, the World Health Organization, the Food and Agricultural Organization, and the United Nations Industrial Development Organization;

(b) the intergovernmental organizations which serve regional or subregional groupings of States and include science and technology in their terms of reference. Examples are the European Economic Commission, the Council of Mutual Economic Assistance, the Organization for Economic Co-operation and Development, the

League of Arab States - ALECSO, the Organization of African Unity, the Organization of American States, and the Andres Bellow Convention (SECAB);

(c) specialized intergovernmental scientific organizations outside the U.N. system (such as the International Bureau of Weights and Measures and the International Bureau of Informatics);

(d) non-governmental scientific organizations such as those federated under the Council of Scientific Unions (ICSU), the Council of International Organization of Medical Sciences (CIOMS) and the Union of International Engineering Organizations (UIEO/UATI).

The practical modalities of co-operation between individual scientists and technologists varies greatly according to the degree and functional levels[1] of governmental involvement. Some schemes allow for person-to-person co-operation; while in others the joint effort is inter-institutional; a certain number are under the direct control and management of national bodies entrusted with science/technology policy-making or with the promotion of R and D.

The activities of Unesco in regard to co-operation have been mainly devoted to the following:

(i) the identification of priority fields of research and scientific or technological services suitable for launching international co-operative projects;

(ii) the development of new modalities and schemes for international scientific and technological co-operation;

(iii) the management - often with the collaboration of international scientific unions - of specific intergovernmental scientific programmes in various disciplines, such as ecology, oceanography, microbiology, hydrology, geology and informatics, and the conduct of international studies in the field of science policy and the organization of research;

(iv) the establishment of bilateral institutional links or co-ordinative network relationships between scientific institutions of different countries, so as to promote rapid exchange of knowledge, information and personnel;

(v) the support of non-governmental organizations, such as the International Council of Scientific Unions, in their own effort to foster international S and T co-operation;

(vi) the promotion of international transfer of information in science and technology through direct personal contact, is achieved, for example, in the exchange of scientific workers and at international meetings, and through the setting up or strengthening of appropriate international information systems.

The rising complexity and costs of collective undertakings in both basic and applied fields of scientific or technological endeavour (subnuclear physics, nuclear energy, space exploration, computer development, environmental research, and marine sciences), as well as their far-reaching economic and political implications, have increasingly forced governments to step in, both financially and managerially, in developed and developing countries. Consequently, the machinery for international scientific co-operation is nowadays growingly dependent on intergovernmental agreements.

6. Operational patterns of multilateral co-operative undertakings in the field of science and technology

As to the actual performance of research, experimental development and scientific/technological services, the modalities of multilateral co-operation are extremely varied. The following are but a few of the more widely practised organizational patterns appearing in intergovernmental co-operative agreements, some of which have been concluded and implemented under the auspices of Unesco.

(a) The international scientific or technological research organizations set up under international agreements

Multilateral co-operation in research activities has now been successfully established through these organizations for some time. Very often the co-operative use of expensive equipment (as, for example, in nuclear physics) which could not be afforded by individual countries justified the need for such bodies. However, the benefit which smaller scientifically less advanced countries can gain from this kind of communal activity has been questioned. It is therefore desirable that the institutions chosen should function in a way which enables participating countries to count on a moderate practicable level of expenditure and on operational methods securing reasonable scientific returns to all participants. This twofold problem of reasonable cost and of reasonable return needs careful attention in order to avoid a widening "scientific/technological gap" between countries in their capacities for performing research and assimilating its results. Examples of existing organizations in this group that have been set up by intergovernmental agreements under the auspices of Unesco include the Organization for European Nuclear Research (CERN), the Latin American Centre for Physics located in Brazil, and the recently established International Balkan Centre for Archives (CIBAL).

(b) National scientific institutions with an international vocation

There are several of these institutions, some of which were established more than 100 years ago, like the Stazione Zoologica in Naples (Italy). It is felt that many national institutions, laboratories or units that have already achieved success could acquire a truly international vocation through adequate organizational and financial support.

1. As described and defined in Part I, section 8, page 22.

(c) Unesco's major intergovernmental scientific programmes

are placed under the managerial guidance of an Intergovernmental Council whose members are appointed by the Governments of countries designated by the Unesco General Conference. States participating in these programmes often support the scientific work carried out by their national institutions with considerable resources which are additional to those allocated to the programmes by Unesco on its Regular Budget. Examples are the Man and Biosphere (MAB) programme, the International Hydrological Programme (IHP), and to a certain extent also the International Geological Correlation Programme (IGCP) and the Oceanographic activities carried out by (or in conjunction with) the International Oceanographic Commission.

(d) Joint-management research projects

Under this pattern, the co-operative research projects are placed under the planning authority and supervisory control of a Joint Management Committee composed of directors of research units appointed by the body responsible for science policy in each participating country. The active collaboration of at least one international organization is required, with which the national policy bodies enter into a formal contractual agreement during the project.

It seems preferable for both the national science policy bodies and the international organization(s) involved in the project to participate in the financing of the research programmes undertaken. This method was successfuly tried out by Unesco itself in the International comparative study of the organization and performance of research units, the results of which were published jointly by the Unesco and the Cambridge University Press in 1979.(1) Another example is the plan for scientific and technological co-operation conducted under the auspices of the secretariat of the Andres Bello Convention (SECAB) with UNDP financing, for the countries of the Andean region.(2)

This pattern of co-operation is particularly suitable for mission-oriented research with a specific practical purpose and for projects of limited duration.

7. Concluding remark

In spite of the efforts of Unesco and other intergovernmental organizations, there remains a serious imbalance in the opportunities for participation and communication by scientists and technologists from developing countries. Considerably more resources should be provided and greater attention given to the above aspects of international co-operation if their potential contribution to a New International Economic Order is to be fulfilled. For this reason,arrangements, will have to be discovered in the years to come for linking weak and isolated national scientific communities in a much closer way to the mainstream of world scientific and technological endeavour.

CHRONOLOGICAL LIST OF REFERENCES FOR PART IV

1. "Science Policy and the European States", Final Report on the MINESPOL I Conference, Unesco Science Policy Studies and Documents No. 25, Unesco,Paris, 1971.
2. "Science and Technology in African Development", Final Report on the CASTAFRICA Conference, Unesco Science Policy Studies and Documents No. 35, Unesco, Paris, 1974.
3. Final Report of the Bogota Meeting, Unesco document SC-76/Conf. 662, June 1976.
4. "Medium-Term Plan" (1977-1982), 19 C/4, Unesco, Paris, 1977.
5. "Science, Technology and governmental policy", Final Report on the MINESPOL II Conference (September 1978), Science Policy Studies and Documents No. 44, Unesco, Paris 1979.

1. See: "Scientific Productivity: The Effectiveness of Research Groups in Six Countries". Co-publication of Unesco and Cambridge University Press, 1979.
2. See: UNDP/Unesco/SECAB project RLA/76/033.

Annex

STATISTICAL TABLES

ON HUMAN AND FINANCIAL RESOURCES FOR

SCIENCE AND TECHNOLOGY(1)

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1. Compiled by the UNESCO Division on Science and Technology Statistics, Paris, April 1978.

ANNEX

TABLE OF CONTENTS

Annex

1. GENERAL INTRODUCTION

1.1 Background

The statistics on science and technology set out in the two tables presenting comprehensive regional distributions of the development of R and D activities bring up to date the tables originally prepared in 1975 relevant to the implementation of the World Plan of Action for the Application of Science and Technology to Development.[1] In view of the general interest shown in the world-wide coverage of the tables it was decided to substantially improve and revise them and incorporate the latest data available. These data are intended for illustrative purposes rather than as a basis for comparisons. Researchers may however proceed with certain analyses provided they bear in mind the limitations of the data.

1.2 Coverage and limitations

The first table relates to scientific and technical manpower, showing the stock of scientists and engineers, the number of those engaged in R and D activities and their support ratio, i.e. the number of technicians per scientist or engineer. The other table is concerned with the financial resources for R and D activities and sets out both in national currency and in U.S. dollars, the total and per capita expenditure on R and D as a percentage of the G.N.P.

An attempt has been made to present data for two periods in time. In order to include as many countries as possible no fixed period was selected but the earliest and latest years for which relatively comparable data are available were taken. In general the years range from 1967 to 1975 but for many countries the time period is shorter.

Most of the data on scientific and technical manpower and expenditure devoted to research and experimental development (R and D) were obtained from replies to the Statistical Surveys of scientific and technological activities sent to the Member States of Unesco since 1968. In utilizing these data the reader should keep in mind the factors which have an obvious bearing on the comparability and the degree of accuracy of the data. Science statistics have not reached the same stage of development in all countries. For the most part the national surveys which furnished the basic data were organized to meet the specific needs of the country on an *ad hoc* basis for limited purposes. Also national statistical practices and concepts are not necessarily designed for the specific requirements of international comparisons. In some cases the coverage of the data may not always relate to national aggregates but may only correspond to certain areas of the economy or to certain sectors of performance. In other cases the subject coverage may differ as in earlier surveys some countries included R and D in the social sciences and humanities and others omitted this significant segment of R and D.

For further details concerning the limitations of the data and differences in definitions as well as supplementary information concerning R and D activities reference should be made to the Unesco Statistical Yearbooks. An abbreviated form of the definitions of the various concepts utilized in the Unesco Statistical surveys is set out below.

1.3 General definitions

Type of personnel

Scientist and engineer This category includes persons who have received scientific or technical training in any field of science and technology as follows: (a) completed education at the third level leading to an academic degree, (b) completed third level non-university education (or training) which does not lead to an academic degree but which is nationally recognized as qualifying for a professional career, or (c) nationally-recognized equivalent training and professional experience.

1. UNESCO. Implementation of the World Plan of Action for the Application of Science and Technology to Development. *Report of the Secretary General responding to Parts II and IV of ECOSOC Resolution 1900 (LVII) Addendum (SC-75/WS/97 Add. 1)*, Paris, December 1975.

