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Societal Utilisation of Scientific and Technological Research

An Expanded Conceptual Framework for an International Study

SUMMARY

This study explores the concept of "societal utilisation of R&D". Several models of interation between science, technology and society are examined in connection with governmental policy-making in this area. A brief review is then made of the global problems which face mankind and how relevant research can be derived therefrom by national policy-making authorities dealing with science and technology. The concept of "ethnoscience" is broached and its implications for national R&D systems evoked. Finally, proposals are made for the undertaking of an International Cooperative Study on the "societal utilisation of R&D" including three alternative choices for the execution of the research work involved.

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This study has been prepared jointly by a member of the Unesco Secretariat, Y. de Hemptinne, Division of Science and Technology Policies, Unesco, Paris, and two consultants K.D. Knorr, Institute for Advanced Studies, Vienna, Austria, and V. Stolte-Heiskanen, University of Helsinki, Department of Sociology, Helsinki, Finland.

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1. Introduction

The purpose of the present paper is to review major issues of concern for the production, dissemination and utilisation of knowledge and to propose a framework for the possible launching of an international cooperative research on the societal [1] utilisation of scientific and technological research together with some recommendations for alternative forms of implementation of such an international undertaking.

Recent attempts to understand the features of present industrial (or post-industrial) societies have tended to agree on a series of characteristics such as a decreasing efficiency of patterns of motivation and legitimation, an increasing interdependency of different societal systems due, among other things, to different access to raw materials and resources and finally shifts in the international balance of power both within highly technological societies and between the latter and those which came to be called developing countries. On the most general level, the situation has been described in terms of change toward greater complexity of societal systems and of their relations with the natural and social environment. Conscious use of scientific and technological research (including the field of social sciences) to help deal with this complexity is thought to be of ever increasing necessity.

Needless to say, science and technology itself had their share in generating this complexity. In the process of managerial escalation in R&D [2] associated with the Manhatten project and the development of the first atomic bomb during the Second World War, scientific and technological research constituted not only a powerful strategic and diplomatic <u>resource</u>, but also a condition (and influencing factor) of this kind of international competition in

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(1) The term "societal" here refers to the larger context of a society, including its needs and problems as well as its national decision-making structures (political, legislative, administrative and consultative) and the related corrective feedback processes. The term "societal utilisation of R&D" consequently refers to the scientific and technological research carried out in the context of organised societies with the purpose of acquiring and applying the knowledge and know-how that is necessary in order to satisfy the needs and aspirations of peoples'. The term "social" will be used in this document, mainly when referring to the social mechanisms on the basis of which National R&D subsystems operate, in contrast to the cognitive mechanisms and models underlying their functioning.

(2) Cf. Salomon (1976 : 44, 46). See also other details on the development of science policy after the Second World War as summarised in the same article. Hirsch (1971) shows the interrelation between scientific and technological progress and the political system. See particularly Chapter 4.

warfare which, soon after the end of the war, spilled over into civilian life. The universal rise of science and technology policy after 1945 shows the political awareness and institutional recognition of this increasingly important role of science and technology. In a sense, this role was anticipated earlier by Polish and Soviet writers, and by Bernal, (1) whose postulation in the twenties and thirties of a necessary interrelationship between science and society was vehemently criticised by the adherents of an "autonomous" republic of science. Whereas Bernal's battle seemed lost in market economy countries at the time, history proved him right because this interrelationship is no longer an issue of debate, and because scientists themselves nowadays generally accept their responsibility toward society with respect to the kind of research they are doing.(2) In the optimistic interpretation of the above interrelationship, science is seen to help solving the problems of a better society characterised by a kind of inbuilt stabilised harmony. However, in the early sixties there arose also a pessimistic interpretation of the historical "links" between science and society in which the harmony was seen for example to reflect the link between science and "repressive" forces. Given the increasing awareness of factors like the deterioration of the quality of life on an almost world-wide basis, the increasing pollution and the threat to mankind's ecological environment, the criteria of "social utility" of investment in R&D - as against the previously dominating ones of "economic returns" - became a focus of discussion. With respect to the underdeveloped countries it became definitely apparent that the transplantation of industrial innovations from developed countries (technology transfer) would not by itself solve their crucial problems of health, food, overpopulation, deculturation and economic dependency. Phrased differently, it was realised that there is a potential gap between a "science for the benefit of man" and the "instrumentalised" science as it had existed in highly industrialised societies for a long period of time, and that some kind of reorientation of scientific and technological development will be called for in the future.

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(1) See Bernal (1939).

(2) Clearly, this acceptance sometimes seems to be no more than a lip service paid to an idea which is not truly acted out in practice. However, one should not forget that the necessity for scientists to pay at least lip service to this responsibility is in itself a meaningful indicator of the changing situation.