Technician This category includes persons who have received specialized vocational or technical training in any branch of knowledge or technology as follows: (a) one to two years' training beyond completed education at the second level, (b) three to four years' training beyond the first cycle of secondary education, whether or not leading to a degree or diploma, or (c) nationally-recognized equivalent on-the-job training and professional experience.

Auxiliary personnel This category includes skilled as well as unskilled workers, all clerical, administrative and some other supporting personnel such as secretarial personnel.

Total stock of scientists, engineers and technicians All scientists, engineers and technicians as described above without regard to age, sex, economic activity or any other characteristic.

Economically active scientists, engineers and technicians This concept refers to all scientists, engineers and technicians as specified above, who are engaged in, or actively seeking work in, some branch of the economy at the time of reference.

Full-time equivalent (FTE) Whenever possible the figures for scientists and engineers engaged in R and D are shown in full-time equivalent. This is a measurement unit representing one person working full-time for a given period.

Research and experimental development (R and D)

In general R and D is defined as any creative systematic activity undertaken to increase the stock of scientific and technical knowledge and to devise new applications. It includes fundamental research, applied research and experimental development (i.e. work leading to new devices, products or processes) in all fields of science and technology.

R and D expenditure

Total national intramural expenditure for R and D is the total expenditure for R and D within the national territory of a particular country. To cover the full costs of R and D activities and to avoid double-counting, the measurement of expenditure should include all intramural current expenditure including overheads and intramural capital expenditure.

Sectors of performance

The sectors of performance identify those areas of the economy in which R and D work is performed. The term "sector of performance" distinguishes the execution or performance of R and D activities from their financing. Three sectors of performance have been established for the purpose of the survey and defined, to the fullest extent possible, in accordance with the definitions of the United Nations "System of National Accounts" (SNA) and those of the "System of Balances of the National Economy of the Council for Mutual Economic Assistance" (Material Product System, MPS), as follows: The productive sector, measured on two levels, integrated and non-integrated R and D (this is to facilitate comparisons between countries with different socio-economic systems which have a different structure of the productive sector), the higher education sector and the general service sector.

Fields of science and technology

The fields covered are the following: natural sciences, engineering and technology, medical sciences, agriculture and social sciences and humanities.

1.4 Explanatory note

The data presented in this publication relate in general to territorial units within de facto boundaries as at October 1977, depending in part on the availability of official statistics relating to such territories. For printing purposes the names of countries and territories in the different groupings of countries have been listed in English alphabetical order.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Unesco Secretariat concerning the legal status of any country or territory, or of its authorities, or concerning the delimitations of the frontiers of any country or territory.

The data which relate to the Federal Republic of Germany include the relevant data relating to Berlin for which separate data have not been supplied. This is without prejudice to any question of status which may be involved. Data concerning Byelorussian S.S.R. and Ukrainian S.S.R. are set out in parentheses as the figures are already included in those for U.S.S.R.

The following symbols are used:

- \- Magnitude nil
- ... Data not available
- . Category not applicable
- * Provisional or estimated data

TABLE I Scientific and technical manpower resources

Region Country	Stock of scientists & engineers: Year	Stock: Total	Stock: per 10 000 population	Scientists & engineers engaged in R & D (in F.T.E.): Year	R & D: Total	R & D: per 10 000 population	Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
AFRICA										
Botswana				1967	10	0.2	0.6	1967	0.55	131
	1972 1/	786	12.5	1973	24	0.4	0.8	1975	0.69	315
Central African	1969 2/	124	0.8	1969 3/	26	* 0.2	3.9	1967	* 1.50	* 133
Empire				1975 4/	76	* 0.3	0.04	1971	* 1.64	* 180
Chad				1969 2/	19	0.1	1.1	1967	3.43	78
				1971 5/	85	0.2	1.2	1975	4.03	121
Djibouti	1973	35	3.5					1967	0.09	...
								1975	0.11	...
Gabon				1969 6/	6	0.1	3.3	1967	0.47	832
				1970 6/	8	0.2	2.5	1975	* 0.53	*2 267
Ghana	1966 7/	5 137	* 6.5	1969	1 015	* 1.2	8/1.1	1967	* 8.08	* 276
	1970 7/	6 897	8.0	1975	3 889	3.9	8/1.4	1975	9.87	464
Ivory Coast				1967	204	0.5	0.8	1967	* 4.02	* 304
				1970	319	0.7	0.7	1975	4.89	686
Kenya	1970 1/7/9/	3 000	2.7	1970 10/	569	* 0.5	17/* 1.8	1967	10.12	111
	1975 7/	5 130	* 3.8	1975 11/	361	0.3	0.5	1975	13.40	217
Madagascar				1970 12/13/	165	0.2	* 0.4	1967	6.33	133
				1971 13/	201	* 0.3	0.5	1970	6.75	166
Malawi				1967 3/14/	14	0.0	...	1967	4.12	67
								1975	* 5.04	* 150
Mauritius				1970	78	0.9	0.7	1967	0.79	325
				1975	135	1.5	1.1	1975	0.88	581
Nigeria								1967	* 51.11	* 116
	1970/71 15/	19 885	* 3.6	1970/71 15/	2 083	* 0.4	* 0.4	1975	* 62.93	* 390

TABLE I (contd.)

Region Country	Stock of scientists & engineers: Year	Stock: Total	Stock: per 10 000 population	Scientists & engineers engaged in R & D (in F.T.E.): Year	R & D: Total	R & D: per 10 000 population	Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
Senegal				1972	392	1.0	1.3	1967 1975	3.62 4.14	258 447
Seychelles	1971[1] 1973[1]	256 300	51.2 50.0	1970 1973	1 1	0.2 0.2	... ...	1967 1975	0.05 * 0.06	... ...
Sierra Leone	1971/72	126	0.5					1967 1975	2.44 * 2.75	117 213
Togo	1971[7]	461	* 2.3	1971 1976	118 261	0.6 1.1	0.2 0.7	1967 1975	* 1.80 2.22	* 144 267
United Rep. of Cameroon	1965/66[16] 1970/71[16]	* 2 500 * 3 500	* 4.7 * 6.0	1970/71[1]	329	0.6	...	1967 1975	5.52 6.40	153 331
United Rep. of Tanzania	1968/69[7]	* 4 080	3.2					1967 1975	12.26 15.31	95 167
Upper Volta				1967[14]	48	0.1	0.7	1967 1975	5.05 * 6.03	65 * 93
Zambia	1970 1973	* 5 900 11 000	* 14.1 23.7	1969 1973	* 60 260	* 0.1 0.6	* 3.0 [8]3.1	1967 1975	3.90 4.98	330 532
ARAB STATES										
Algeria				1972[4]	242	0.2	0.4	1967 1975	13.08 16.78	342 730
Egypt	1973	593 254	166.6	1968[17] 1973[17]	6 522 6 913	2.0 1.9	... ...	1967 1975	30.91 *37.23	170 310
Iraq	1971[7/18] 1972[7/19]	7 862 * 43 645	8.1 *43.3	1969[9/20] 1974[21]	116 1 486	0.1 1.4	0.2 ...	1967 1975	8.58 11.12	475 1 072
Jordan [22]	1973 [7] 1975	4 288 * 9 787	16.9 * 36.4	1971[17] 1976	43 208	0.2 0.7	1.4 0.5	1967 1975	2.04 * 2.70	362 * 461

TABLE I (contd.)

Region Country	Stock of scientists & engineers: Year	Total	per 10 000 population	Scientists and engineers engaged in R & D (in F.T.E.): Year	Total	per 10 000 population	Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
Kuwait	1970[1/][15/] 1973[1/]	4 063 10 754	54.9 120.8	1973	205	2.3	0.1	1967 1975	0.57 * 1.00	6 141 * 9 162
Lebanon	1969[9/]	5 134	* 21.4	1967[15/]	253	* 1.1	0.6	1967 1975	* 2.27 2.87	... **1 146
Libyan Arab Jamahiriya	1973[1/][7/]	8 319	* 37.0	1973[1/]	* 50	* 0.2	2.8	1967 1975	1.76 * 2.44	2 319 * 4 277
Qatar	1974/75[1/][7/]	1 352	*150.2					1967 1975	* 0.07 * 0.09	* 5 270 *13 892
Saudi Arabia	1974/75	*33 376	* 37.8					1967 1975	* 7.13 * 8.97	* 956 * 2 825
Sudan	1971/72 1973[1/]	*13 792 *11 463	* 8.5 * 6.8	1971/72 1974	249 *2 731	0.2 *1.6	0.9 *0.7	1967 1975	14.50 * 17.76	84 254
Syrian Arab Rep.	1970	27 369	43.7					1967 1975	5.68 7.35	260 663
Tunisia	1968[7/][15/] 1974[7/][23/]	* 2 228 3 421	* 4.5 6.1	1972[14/]	* 818	*1.5	0.7	1967 1975	4.82 5.61	275 753
Yemen	1974/75	1 394	2.1	1974/75[17/]	60	0.1	0.9	1967 1975	5.37 * 6.67	... **181
ASIA										
Bangladesh	1973/74[7/]	23 500	3.2	1973/74[24/]	1 649	0.2	0.5	1967 1975	63.43 76.82	77 115
Brunei	1971[7/]	589	42.1	1971 1974	7 22	0.5 1.5	8.0 0.8	1967 1975	0.11 0.16	... ...
Burma	1975[7/][25/]	18 500	5.9	1975	1 720	0.6	0.3	1967 1975	25.81 30.33	56 108

TABLE I (contd.)