Obviously, there is an essential question which remains to be answered - and that is how this reorientation can be achieved, how some kind of effective societal utilisation of science and technology will be made possible, how R&D in general can be oriented toward impending social problems and agreed upon goals. Equally obviously, this question is multifold: it concerns the national/political system and its decision making potential for attaining or fulfilling these goals (both in terms of consciousness and practice) and it concerns the national R&D system and its potential for generating results which interlock with these decisions. In order to achieve conscious, voluntaristic or planned societal utilisation of knowledge, it will be crucial to understand how societal decisions are made in the first case, as well as the processes by which scientific and technological knowledge is produced in the second. In Sections 2-7 of this paper some conceptual questions will be outlined which will have to be answered when trying to reach such an understanding. In Section 7.3 and the following, implications accordingly will be drawn for the research design of the proposed study on societal utilisation of R&D.

More specifically, after defining the concept of "societal utilisation", the notion of "R&D system" will be introduced and certain conceptual models of utilisation of R&D results, as they are beginning to emerge in the current literature on the topic, will be reviewed. On the basis of this review, a specific conception of the process of utilisation will be suggested as a working hypothesis. Section 5 will turn to a more general discussion of societal aspects of utilisation of R&D, including a discussion of the essentially normative character of the question of what type of scientific and technological results are needed, and how such results could be included. Some of the more global problem-areas which call for scientific/technological solutions in many countries will then be outlined and attention drawn on the specific national character of these solutions which must be appropriate and relevant to the local situation and its inherent constraints at a given point in time. Finally, the above mentioned implications for the design and methodology of research directed to the question of societal utilisation of R&D will be drawn and suggestions for immediate action will be given.

2. The Concept of Societal Utilisation of R&D

Any discussion of the use of scientific and technological knowledge must recognise that the concept refers to a complex set of multidimensional phenomena. Utilisation may vary in terms of scope from the application of studies conducted by technical specialists using routine problem-solving techniques in a wide variety of so-called applied areas, to the formulation of alternative policy options in R&D involving long-range and sometimes large-scale consequences. Correspondingly, the objectives governing the use of scientific knowledge may range from the development of some product or process to the solution of long-term problems confronting mankind. In addition, utilisation may be also differentiated by the way scientific knowledge is used. According to some statements appearing in the modern literature, scientific/technological knowledge may be "legitimising" decisions taken independently and outside the sphere of S&T, it may be "instrumental" in solving a problem, or it may be used for conceptual clarification in an "enlightening" way, (particularly in the social sciences). Awareness of the complexity of the issue of utilisation of R&D makes the traditional distinction between pure and applied research less and less useful because it largely rests on the personal motivations of the researchers themselves; (1) it is therefore an artificial distinction intrinsic to S&T which is of little help in the present context. (2)

To define the problem of societal utilisation of R&D, a distinction introduced by Ravetz seems more fruitful. (3) He suggests three distinct varieties of science which have been historically perceived and associated with particular interest groups:

1) academic science based on the ideology derived from the 19th century German universities;

2) "ideologically engaged" science which is considered a bearer of truth and reason, standing against dogma, etc.; and

3) useful science - where the results and methods of science are oriented by technical and practical problems, which provide stimuli, goals and partial justifications for scientific work. A further distinction which encompasses both science and technology, categorizes research into discipline-oriented R&D

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(1) Indeed, pure research is more often than not defined by stating that it is undertaken by scientific researchers who have no practical applications either in view or in mind.

(2) Cf. Korach (1964); Krohn (1977).

(3) Cf. Ravetz (1976).

and mission-oriented R&D. From the point of view of the concerns of the present study the focus is on "useful science" or, if one prefers, on mission-oriented R&D, whatever the motivating force which drives the research worker. In other words, societal utilisation of R&D is considered to take place when the research serves in its problem-solving (or anticipating)capacity and the results are - or may be - put to use to improve mankind's predicament. (1) In terms of the above distinction between "legitimative", "instrumental" and "enlightening" use of science and technology (or R&D), it should be added that purely symbolic manifestations of utilisation interests are not the concern of the present study, although there is a general awareness of the fact that the aspect of legitimation cannot be excluded a priori from any form of realisation of science. It should also be noted that societal utilisation is not necessarily identical to social usefulness, as exemplified by the distinction between social utility and economic profitability drawn in the Introduction. Notwithstanding the fact that the normative question of what is socially useful and considering that the empirical problem of identifying side effects and potential long-term consequences of a supposedly useful result add to the complexity of the undertaking, it should be made clear that it is social usefulness that is primarily being addressed to in this paper.

The concept of useful science outlined above suggests the need for dealing with the three-pronged question concerning the societal application of the so-called "scientific approach":

1) forecasting and identification of emerging issues or problems in society (societal awareness) or in the R&D system;

2) the creation or development of relevant knowledge (R&D); and

3) the practical application of R&D results. In order to conceive of this process, it appears to be necessary to develop an understanding of how the national R&D (sub)system on the one hand, and the corresponding (national) societal system on the other hand, operate, as well as to develop an understanding of the interaction, interdependency and transformations between the two.

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(1) This has also been called "the product value of science", Weingart (1977).

In the following section, a specific conception of the R&D system will be suggested which might serve to guide this understanding. While equivalent conceptions of the relevant societal system and decision-making process would have to be developed for human societies in the future, the cultural, national and political specificity of these societal systems makes it impossible to present one general model of societal systems in the present paper. The corresponding sections of this paper (5-6) will therefore be restricted to the outlining of some dimensions of societal systems which are relevant for the present purpose, whatever specific society is considered.

3. The R&D System

3.1 The context of a field or discipline

As stated in the Introduction, understanding the process of societal utilisation of R&D and its difficulties requires not only an understanding of how relevant knowledge is produced in the laboratory, it also requires a workable conceptualisation of how the R&D system operates on a more general level. In order to capture phenomena like the resistance and evasiveness of scientists with respect to treating certain questions, the proliferation of certain rather than other research areas, etc., it is necessary to understand the R&D subsystem in the context of a scientific or technological field or discipline. In accordance with some recent theories [1] such a field or discipline is defined as the locus of an "agonistic" [2] struggle for the monopoly of scientific credit;[3] this credit is a symbolic capital which is at the same time scientific (technical, cognitive) competence and social authority. It is very important to see that the currently predominant additive (or at best interactive) model which conceives of social

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(1) The conception of the scientific field is here adapted from Bourdieu (1975). See also Latour and Woolgar (1978) and Knorr (1977).

(2) The term agonistic is used here in the Greek sense to describe a context of generalised competitive rather than direct individual conflict. For example, in order to compete successfully in their field, scientists are at the same time antagonists and accomplices, arguing against each other's products through drawing on these products.

(3) The notion of scientific credit is not to be confused with the "recognition" or "reputation" in studies of scientific communities. Credit is a commodity which can be exchanged for different kinds of resources (project money, assistant scientists etc.), i.e. it is linked to the process of research performance rather than being restricted to research evaluation. Furthermore, credit is linked to the future promise of a R&D work on the basis of which resources and opportunities are allocated rather than exclusively to past achievements.

factors as acting on top of, or in addition to, cognitive factors is rejected here in favour of a conception which holds the so-called cognitive and social factors to be facets of the same phenomenon within the R&D (sub)system, which emerge when looked at from a certain angle or in the light of a specific perspective. Thus the use of a highly expensive Laser-electron microscope is a technical solution to the cognitive problem of determining the molecular structure of proteins, but it is at the same time the social element of a career-promoting move of the scientist concerned, since the use of (and competence in dealing with) this scarce and expensive equipment eases access to publication of results and to certain career positions. In the above context, it should be stressed that what counts as a successful research finding that can be published, is determined by the field and by the individual scientist's position in the field. As a social sphere, the field is constituted by the research scientists, groups and organisations working in an area. As a regulating force which structures and orients the perceptions and decisions of scientific researches, the field operates through its "scriptures", a body of writings considered to be authoritative. The writings are structured by indicators having different values, such as the names of authors, journals or publishing companies, citation indexes and the date of appearance or of circulation. In academic research these writings - together with what relevant research scientists say about their current undertakings - constitute traditionally the agonistic context in which research decisions are embedded. In the case of a technological R&D group in industry, this context will have to be respecified such as to include conditions set by the enterprise and by the agonistic market conditions which presumably are only incompletely mapped into the technological literature of the area. At the same time, the social aspect of the context, e.g. the constellation of relevant agents/actors as well as what is at stake in their undertakings will have to be redefined so as to match the new situation. How these respecifications will have to look like in contexts where R&D results are effectively applied is at present largely unknown. To give an example of the kind of respecification that might be expected, it may well be that the role of the enterprise in its active (e.g. as a scientific agent in the field which produces certain outputs under its name) but also in its passive aspect (e.g. as an opportunity niche providing the scientist with resources and access) will gain in importance as compared with exclusively academic contexts.