Region Country	Stock of scientists & engineers: Year	Stock of scientists & engineers: Total	Stock of scientists & engineers: per 10 000 population	Scientists and engineers engaged in R & D (in F.T.E.): Year	Scientists and engineers engaged in R & D (in F.T.E.): Total	Scientists and engineers engaged in R & D (in F.T.E.): per 10 000 population	Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
Cyprus	1967 [7/9]	* 4 561	* 76.0	1967	72	1.2	2.2	1967	0.60	795
	1969 [7/9]	* 4 650	76.2	1971	117	1.9	1.3	1975	0.64	1 149
Hong Kong	1971 [7]	* 41 420	102.3					1967	6.42	448
								1975	8.11	928
India	1968/69 [15/16]	984 800	* 18.9	1968/69 [16/26]	62 349	.	...	1967	504.35	88
	1971 [16]	1 174 500	21.3	1973	96 954	.	...	1975	*598.10	* 153
Indonesia				1975	12 244	0.9	0.6	1967	110.61	81
								1975	136.04	178
Iran	1970	*99 140	34.6	1970	3 007	1.0	0.2	1967	26.30	496
	1972	127 793	41.8	1972	4 896	1.6	0.2	1975	33.02	1 479
Israel	1969 [9/27]	* 38 000	135.2	1970 [15/27]	2 800	9.4	...	1967	2.68	1 503
	1974	96 300	291.8	1974 [15]	3 350	10.2	...	1975	3.37	3 679
Japan	1975 [7]	4 127 200	372.0	1969	275 686	26.7	0.3	1967	100.83	1 702
				1976	399 842	35.6	0.2	1975	110.57	4 410
Korea, Rep. of	1969 [28]	223 710	72.8	1968 [9/14]	5 024	1.7	0.5	1967	29.54	178
	1975 [28]	460 037	*132.7	1974 [9/14]	6 314	1.9	0.5	1975	* 34.66	* 538
Lao, People's Democratic Republic				1970	364	1.2	...	1967	2.76	...
								1975	* 3.30	** 91
Malaysia West Malaysia	1970 [16]	35 415	...						...	...
Mongolia	1972	1 908	14.5	1971 [29]	797	6.2	...	1967	1.15	** 868
								1975	1.44	...
Pakistan	1973/74 [15]	* 111 000	16.5	1973/74 [30]	4 164	0.6	1.1	1967	55.65	75
								1975	70.26	140
Philippines	1967 [7/9]	* 94 302	28.0	1965 [9]	5 600	1.8	[8] *0.4	1967	33.71	183
	1970	1 083 742	294.1					1975	42.52	370

TABLE I (contd.)

Region Country	Stock of scientists & engineers: Year	Stock of scientists & engineers: Total	Stock of scientists & engineers: per 10 000 population	Scientists & engineers engaged in R & D (in F.T.E.): Year	Scientists & engineers engaged in R & D (in F.T.E.): Total	Scientists & engineers engaged in R & D (in F.T.E.): per 10 000 population	Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
Singapore	1971 7/	* 5 660	* 26.8	1971 14/15/32/	370	1.8	...	1967	1.98	798
	1975 31/	10 574	47.0	1975	635	2.8	0.7	1975	2.25	2 508
Sri Lanka	1972 7/	7 457	5.7	1972 9/17/33/	2 076	1.6	2.5	1967	11.70	79
	1973 7/	6 845	5.2	1973	3 611	2.7	...	1975	*13.99	* 142
Thailand	1969 9/	5 583	1.6	1973 15/17/	7 840	2.0	...	1967	33.00	161
	1975 7/15/	20 288	4.8	1974/75 34/	6 097	1.5	...	1975	41.87	347
Turkey				1967 9/14/	5 856	1.7	...	1967	32.66	383
				1975 15/	8 910	2.3	0.4	1975	39.18	883
Austria	1971	118 294	158.6	1967 9/13/	1 863	2.5	0.4	1967	7.32	2 114
				1972 35/	1 870	2.5	1.5	1975	7.52	4 751
Belgium	1966/67 9/	69 965	73.2	1967 36/	9 010	9.4	0.6	1967	9.58	2 779
				1973	12 932	13.3	0.8	1975	* 9.80	* 6 008
Bulgaria	1971 7/	171 311	200.6	1969	19 990	23.7	0.4	1967	8.31	37/ 808
	1976 7/	218 996	250.0	1976	32 343	36.9	0.4	1975	* 8.72	37/* 1 689
Czechoslovakia	1967	227 350	158.9	1967 38/	40 734	28.5	1.1	1967	14.31	37/* 2 262
	1973 7/	327 772	225.1	1975 38/39/	44 508	30.1	1.3	1975	*14.80	37/* 4 575
Denmark	1965 9/	* 34 800	7.3	1967	4 335	9.0	8/ 0.7	1967	4.84	3 296
				1973	4 717	9.4	1.6	1975	5.06	6 644
Finland	1970	92 734	201.2	1967 9/38/	2 109	4.6	8/ 1.6	1967	4.61	2 203
	1975	223 527	474.6	1975	7 503	15.9	0.8	1975	4.71	5 050
France	1968 7/	992 000	198.8	1968 9/	55 650	11.2	1.4	1967	49.55	2 683
				1974	65 069	12.4	2.3	1975	* 52.79	* 5 774

TABLE I (contd.)

Region Country	Stock of scientists & engineers Year	Total	per 10 000 population	Scientists & engineers engaged in R & D (in F.T.E.) Year	Total	per 10 000 population	Number of R/D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
Germany, Fed. Rep. of	1961	918 710	163.4	1967	63 110	10.5	1.0	1967	59.87	3 203
	1970	1 083 000	178.6	1975	103 857	16.8	1.0	1975	*61.83	*6 596
Gibraltar	1970	41	13.7	1969	-	-	-	1967	0.03	...
				1971	-	-	-	1975	0.03	**3 000
Greece				1966 15/	1 217	1.4	0.5	1967	8.72	956
				1969 15/	1 032	1.2	0.8	1975	9.05	2 376
Hungary	1967	195 838	191.6	1967	10 469	10.2	1.4	1967	10.22	37/ 1 720
	1973 40/	336 143	322.3	1976 38/	23 573	22.2	1.1	1975	10.54	37/ 4 057
Iceland	1970	3 169	158.5	1965 15/	98	5.2	1.1	1967	0.20	3 121
				1970 15/	126	6.3	1.0	1975	0.22	6 928
Ireland	1967 15/	* 13 000	44.8	1967 9/	1 215	4.2	0.8	1967	2.90	1 256
	1971 15/	21 886	73.4	1975	2 545	8.1	0.6	1975	3.13	2 417
Italy	1961	603 205	120.9	1967 15/	19 670	3.7	0.7	1967	52.60	1 497
				1975	37 925	6.8	0.7	1975	* 55.81	2 923
Malta	1969/70 41/	1 751	53.9	1969/70 9/ 42/	23	0.7	2.0	1967	0.32	459
				1973 4/	39	1.2	0.6	1975	* 0.30	1 495
Netherlands	1970	* 425 000	326.2	1967 43/	15 700	12.5	2.2	1967	12.60	2 707
	1971	* 442 000	335.1	1975 43/	23 750	17.4	1.3	1975	13.65	5 570
Norway	1967	41 500	109.5	1967	3 512	9.3	1.0	1967	3.79	3 104
	1976	80 800	200.5	1975	6 080	15.2	1.2	1975	* 4.01	6 559
Poland	1968	569 000	176.2	1967	*44 978	14.1	0.9	1967	31.94	37/ 4 740
	1974	803 000	238.3	1976	99 500	29.0	0.7	1975	*34.02	37/* 12 006
Portugal				1972	2 216	2.6	0.8	1967	9.38	...
								1975	* 8.76	1 717

TABLE I (contd.)

Region Country	Stock of scientists & engineers			Scientists & engineers engaged in R & D (in F.T.E.)			Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
	Year	Total	per 10 000 population	Year	Total	per 10 000 population				
Romania	1964 1968 7/	210 230 274 541	110.5 142.4	1967 1973	19 231 26 107	10.0 12.5	0.4 0.5	1967 1975	19.28 21.24	... ...
San Marino	1970 1973	171 228	90.0 114.0		- -	- -	- -	1967 1975	0.02 0.02	... ...
Spain	1967 44/	*188 000	* 57.4	1967 44/ 1974	* 3 486 7 924	1.1 2.3	*1.0 0.5	1967 1975	32.73 35.47	... 2 696
Sweden				1967 15/ 1975 15/	7 395 14 993	9.4 18.3	1.4 1.5	1967 1975	7.87 * 8.19	3 962 7 711
Switzerland	1960 7/45/ 1970	59 956 175 090	111.9 282.9	1967 14/ 1975	* 9 508 16 230	* 15.9 * 25.3	8/* 0.3 8/* 0.7	1967 1975	5.99 * 6.40	4 442 8 322
United Kingdom				1968 46/ 1972 47/	43 588 77 086	7.9 * 13.8	2.4 1.0	1967 1975	54.80 *55.96	2 060 3 755
Yugoslavia	1966 48/ 1974	144 568 239 770	73.6 113.3	1966 48/49/ 1975 49/	11 568 18 200	5.9 8.5	0.9 0.7	1967 1975	19.84 21.35	593 1 482
NORTH AMERICA										
Bermuda	1970 7/	1 626	325.2	1970 9/50/	4	0.8	0.8	1967 1975	0.05 0.06	... **6 000
Canada	1971	*621 645	287.8	1967 15/ 1975 47/51/	19 350 16 505	9.5 7.2	8/1.7 0.8	1967 1975	20.41 22.83	3 301 6 572
St. Pierre and Miquelon				1970 52/ 1972 52/	7 7	14.00 14.00	0.6 0.6	1967 1975	0.0 0.005	... ...
United States of America	1966/67 9/ 1975 7/15/ 1976 7/15/	1 412 500 1 619 500 1 647 000	71.5 75.8 76.6	1968 9/ 1975 9/ 1976 9/	550 600 532 700 541 100	27.4 25.0 25.2	0.4 0.08 0.08	1967 1975 1976	198.71 213.54 215.12	3 935 6 970 ...

TABLE I (contd.)

Region Country	Stock of scientists & engineers			Scientists & engineers engaged in R & D (in F.T.E.)			Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
	Year	Total	per 10 000 population	Year	Total	per 10 000 population				
LATIN AMERICA										
Antigua	1970	* 480	68.6					1967 1975	0.06 0.07	... ...
Argentina	1970 1974	303 650 390 000	127.9 155.7	1969[53/] 1974[53/]	* 4 452 * 8 100	1.9 3.2	1.4 1.4	1967 1975	22.80 25.38	785 1 570
Bahamas	1970	* 3 000	176.5	1970[54/]	* 19	* 1.1	* 0.05	1967 1975	0.15 0.20	2 102 2 662
Belize	1969[9/] 1970	138 201	11.5 * 16.8	1969 1970	26 15	2.2 * 1.3	2.3 0.3	1967 1975	0.12 *0.14	... ** 643
British Virgin Islands	1971[7/] 1973[1/]	7 * 120	7.0 120.0	1971 1973	- -	- -	- -	1967 1975	*0.01 *0.01	... ...
Bolivia	1967[9/] 1974	10 925 9 674	24.0 17.7	1967[9/]	400	0.9	[8/]2.0	1967 1975	4.56 5.63	164 314
Brazil	1970	541 328	58.5	1974[55/]	* 7 725	0.8	...	1967 1975	85.24 106.23	386 1 015
Cayman Islands	1971	200	200.0	1971	3	3.0	1.0	1967 1975	0.01 0.01	... ...
Chile				1969[56/] 1975	4 904 5 948	5.4 5.8	0.3 ...	1967 1975	8.85 10.25	545 786
Colombia				1971[9/14/]	1 140	0.5	...	1967 1975	19.22 23.54	262 559
Cuba				1969	1 850	2.2	1.3	1967 1972	8.05 9.09	[37/]507 [37/]816
Ecuador				1970 1973	595 544	1.0 0.8	0.9 0.4	1967 1975	5.51 6.73	265 587

TABLE I (contd.)

Region Country	Stock of scientists & engineers			Scientists & engineers engaged in R & D (in F.T.E.)			Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
	Year	Total	per 10 000 population	Year	Total	per 10 000 population				
El Salvador	1974	5 489	14.1	1974[57]	802	2.1	0.6	1967 1975	3.15 4.01	255 454
Falkland Islands				1969 1975	5 -	25.0 -	- -	1967 1975	0.002 0.002	... ...
Guatemala	 1974[7]	 5 551	 10.0	1970 1974	*230 310	0.5 0.6	* 0.6 1.4	1967 1975	4.70 6.26	287 564
Honduras	1974[7/58]	6 702	23.7	1974[17/59]	5	0.02	0.2	1967 1975	2.33 3.04	214 332
Mexico	1969	*326 765	69.1	1969[9/14] 1974	3 665 5 896	0.8 1.0	0.2 ...	1967 1975	44.16 60.15	631 1 183
Panama	1975	359	2.2	1975	204	1.2	1.5	1967 1975	1.31 1.67	557 1 061
Paraguay				1971	134	0.6	...	1967 1975	2.13 2.65	274 549
Peru	1974[7]	* 84 923	55.2	1970[12] 1975	1 686 2 084	1.2 1.3	0.6 1.0	1967 1975	12.39 15.62	431 801
Trinidad and Tobago				1970[14/44]	380	3.7	0.5	1967 1975	1.01 1.07	987 1 893
Turks & Caicos Islands	 1975	 16	 26.7	1972[60] 1975	2 3	3.3 5.0	- -	1967 1975	0.006 0.006	... ...
Uruguay	1970	20 069	69.4	1971/72	* 1 150	3.9	0.9	1967 1975	2.78 3.06	718 1 198
Venezuela				1970 1973	1 779 2 720	1.7 2.6	0.6 0.3	1967 1975	9.35 11.99	1 159 2 208

TABLE I (contd.)

Region Country	Stock of scientists & engineers			Scientists & engineers engaged in R & D (in F.T.E.)			Number of R&D technicians per R & D scientist or engineer			G.N.P. per capita in U.S. $
	Year	Total	per 10 000 population	Year	Total	per 10 000 population		Year	Population (millions)	
OCEANIA										
American Samoa	1971 1973[7/]	11 327	3.7 109.0	1971[59/]	3	1.0	0.7	1967 1975	0.03 0.03	... ** 5 333
Australia	1971[7/]	* 147 758	* 115.8	1968/9[61/] 1973/4	13 780 25 746	11.4 19.5	0.5 0.7	1967 1975	11.80 13.50	2 788 5 669
Cook Islands	1970	164	82.0	1970	9	4.5	-	1967 1975	0.02 * 0.03	... ...
Fiji	1969[7/9/]	315	6.2	1969[9/]	18	0.4	...	1967 1975	0.48 0.57	... ** 1 088
French Polynesia				1974[17/59/] 1976[17/59/]	9 11	0.8 0.8	1.8 1.9	1967 1975	0.10 *0.13	... **2 923
Gilbert Islands	1969[9/] 1971[7/9/]	42 112	8.4 18.7	1969[9/]	4	0.8	0.5	1967 1975	0.05 * 0.07	... ** 857
Guam				1973[4/]	10	1.1	0.3	1975 1975	0.09 0.10	... ** 6 100
New Caledonia	1973	69	5.3	1971	0.25	0.02	2.0	1967 1975	* 0.10 0.13	... **4 615
New Hebrides				1971 1974	3 4	0.4 0.4	0.3 0.25	1967 1975	0.08 0.10	... ** 500
New Zealand	1973	*8 120	27.4	1970[62/] 1973	1 141 2 948	4.1 10.0	8/ 2.0 ...	1967 1975	2.72 3.07	2 582 4 710
Niue Island				1971	2	5.0		1967 1975	 0.004	 ...
Norfolk Island	1971[7/] 1975[7/]	20 22	100.0 110.0	1969	-	-	-	 1975	 0.002	 ...

TABLE I (contd.)

Region Country	Stock of scientists & engineers Year	 Total	 per 10 000 population	Scientists & engineers engaged in R & D (in F.T.E.) Year	 Total	 per 10 000 population	Number of R&D technicians per R & D scientist or engineer	Year	Population (millions)	G.N.P. per capita in U.S. $
Pacific Islands	1973	161	14.6	1973	23	2.1	1.0	1967 1975	0.10 * 0.12	... **1 000
Papua New Guinea	1971 1/ 7/ 1973 1/ 7/	2 176 2 646	8.6 10.3	1971 1973	* 110 131	0.4 0.5	... ...	1967 1975	2.25 2.76	245 441
Solomon Islands	1969/70 7/ 9/ 1971/72 7/	95 129	5.9 7.6	1969 9/	16	1.0	2.4	1967 1975	0.15 0.19	192 334
Tokelau Islands				1971	-	-	-	1967 1975	0.002 * 0.002	... ...
Tonga	1976	211	23.4					1967 1975	0.08 0.10	... ...
Western Samoa	1975 1976	391 323	26.1 21.5	1975 15/ 17/ 1976 17/	234 135	15.6 * 9.0	0.5 0.6	1967 1975	0.13 0.15	188 338
USSR	1968 7/ 63/ 1975 7/ 63/	6 042 000 9 477 000	253.5 372.6	1967 64/ 1975 64/	770 013 1 223 400	32.6 48.1	... ...	1967 1975	235.99 254.38	37/ 1 062 37/ 1 885
Byelorussian SSR 65/	1968 7/ 63/ 1971 7/ 63/	(200 800) (339 900)	226.1 (373.1)	1967 64/ 1975 64/	(17 073) (31 020)	19.4 (33.2)	... ...	1967 1975	(8.80) (9.35)	... ...
Ukrainian SSR 65/	1968 7/ 63/ 1974 7/ 63/	(1 166 000) (1 704 000)	250.3 (351.2)	1967 64/ 1975 64/	(107 180) (171 478)	23.2 (35.1)	... ...	1967 1975	(46.20) (48.90)	37/ 1 024 37/ 1 773

1. Of which non-national scientists and engineers are as follows: Botswana 1972 : 557 (stock), Kenya 1970 : 70% (stock), Seychelles 1971 : 48% (stock), 1973 : 50% (stock), United Republic of Cameroon 1965 : 1680 (stock) 1970 : 1000 (stock) 1970 : 204 (R & D), Zambia 1973: 69% (R & D), Kuwait 1970 : 3746 (stock), 1973 : 8603 (stock), Libyan Arab Jamahirya 1973: 79% (stock), 80% (R & D), Qatar 1974 : 90% (stock), British Virgin Islands 1973 : 75 (stock), Papua New Guinea 1971 : 2078 (stock) 1973 : 2501 (stock).
2. Data relate to 2 research institutes only.
3. Data relate to 5 research institutes only.
4. Data relate to the higher education sector only.
5. Data relate to 4 research institutes only.
6. Data relate to the (French) "Office de la Recherche Scientifique et Technique d'Outre Mer" (ORSTOM) only. The scientists and engineers are all non-nationals.
7. Data refer to the number economically active.
8. Data for technicians are including auxiliary personnel.
9. Not including data for law, humanities and education.
10. Data for scientists and engineers do not include humanities and education but do include some educational research whilst data for technicians exclude social sciences and humanities.
11. Not including data for humanities.
12. Not including data for humanities and education.
13. Not including data for the productive sector (integrated R & D).
14. Scientists and engineers are full-time plus part-time.
15. Not including data for social sciences and humanities
16. Including technicians.
17. Full-time scientists and engineers only.
18. Data refer to engineers only.
19. Data refer to persons employed in government institutions only. (The number of registered engineers in 1972/73 was 10511).
20. Data refer to the Council of Scientific Research only. In 1974, the corresponding figure for scientists and engineers at this institution was 240.
21. Data refer only to persons working in government departments concerned with scientific activities.
22. Data refer to the East Bank only.
23. Partial data, underestimated by around 20%.
24. Scientists and engineers are full-time only and refer to those engaged in natural sciences and engineering
25. Refers to graduates employed in science, engineering, agriculture and medicine.
26. Data refer to scientists and engineers, technicians and auxiliary personnel.
27. Data refer to the civilian sector only.
28. Data for 1969 refer to graduates from higher education institutes 1963-69 and in 1975 to graduates from higher education institutes 1963-75.
29. Data relate to the Academy of Sciences only and refer to scientific workers.
30. Data relate to R & D activities concentrated mainly in government-financed research establishments only; social sciences and humanities in the higher education and general service sectors are excluded.
31. Not including agriculture, social sciences and humanities.

32. Not including medical sciences but including pharmacy.
33. Not including data for the productive sector (non-integrated R&D).
34. Data relate to the National Research Council only.
35. Data refer to the productive sector only.
36. Not including scientists and engineers engaged in administration in the productive sector (integrated R&D).
37. Net material product except for Cuba which is gross material product.
38. Not including scientists and engineers engaged in the administration of R&D.
39. Of military R&D only that part carried out in civil establishments is included.
40. Including teaching staff at the preprimary and first levels of education.
41. Data do not include some law, humanities and education.
42. Not including higher education sector; not including medical sciences.
43. Not including social sciences and humanities for the productive sector (integrated R&D).
44. Not including law, education and arts.
45. Excluding education and arts and including only some of the humanities.
46. Not including data for Northern Ireland ; figures refer to full-time personnel only and do not include social sciences, humanities and medical sciences; data exclude higher education sector.
47. Not including the higher education sector.
48. Not including education and arts.
49. Not including activities of a military nature or relating to national defence.
50. Not including the productive sector.
51. Not including social sciences and humanities in the productive sector.
52. Data relate to the "Institut scientifique et technique des Pêches Maritimes" only.
53. Data are in net man-years.
54. Data relate to the central government only.
55. Data refer only to post-graduate fundamental research and post-graduate teaching in the higher education sector.
56. Not including data for education.
57. Data concern 28 institutions out of a total of 41 which perform R&D.
58. Data refer to persons having 4 to 7 years and more of higher education.
59. Data relate to 1 research institute only.
60. Data refer to 1 government department only.
61. Not including 12,167 persons for whom a breakdown by category of personnel is not available.
62. Data refer to scientific staff in government departments only.
63. Specialists only employed in the national economy.
64. Data refer to scientific workers (i.e. research workers including teaching staff at institutions of higher education).
65. Figures relating to the Byelorussian S.S.R. and the Ukrainian S.S.R. are already included with those of U.S.S.R. .

**Based on estimated G.N.P. from World Bank Atlas 1977.

3.

Table II. Financial resources for research and experimental development activities

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D			G.N.P. in '000's of US $	Per capita expenditure on R & D		Expenditure per R & D scientist or engineer in national currency
			in national currency (000's)	in US dollars (000's)	As % of G.N.P.		in units of national currency	in US dollars	
AFRICA									
Botswana	S.A. Rand	1968	*468	* 655	* 0.9	76 600	*0.8	*1.2	36 000
		1973	220	318	0.2	157 300	0.3	0.4	9 167
Central African Empire	Franc C.F.A.	1969	183 908	710	0.3	258 400	116.4	0.5	7 073 400
Chad	Franc C.F.A.	1/ 1969	227 060	876	0.3	313 100	63.6	0.3	11 950 500
		2/ 1973	255 220	1 151	0.3	356 500	65.9	0.3	...
Gabon 3/	Franc C.F.A.	1969	1 647	6.4	0.001	486 500	3.4	0.01	274 500
		1970	1 895	6.8	0.001	554 300	3.8	0.01	236 875
Ghana 4/	Cedi	1971	21 612	21 011	0.7	3 214 700	2.4	2.4	* 7 047
Ivory Coast	Franc C.F.A.	1967	1 661 000	6 727	0.6	1 221 600	413.2	1.7	8 142 160
		1970	1 401 124	5 044	0.3	1 848 500	325.1	1.2	4 392 200
Kenya	Shilling	5/ 1971	* 102 940	*14 412	0.8	1 793 300	*8.8	*1.2	* 180 914
Madagascar	Franc	5/6/1969	1 480 000	5 713	0.6	1 020 700	219.3	0.8	6 577 778
		7/1971	2 294 000	8 281	0.7	1 216 500	321.3	1.2	11 412 935
Malawi	Pound	1971	* 1 581	*1 934	* 0.4	425 400	*0.3	*0.4	...
Mauritius	Rupee	1967	* 3 622	* 752	0.3	256 700	*4.7	*1.0	* 62 448
		1975	17 795	2 965	0.6	511 300	20.7	3.4	131 815
Nigeria	Naira	8/ 1966	* 15 380	21 532	* 0.3	6 562 300	*0.3	*0.4	...
		9/ 1970	23 800	33 320	0.3	11 384 400	*0.4	*0.6	*11 426
Senegal 10/11/	Franc C.F.A.	1972	2 176 000	8 639	0.7	1 246 000	*528.1	*2.1	5 551 020
Seychelles	Rupee	11/ 1970	209	38	...	...	4.2	0.8	209 000
		1973	402	74	...	...	6.7	1.2	402 000

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Togo 11/	Franc C.F.A.	1971	1 070 829	3 866	1.0	388 100	532.8	1.9	9 074 822
United Republic of Cameroon	Franc C.F.A.	1967	*1 055 000	4 273	*0.5	845 800	*189.3	* 0.8	...
		1970	*1 765 000	6 363	*0.5	1 341 200	*299.7	* 1.1	5 364 742
Upper Volta	Franc C.F.A.	1970	*412 768	*1 486	0.3	426 600	* 76.7	* 0.3	...
Zambia	Kwacha	11/ 1969	*1 500	*2 100	0.1	1 552 700	* 0.4	* 0.5	* 25 000
		1972	6 261	8 765	0.4	2 007 100	1.4	2.0	* 24 081
ARAB STATES									
Bahrain	Dirham	1976	498	1 259	*0.2	12/ 576 800	1.8	* 4.7	...
Egypt	Pound	1973	29 940	75 646	0.8	8 966 700	0.8	2.1	2 807
		13/1976	33 440	85 459	*0.7	12/11 546 000	0.9	2.2	...
Iraq 14/	Dinar	1971	1 840	5 189	0.1	5 969 800	0.2	0.5	13 630
		1974	7 409	25 026	0.2	12 530 700	0.7	2.3	4 986
Jordan 15/	Dinar	1975	1 540	4 821	0.4	1 244 700	0.6	1.8	6 553
		1976	2 074	6 246	*0.5	12/1 244 700	0.7	2.2	...
Kuwait 16/	Dinar	1973	* 230	* 780	0.01	7 669 600	* 0.3	* 0.9	* 1 122
		1976	13 279	45 416	*0.5	12/9 162 000	12.9	44.1	...
Lebanon 6/17/	Pound	1967	10 000	3 121	...	...	* 4.4	* 1.4	39 526
		1974	13 175	5 665	...	...	* 4.7	* 2.0	...
Libyan Arab Jamahiriya	Dinar	1976	14 300	48 303	*0.5	12/10 435 200	* 5.9	*19.8	...
Morocco 18/	Dirham	1976	6 196	1 402	*0.01	12/7 889 800	0.3	0.08	...
Oman	Ryal	1976	427	1 236	*0.07	12/1 599 300	0.5	1.6	...
Qatar	Ryal	1976	3 775	953	...	...	37.8	9.5	...

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: as % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Somalia	Shilling	1976	26 250	4 170	* 1.3	12/ 318 800	8.0	1.3	...
Sudan	Pound	1973	3 012	8 649	0.3	3 002 800	0.2	0.5	* 1 103
Syrian Arab Republic	Lira	1976	27 077	6 965	* 0.1	12/ 4 869 500	3.6	0.9	...
Tunisia	Dinar	1977	8 544	19 916	* 0.5	12/ 4 225 200	*1.5	*3.5	...
Yemen Arab Republic	Rial	1974	9 923	2 171	...	...	6.0	1.3	165 383
ASIA									
Bangladesh 19/	Taka	1974	113 530	24 159	0.3	7 909 100	1.5	0.3	* 68 848
Brunei	Dollar	11/ 1971	2 425	795	...	...	* 17.3	* 5.7	346.429
		1974	3 055	1 270	...	...	20.4	8.5	138 864
Burma	Kyat	1973	11 960	2 439	0.1	2 523 600	0.4	0.08	...
Cyprus	Pound	1967	633	1 751	0.4	477 100	1.1	3.0	8 792
		1971	1 088	2 650	0.3	779 100	1.8	4.3	9 299
India	Rupee	1969	1 166 200	155 489	0.3	53 634 900	2.2	0.3	15 838
		1972	1 942 600	256 229	0.4	66 506 900	3.4	0.5	18 721
Indonesia 20/	Rupiah	1972	3 315 570	7 991	0.05	16 028 400	26.3	0.06	...
		1975	19 496 580	46 987	0.2	24 184 900	143.3	0.3	1 592 337
Iran	Rial	1970	4 414 595	58 273	0.3	20 206 100	154.0	2.0	1 468 106
		21/ 1972	3 531 807	46 620	0.2	27 437 100	115.6	1.5	721 366
Israel 11/ 22/	Pound	1969	175 000	49 998	0.9	5 836 700	62.3	17.8	* 62 500
		1975	803 000	126 312	1.0	12 398 000	236.9	37.3	* 239 701

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Japan	Yen	1968	877 487 000	2 439 414	1.2	203 431 800	8 606.2	23.9	4 410 103
		1975	2 974 573 000	10 024 310	2.1	487 616 500	26 661.0	89.8	7 439 371
Korea, Rep. of 17/	Won	1969	9 773 985	34 209	0.5	7 481 400	309.9	* 1.2	1 831 363
		1976	60 900 000	127 890	0.7	11/ 18 652 500	1 698.3	* 3.6	5 223 000
Mongolia 25/	Tugrik	1966	13 200	3 300	...	...	11.8	2.9	...
		1971	14 720	3 999	...	...	11.5	3.1	18 469
Pakistan 24/	Rupee	1973	150 430	15 085	0.2	7 686 400	2.2	0.2	36 126
Philippines	Peso	11/ 17/ 1965	40 707	10 438	0.2	5 227 700	1.3	0.3	* 7 269
		1973	218 106	32 201	0.3	11 752 500	5.4	0.8	...
Singapore	Dollar	1975	5 322	2 249	0.04	5 642 900	2.4	1.0	8 381
Sri Lanka	Rupee	17/ 1970	21 887	3 677	0.3	1 267 400	1.7	0.3	...
		1975	45 097	5 847	0.3	1 979 900	3.3	0.4	...
Thailand 17/ 25/	Baht	1968	294 146	14 143	0.2	6 024 300	8.6	0.4	* 588 292
Turkey 17/ 26/	Lira	1969	* 434 700	* 48 300	* 0.3	15 437 400	* 12.3	* 1.4	...
		1972	* 622 400	* 43 985	* 0.2	22 379 400	* 17.1	* 1.2	...
EUROPE									
Austria	Schilling	17/ 1966	1 693 654	65 138	0.4	14 685 700	231.8	8.9	* 548 463
		27/ 1972	2 363 740	102 255	0.4	26 435 600	315.6	13.7	1 264 032
Belgium	Franc	17/ 1967	9 081 562	181 631	0.7	26 619 700	948.0	19.0	1 007 943
		1973	25 026 578	644 434	1.3	48 652 500	2 569.4	66.2	1 935 244
Bulgaria 16/	Lev	1967	106 415	90 985	28/ 1.4	28/ 6 714 315	12.9	11.0	9 619

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Czechoslovakia	Koruna	1967	8 410 000	1 168 149	28/3.7	28/32 363 700	587.7	81.6	206 461
		1975	15 867 000	2 627 572	28/3.9	28/67 703 500	1 072.1	177.5	356 498
Denmark	Krone	1967	685 500	98 589	0.6	15 953 200	141.6	20.4	158 131
		1973	1 654 000	274 432	1.0	28 244 700	329.5	54.7	350 647
Finland	Markka	17/1967	194 688	57 219	0.6	10 156 900	42.2	12.4	92 313
		1975	953 924	259 296	1.1	23 787 200	202.3	55.1	127 139
France	Franc	17/1967	11 690 900	2 367 992	1.8	132 962 600	235.9	47.8	222 55
		1975	26 203 100	6 121 568	2.0	304 788 100	496.4	116.0	399 176
Germany, Federal Rep. of.	Deutsche Mark	1967	9 241 500	2 310 375	1.2	191 789 200	154.4	38.6	146 435
		1975	22 969 000	9 358 719	2.3	407 845 300	371.5	151.4	221 160
Greece 29/	Drachma	1967	338 674	11 288	0.1	8 335 300	38.8	1.3	*278 057
		1969	453 848	15 126	0.1	10 719 500	51.8	1.7	439 775
Hungary	Forint	1967	2 915 959	247 857	28/1.4	28/17 637 500	285.3	24.3	278 533
		1976	14 489 000	1 702 458	28/*3.3	28/51 853 000	1 366.9	160.6	614 644
Iceland 29/	Króna	1966	87 400	2 033	0.3	618 300	437.0	10.2	874 000
		1970	*164 500	* 1 869	* 0.3	739 600	822.5	8.4	1 305 556
Ireland	Pound	17/1967	6 389	17 676	0.5	3 641 500	2.2	6.1	5 258
		1975	31 472	69 915	0.9	7 564 400	10.1	22.3	12 198
Italy	Lira	29/1967	979 453 000	447 125	0.6	78 750 300	5 312.8	8.5	14 207 067
		1975	1 168 103 000	787 198	1.1	163 126 500	20 922.5	32.0	30 800 340
Malta 17/ 30/	Pound	1968	195	468	0.3	169 300	0.6	1.5	* 8 478
Netherlands	Guilder	29/1967	1 860 000	513 806	1.5	34 109 700	147.6	40.8	118 471
		31/1975	4 440 000	1 759 794	2.3	76 029 200	325.3	128.9	186 947

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Norway	Kroner	1967	638 286	89 360	0.8	11 764 200	168.4	23.6	181 744
		1975	2 002 000	384 084	1.5	26 300 300	* 499.3	* 95.8	337 605
Poland	Zloty	1967	*10 825 480	*2 706 370	28/ 1.8	[illegible]/ 151 400 000	* 338.9	* 84.7	* 240 684
		1976	36 241 600	10 908 722	28/ *2.3	[illegible]/ *477 416 000	1 054.8	317.5	362 416
Portugal	Escudo	1972	854 150	31 621	0.3	11 123 900	99.4	3.7	385 447
Romania	Leu	1967	1 666 254	278 264	...	...	66.4	14.4	86 644
		1973	3 354 196	667 485	...	...	161.0	32.0	128 479
Spain	Peseta	32/ 1967	*3 636 800	* 59 898	*0.2	*30 579 849	* 111.1	* 1.8	1 043 259
		1974	15 536 477	269 247	0.3	87 253 500	* 441.1	* 7.6	1 960 686
Sweden 29/	Krona	1966	1 738 500	336 052	1.1	31 178 700	222.0	43.0	* 235 091
		1975	5 133 200	1 239 462	2.0	63 153 700	626.8	151.3	342 373
Switzerland	Franc	1967	1 228 900	281 025	1.1	26 606 000	205.2	46.9	* 129 249
		1975	3 104 000	1 203 731	2.3	53 261 600	485.0	188.1	191 251
United Kingdom 29/	Pound sterling	1967	962 067	2 485 356	2.1	112 891 100	17.5	45.3	* 22 072
		1972	1 310 134	3 277 693	2.0	160 920 300	23.5	58.7	* 16 996
Yugoslavia 33/	Dinar	1969	1 255 969	100 478	0.7	14 730 900	62.1	5.0	86 900
		1975	4 064 000	234 086	0.7	31 637 100	190.4	11.0	223 297
NORTH AMERICA									
Bermuda 6/ 17/	Dollar	1967	197	197	...	...	3.9	3.9	...
		1970	240	240	...	...	4.8	4.8	60 000
Canada 29/	Dollar	1967	895 500	828 336	1.2	67 375 200	43.9	40.6	46 279
		1975	1 729 700	1 700 814	1.1	150 030 600	75.8	74.5	104 799
St. Pierre et Miquelon 34/	Dollar	1972	110 000	437	...	...	22 000	87.4	15 714 286

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
United States of America	Dollar	1968	*26 620 000	*26 620 000	* 3.0	* 879 500 000	* 132.6	* 132.6	* 48 347
		1976	40 113 400	40 113 400	* 2.7	42/ 1 488 335 200	186.5	186.5	74 133
LATIN AMERICA									
Argentine	Peso	35/ 1968	* 154 000	44 044	0.2	19 571 400	* 6.7	* 1.9	* 34 591
		1974	1 630 600	184 256	0.5	37 381 100	*65.1	* 7.4	* 201 309
Bahamas 36/	Dollar	1970	* 550	* 549	*0.1	408 700	* 3.2	* 3.2	* 28 947
Belize 21/	Dollar	1969	572	343	...	...	* 4.8	* 2.9	22 000
		1970	207	124	...	...	* 1.7	* 1.0	13 800
Bolivia 16/ 17/	Peso	1967	8 719	732	0.1	749 100	1.9	0.2	21 798
Brazil 37/	Cruzeiro	1973	*1 958 000	* 313 280	* 0.4	*79 627 600	*19.5	* 3.1	*253 463
		1974	*2 309 000	* 346 350	* 0.4	95 916 200	*22.3	* 3.4	*298 900
Colombia 17/	Peso	1971	210 614	10 497	0.1	7 781 300	9.7	0.5	*184 749
Cuba	Peso	1969	91 735	91 735	38/ *2.2	38/ 4 181 000	11.0	11.0	49 586
Ecuador	Sucre	1970	90 515	4 442	0.2	1 988 400	14.8	0.7	*152 126
		1973	142 310	5 692	0.2	3 050 300	21.1	0.8	261 599
El Salvador 39/	Colon	1974	31 273	12 509	0.8	1 590 800	8.0	3.2	38 994
Falkland Islands	Pound sterling	1969	4	10	...	...	0.002	0.005	800
		1971	-	-	-	...	-	-	-
Guatemala	Quetzal	1970	3 008	3 008	0.2	1 870 400	0.6	0.6	* 13 078
		1974	* 5 139	* 5 139	*0.2	3 064 700	0.9	0.9	* 16 577
Jamaica 11/	Dollar	1969	833	1 000	0.1	1 251 700	0.4	0.5	...
		1971	1 095	1 333	0.1	1 619 600	0.6	0.7	...

TABLE II (contd.)

Region Country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
Mexico	Peso	1970	761 611	60 929	0.2	39 479 700	15.0	1.2	* 203 476
		1973	1 277 618	102 209	0.2	54 535 900	22.7	1.8	* 216 685
Nicaragua [1/]	Córdoba	1971	7 847	1 121	0.1	922 800	4.2	0.6	...
Panama	Balboa	1974	2 908	2 908	0.2	1 611 000	1.8	1.8	...
		1975	3 296	3 296	0.2	1 771 900	2.0	2.0	16 157
Paraguay	Guarani	1971	167 265	1 328	0.2	844 800	70.6	0.6	1 248 246
Peru [5/]	Sol	1970	984 636	25 443	0.4	6 915 600	72.5	1.9	584 007
Trinidad & Tobago [32/]	Dollar	1968	4 031	2 016	0.2	1 101 600	4.0	2.0	...
		1970	5 171	2 586	0.2	1 209 900	5.0	2.5	13 608
Turks & Caicos Islands	Dollar	1972	41	51	...	...	6.8	8.5	20 500
		[40/] 1974	8	9	...	...	1.3	1.5	2 667
Uruguay	Peso	1972	1 858	3 437	0.1	2 732 400	0.6	1.1	...
Venezuela	Bolivar	1970	102 270	22 726	0.2	14 836 200	9.8	2.2	57 487
		1973	289 697	67 314	0.3	19 517 700	25.7	6.0	106 506
OCEANIA									
American Samoa [41/]	U.S. Dollar	1968	50	50	...	...	1.7	1.7	25 000
		1971	120	120	...	...	4.0	4.0	40 000
Australia	Dollar	1968	334 000	374 080	1.0	35 636 700	27.5	30.8	24 238
		1973	657 293	1 882 159	2.9	59 734 700	49.7	142.2	25 530
Cook Islands	N.Z. Dollar	1967	35	48	...	...	1.8	2.4	7 000
		1970	112	125	...	...	5.6	6.3	12 444

TABLE II (contd.)

Region country	National currency	Fiscal year beginning	Total expenditure on R & D: in national currency (000's)	Total expenditure on R & D: in US dollars (000's)	Total expenditure on R & D: As % of G.N.P.	G.N.P. in '000's of US $	Per capita expenditure on R & D: in units of national currency	Per capita expenditure on R & D: in US dollars	Expenditure per R & D scientist or engineer in national currency
French Polynesia 41/	Franc C.F.P.	1970	69 322	686	...	...	630.2	6.2	9 903 143
		1976	140 240	1 614	...	...	1 078.8	12.4	12 749 090
Guam 42/	U.S. Dollar	1973	579	579	...	...	6.4	6.4	57 900
New Caledonia	Franc C.F.P.	1967	1 440	16	...	...	* 14.4	* 0.2	5 760 000
		1971	1 440	14	...	...	12.0	0.1	5 760 000
New Hebrides	Franc	1971	21 600	214	...	...	270.0	2.7	7 200 000
		11/1975	21 603	278	...	...	216.0	2.8	7 201 000
New Zealand	Dollar	43/1968	17 684	19 806	0.3	7 448 100	6.4	7.2	17 719
		1972	* 54 878	*65 579	0.6	10 753 200	* 18.9	* 22.6	* 18 615
Solomon Islands 17/	Australian dollar	1969	355	398	1.2	32 900	2.2	2.5	22 188
Western Samoa	Tala	1975	1 437	2 248	4.4	50 700	9.6	15.0	6 141
		1976	1 385	2 167	* 4.2	* 50 700	9.2	14.4	10 259
U.S.S.R. 44/	Rouble	1967	8 200 000	9 110 200	28/ 3.6	28/250 530 500	34.7	38.6	10 649
		1976	17 700 000	* 23 399 400	* 4.9	12/28/479 621 600	69.0	91.2	14 120
Byelorussian SSR	Rouble	1969	(45 444)	(50 488)	...	...	(5.1)	(5.6)	(2 203)
		1970	(46 399)	(51 549)	...	...	(5.2)	(5.7)	(2 122)

1. Data relate to 2 research institutes only.
2. Data relate to 4 research institutes only.
3. Data relate to the (French) "Office de la Recherche Scientifique et Technique d'Outre Mer (ORSTOM)".
4. Current national scientific budget allocated to the 3 universities of Ghana, the Council of Scientific and Industrial Research, the Atomic Energy Commission and the Fisheries Research Unit.
5. Not including data for humanities and education.
6. Not including data for the productive sector
7. Not including data for the productive sector (integrated R & D).
8. Not including data for the productive sector and excluding capital expenditure for the higher education sector. Not including data for law, humanities and education.
9. Data refer to federal and state government's budgetary estimates. Not including data for social sciences and humanities.
10. Data relate to the productive sector (integrated R & D) and the higher education sector only.
11. Current expenditure only.
12. Data relate to 1975.
13. Not including data for productive enterprises.
14. Data refer to government departments concerned only with scientific activities
15. Data relate to the East Bank only.
16. Not including data for the higher education sector.
17. Not including data for law, humanities and education
18. Data do not include the salaries of research workers in the higher education sector.
19. Data do not include current expenditure in the higher education sector.
20. Data refer to the development budget.
21. Data relate to government expenditure only.
22. Data refer to the civilian sector only and do not include social sciences and humanities
23. Data refer to the budget for the Academy of Sciences only
24. Data refer to R & D activities which are concentrated mainly in government financed research establishments but exclude social sciences and humanities in the higher education and general service sector.
25. Data relate to government funds, special funds and other funds for the higher education and general service sector only
26. Data are based on government budget.
27. Data relate to the productive sector only.
28. Data relate to the net material product
29. Not including data for social sciences and humanities.
30. Data relate to the general service sector only.
31. Not including social sciences and humanities in the productive sector (integrated R & D).
32. Not including data for law, education and arts.
33. Not including activities of a military nature or relating to national defence.
34. Data concern the "Institut Scientifique et Technique des Pêches Maritimes" only.
35. Data do not include private enterprises.
36. Data refer to central government only.
37. Data relate to budgetary estimates.
38. Data relate to the gross material product.
39. Data concern 28 institutions out of a total of 41 which perform R & D.

40. Data refer to one government department only.
41. Data relate to one research institute only.
42. Data relate to the higher education sector only.
43. Data refer to national R & D expenditure.
44. "Expenditure on Science" from the national budget and other sources.
45. R & D expenditure relates to research institutions administered by the Council of Ministers of the Byelorussian S.S.R. Figures relating to the Byelorussian S.S.R. are already included with those of the U.S.S.R.

4. APPENDIX

Sources of data

The following documents and publications were utilized for the compilation of the data.

UNESCO. Statistical surveys of scientific and technological activities. Paris. (Annual or Biennial since 1968)

________. Statistical Yearbook. Paris (Annual, since 1969)

________. REGIONAL ARAB STATES. Survey of R and D expenditure in Arab States by Mustapha Hafez. (February 1978)

UNITED NATIONS. Demographic Yearbook, 1975. New York

WORLD BANK. Bank Atlas and Computer print-outs, Washington, 1976.

UNESCO PUBLICATIONS: NATIONAL DISTRIBUTORS

Argentina	EDILYR S.R.L., Tucumán 1699 (P.B. 'A'), 1050, BUENOS AIRES.
Australia	*Publications:* Educational Supplies Pty. Ltd, Post Office Box 33, BROOKVALE 2100, N.S.W. *Periodicals:* Dominie Pty. Subscriptions Dept., P.O. Box 33, BROOKVALE 2100, N.S.W. *Sub-agent:* United Nations Association of Australia (Victorian Division), 2nd floor, Campbell House, 100 Flinders St., MELBOURNE 3000.
Austria	Dr. Franz Hain, Verlags- und Kommissionsbuchhandlung, Industriehof Stadlau, Dr. Otto-Neurath-Gasse 5, 1220 WIEN.
Belgium	Jean De Lannoy, 202, Avenue du Roi, 1060 BRUXELLES. CCP 000-0070823-13.
Benin	Librairie nationale, B.P. 294, PORTO NOVO.
Bolivia	Los Amigos del Libro: casilla postal 4415, LA PAZ; Peru 3712 (Esq. España), casilla postal 450, COCHABAMBA.
Brazil	Fundação Getúlio Vargas, Editora-Divisão de Vendas, caixa postal 9.052-ZC-02, Praia de Botafogo 188, RIO DE JANEIRO, R.J.
Bulgaria	Hemus, Kantora Literatura, boulevard Rousky 6, SOFIJA.
Burma	Trade Corporation no. (9), 550-552 Merchant Street, RANGOON.
Canada	Renouf Publishing Company Ltd, 2182 St. Catherine Street West, MONTREAL, Que., H3H 1M7.
Chile	Bibliocentro Ltda., Constitución n.° 7. Casilla 13731, SANTIAGO (21)
Colombia	Editorial Losada, calle 18A, n.° 7-37, apartado aéreo 5829, BOGOTÁ; Edificio La Ceiba, oficina 804, calle 52 n.° 47-28, MEDELLÍN.
Congo	Librairie Populaire, B.P. 577, BRAZZAVILLE.
Costa Rica	Librería Trejos S.A., apartado 1313, SAN JOSÉ.
Cuba	Instituto Cubano del Libro, Centro de Importación, Obispo 461, LA HABANA.
Cyprus	'MAM', Archbishop Makarios 3rd Avenue, P.O. Box 1722, NICOSIA.
Czechoslovakia	SNTL, Spalena 51, PRAHA 1 (*Permanent display*); Zahranicni literatura, 11 Soukenicka, PRAHA 1. *For Slovakia only:* Alfa Verlag Publishers, Hurbanova nam. 6, 893 31 BRATISLAVA.
Denmark	Ejnar Munksgaard Ltd, 6 Nørregade, 1165 KØBENHAVN K.
Egypt	National Centre for Unesco Publications, 1 Talaat Harb Street, Tahrir Square, CAIRO.
El Salvador	Librería Cultural Salvadoreña, S.A., calle Delgado, n.° 117, apartado postal 2296, SAN SALVADOR.
Ethiopia	Ethiopian National Agency for Unesco, P.O. Box 2996, ADDIS ABABA.
Finland	Akateeminen Kirjakauppa, Keskuskatu 1, SF-00100 HELSINKI 10.
France	Librairie de l'Unesco, 7, place de Fontenoy, 75700 PARIS. CCP Paris 12598-48.
French West Indies	Librairie 'Au Boul' Mich', 1 Rue Perrinon *and* 66 Avenue du Parquet, 97200 FORT-DE-FRANCE (Martinique).
German Dem. Rep.	Buchhaus Leipzig, Postfach 140, 701 LEIPZIG or international bookshops in the German Democratic Republic.
Germany, Fed. Rep. of	S. Karger GmbH, Karger Buchhandlung, Angerhofstrasse 9, Postfach 2, D-8034 GERMERING/MÜNCHEN. *For scientific maps only:* Geo Center, Postfach 800830, 7000 STUTTGART 80. *For 'The Courier' (German edition only):* Colmantstrasse 22, 5300 BONN.
Ghana	Presbyterian Bookshop Depot Ltd., P.O. Box 195, ACCRA; Ghana Book Suppliers Ltd., P.O. Box 7869, ACCRA; The University Bookshop of Ghana, ACCRA; The University Bookshop of Cape Coast; The University Bookshop of Legon, P.O. Box 1, LEGON.
Greece	International bookshop (Eleftheroudakis, Kauffman, etc.).
Hong Kong	Swindon Book Co., 13-15 Lock Road, KOWLOON. Federal Publications (HK) Ltd., 5a Evergreen Industrial Mansion, 12 Yip Fat Street, Wong Chuk Hang Road, ABERDEEN.
Hungary	Akadémiai Konyvesbolt, Váci u. 22, BUDAPEST VI.
Iceland	Snaebjörn Jonsson & Co., H.F., Hafnarstraeti 9, REYKJAVIK.
India	Orient Longman Ltd., Kamani Marg, Ballard Estate, BOMBAY 400038; 17 Chittaranjan Avenue, CALCUTTA 13; 36a Anna Salai, Mount Road, MADRAS 2, B-3/7 Asaf Ali Road, NEW DELHI 1; 80/1 Mahatma Gandhi Road, BANGALORE 560001; 3-5-820 Hyderguda, HYDERABAD 500001. *Sub-depots:* Oxford Book and Stationery Co., 17 Park Street, CALCUTTA 700016; Scindia House, NEW DELHI 110001; Publications Section, Ministry of Education and Social Welfare, 511 C-Wing, Shastri Bhavan, NEW DELHI 110001.
Indonesia	Bhratara Publishers and Booksellers, 29 Jl. Oto Iskandardinata 111, JAKARTA; Gramedia Bookshop, Jl. Gadjah Mada 109, JAKARTA; Indira P.T., Jl. Dr. Sam Ratulangi 37, JAKARTA PUSAT.
Iran	Iranian National Commission for Unesco, Avenue Iranchahr Chomali no. 300, B.P. 1533, TEHRAN; Kharazmie Publishing and Distribution Co., 28 Vessal Shirazi Street, Shahreza Avenue, P.O. Box 314/1486, TEHRAN.
Iraq	McKenzie's Bookshop, Al-Rashid Street, BAGHDAD.
Ireland	The Educational Company of Ireland Ltd., Ballymount Road, Walkinstown, DUBLIN 12.
Israel	Emanuel Brown, formerly Blumstein's Bookstores, 35 Allenby Road *and* 48 Nachlat Benjamin Street, TEL AVIV; 9 Shlomzion Hamalka Street, JERUSALEM.
Italy	Licosa (Librería Commissionaria Sansoni S.p.A.), via Lamarmora 45, casella postale 552, 50121 FIRENZE.
Jamaica	Sangster's Book Stores Ltd., P.O. Box 366, 101 Water Lane, KINGSTON.
Japan	Eastern Book Service Inc., C.P.O. Box 1728, TOKYO 10092.
Kenya	East African Publishing House, P.O. Box 30571, NAIROBI.
Republic of Korea	Korean National Commission for Unesco, P.O. Box Central 64, SEOUL.
Kuwait	The Kuwait Bookshop Co. Ltd., P.O. Box 2942, KUWAIT.
Lesotho	Mazenod Book Centre, P.O. MAZENOD.
Liberia	Cole & Yancy Bookshops Ltd., P.O. Box 286, MONROVIA.
Libyan Arab Jamahiriya	Agency for Development of Publication and Distribution, P.O. Box 34-35, TRIPOLI.
Luxembourg	Librairie Paul Bruck, 22 Grande-Rue, LUXEMBOURG.
Madagascar	Commission nationale de la République démocratique de Madagascar pour l'Unesco, Boite postale 331, TANANARIVE.
Malaysia	Federal Publications Sdn. Bhd., Lot 8238 Jalan 222, Petaling Jaya, SELANGOR.
Malta	Sapienzas, 26 Republic Street, VALLETTA.
Mauritius	Nalanda Co. Ltd., 30 Bourbon Street, PORT-LOUIS.
Mexico	SABSA, Insurgentes Sur, n.° 1032-401, MÉXICO 12, D.F.
Monaco	British Library, 30, boulevard des Moulins, MONTE-CARLO.
Mozambique	Instituto Nacional do Livro e do Disco (INLD), Avenida 24 de Julho, 1921-r/c e 1° andar, MAPUTO.
Netherlands	N.V. Martinus Nijhoff, Lange Voorhout 9, 's-GRAVENHAGE; Systemen Keesing, Ruysdaelstraat 71-75, AMSTERDAM 1007.
Netherlands Antilles	Van Dorp-Eddine N.V., P.O. Box 200, Willemstad, CURAÇAO, N.A.
New Caledonia	Reprex S.A.R.L., Boite postale 1572, NOUMÉA.
New Zealand	Government Printing Office, Government bookshops: Mulgrave Street, Private Bag, WELLINGTON; Rutland Street, P.O. Box 5344, AUCKLAND; 130 Oxford Terrace, P.O. Box 1721, CHRISTCHURCH; Alma Street, P.O. Box 857, HAMILTON; Princes Street, P.O. Box 1104, DUNEDIN.
Niger	Librairie Mauclert, B.P. 868, NIAMEY.
Nigeria	The University Bookshop of Ife; The University Bookshop of Ibadan, P.O. Box 286, The University Bookshop of Nsukka; The University Bookshop of Lagos; The Ahmadu Bello University Bookshop of Zaria.
Norway	*Publications:* Johan Grundt Tanum, Karl Johans gate 41/43, OSLO 1. *For 'The Courier':* A/S Narvesens Litteraturtjeneste, Box 6125, OSLO 6.
Pakistan	Mirza Book Agency, 65 Shahrah Quaid-e-azam, P.O. Box 729, LAHORE 3.
Peru	Editorial Losada Peruana, Jirón Contumaza 1050, apartado 472, LIMA.
Philippines	The Modern Book Co., 926 Rizal Avenue, P.O. Box 632, MANILA D-404.
Poland	ORPAN-Import, Palac Kultury, 00-901 WARSZAWA; Ars Polona-Ruch, Krakowskie Przedmiescie N° 7, 00-068 WARSZAWA.
Portugal	Dias & Andrade Lda., Livraria Portugal, rua do Carmo 70, LISBOA.
Southern Rhodesia	Textbook Sales (PVT) Ltd., 67 Union Avenue, SALISBURY.
Romania	ILEXIM, Romlibri Str. Biserica Amzei no. 5-7, P.O.B. 134-135, BUCUREȘTI. *Periodicals (subscriptions):* Rompresfilatelia, Calea Victoriei nr. 29, BUCUREȘTI.

Senegal	La Maison du Livre, 13, avenue Roume, B.P. 20-60, DAKAR; Librairie Clairafrique, B.P. 2005, DAKAR; Librairie 'Le Sénégal', B.P. 1594, DAKAR.
Singapore	Federal Publications (S) Pte. Ltd., no. 1 New Industrial Road, off Upper Paya Lebar Road, SINGAPORE 19.
Somalia	Modern Book Shop and General, P.O. Box 951, MOGADISCIO.
South Africa	Van Schaik's Bookstore (Pty.) Ltd., Libri Building, Church Street, P.O. Box 724, PRETORIA.
Spain	MUNDI-PRENSA LIBROS S.A., Castelló 37, MADRID 1; Ediciones LIBER, Apartado 17, Magdalena 8, ONDÁRROA (Vizcaya); DONAIRE, Ronda de Outeiro, 20, Apartado de Correos, 341, LA CORUÑA; Librería AL-ANDALUS, Roldana, 1 y 3, SEVILLA 4; LITEXSA, Librería Técnica Extranjera, Tuset, 8–10 (Edificio Monitor), BARCELONA.
Sri Lanka	Lake House Bookshop, Sir Chittampalam Gardiner Mawata, P.O. Box 244, COLOMBO 2.
Sudan	Al Bashir Bookshop, P.O. Box 1118, KHARTOUM.
Sweden	*Publications*: A/B C.E. Fritzes Kungl. Hovbokhandel, Fredsgatan 2, Box 16356, 103 27 STOCKHOLM 16. *For 'The Courier'*: Svenska FN-Forbundet, Skolgränd 2, Box 150 50, S-104 65 STOCKHOLM.
Switzerland	Europa Verlag, Rämistrasse 5, 8024 ZÜRICH; Librairie Payot, 6, rue Grenus, 1211 GENEVA 11.
Thailand	Suksapan Panit, Mansion 9, Rajdamnern Avenue, BANGKOK; Nibondh and Co. Ltd., 40–42 Charoen Krung Road, Siyaeg Phaya Sri, P.O. Box 402, BANGKOK; Suksit Siam Company, 1715 Rama IV Road, BANGKOK.
Togo	Librairie Évangélique, P.B. 378, LOMÉ, Librairie du Bon Pasteur, B.P. 1164, LOMÉ; Librairie Moderne, B.P. 777, LOMÉ.
Turkey	Librairie Hachette, 469 Istiklal Caddesi, Beyoglu, ISTANBUL.
Uganda	Uganda Bookshop, P.O. Box 145, KAMPALA.
U.S.S.R.	Mezhdunarodnaja Kniga, MOSKVA, G-200.
United Kingdom	H.M. Stationery Office, P.O. Box 569, LONDON SE1 9NH; Government Bookshops. London, Belfast, Birmingham, Bristol, Cardiff, Edinburgh, Manchester.
United Rep. of Cameroon	Le secrétaire général de la Commission nationale de la République Unie du Cameroun pour l'Unesco, B.P. 1600, YAOUNDÉ.
United Rep. of Tanzania	Dar es Salaam Bookshop, P.O. Box 9030, DAR ES SALAAM.
United States	Unipub, Box 433, Murray Hill Station, NEW YORK, New York 10016.
Upper Volta	Librairie Attie, B.P. 64, OUAGADOUGOU. Librairie catholique 'Jeunesse d'Afrique', OUAGADOUGOU.
Uruguay	Editorial Losada Uruguay, S.A., Maldonado 1092, MONTEVIDEO.
Venezuela	Librería del Este, Av. Francisco de Miranda, 52, Edificio Galipán, Apartado 60337. CARACAS; La Muralla Distribuciones, S.A., 4a, Avenida entre 3a. y 4a. transversal, 'Quinta Irenalis' Los Palos Grandes, CARACAS 106.
Yugoslavia	Jugoslovenska Knjiga, Trg Republike 5-8, P.O. Box 36, 11-001 BEOGRAD; Drzavna Zalozba Slovenije, Titova C. 25, P.O.B. 50-1, 61-000 LJUBLJANA.
Zaire	La Librairie, Institut national d'études politiques, B.P. 2307, KINSHASA; Commission nationale zaïroise pour l'Unesco, Commissariat d'État chargé de l'Éducation nationale, B.P. 32, KINSHASA.