3.2 The state of affairs in a field or discipline : cognitive deficiencies and institutional resistances

One of the problems which have long been haunting science and technology policy-makers is the phenomenon of institutional resistance vis-a-vis attempts at orienting R&D towards the forecasting, identification and solution of practical problems or societal goals, and the question of how to select, promote and assess the cognitive potential of national R&D in science and technology that could adequately deal with these questions. (1) It seems reasonable to assume that the phenomenon of evasiveness of scientists who may feel inclined to use contract research money in order to pursue their own rather than the financing agency's interests, can be linked to the scientific or technological field and to its career-promoting mechanisms. What is less clear is how phenomena of institutionalisation and de-institutionalisation, but also of increasing differentiation and segmentation into sub-specialities, affect the mechanisms underlying the development of a given field or a discipline. Furthermore, it is open to speculation whether or not these phenomena lead to different degrees of possible societal utilisation of R&D at different points in time. Finally, it is not clear whether the "state of knowledge" of a field, i.e. the amount and the quality of facts and techniques, must be associated with a differentiated feasibility and ease of application of science and technology for practical and societal purposes.

In a recent attempt to conceive of some of these factors with respect to societal utilisation of R&D, a model has been proposed which came to be known as the theory of finalisation. (2) For the present purpose, the theory serves as an example for a further kind of analysis which will be called for in connection with the scientific/technological field or discipline and with respect to the question of societal utilisation of R&D: an analysis of how different stages of cognitive development as they appear from different forms and degrees of institutionalisation affect the possibility of societal application of the scientific approach. The theory of finalisation postulates a three-stage model of the

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(1) Talks given by ministers of science often reflect these problems. See for example Firnberg (1977).

(2) See Böhme et al (1973).

development of a scientific discipline: a "pre-paradigmatic" stage [(1)] of trial and error in which there is no commonly agreed upon theory or paradigm which could consolidate the various efforts, a stage of "paradigmatisation" or theoretical development, and a stage of "finalisation" in which this theoretical development reaches completion and is no longer pushed further. During the pre-paradigmatic stage societal needs can - but must not - be taken into account or met by a discipline. During the stage of paradigmatisation science has and needs autonomy to settle its internal theoretical problems; it should not receive extrinsic orientation and guidance. During the stage of "finalisation" the situation of the discipline does not any longer yield criteria of problem selection and specification from the intrinsic scientific point of view, which means that societal and practical issues can (and should) take over the role of pushing the development further. In sum, societal application of the scientific approach is predominantly possible at the third stage (finalisation) of a discipline's development; the link between science or technology and society will be particularly strong and justified (because it enhances further development in an otherwise "complete" area) in the last stage, a stage which many disciplines are thought to have entered into by now.

The theory of "finalisation" has been a focus of discussions with inconclusive results during the last couple of years, and was recently criticised for legitimising the ever increasing instrumentalisation of science independently of whether it is beneficial for man or not. The discussion raised once again the question of the social responsibility of research scientists both for the kind of results they generate and with respect to the way these results are societally utilised. In the case of the theory of "finalisation", this responsibility will be linked to the stage of development of a field. In a more comprehensive study of societal utilisation, the issue will have to be analysed in the light of the role attributed to individual voluntarism (which is often overestimated when scientists are urged to show more responsibility) in face of the mechanisms and dynamics of a field, and with a view to a potential change of these mechanisms toward a larger degree of responsibility of the researcher.

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(1) The term "pre-paradigmatic", but also the description of this stage, are borrowed from T. Kuhn (1962).

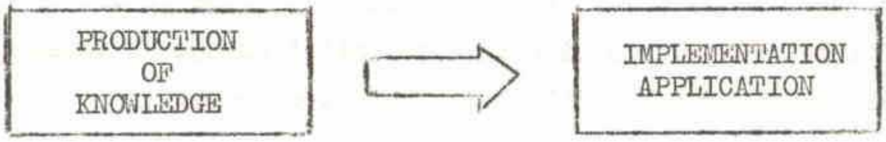
Apart from the above considerations and from more theoretical objections to the somewhat simple evolutionary model of the theory of "finalisation" it is clear that the claims it makes cannot be empirically (or experimentally) validated as long as no criteria for when a scientific discipline is complete - or when it is preparadigmatic - are offered. The question of whether the state of knowledge in a given area or discipline is relevant for the degree of societal knowledge (or R&D) utilisation as considered by the theory of "finalisation" will have to be addressed in a study of the process of societal application of the scientific (R&D) approach.

4. Models of Societal Utilisation of Scientific and Technological Research

The concept of societal utilisation of R&D as outlined in Section 2 was linked to the three-pronged question of societal application of the scientific approach to emerging national (or global) issues and the operating of the respective R&D subsystem and national system involved. Depending on what assumptions are made about the relationship between the stages of such a scientific approach and the systems involved (R&D and national) and depending on the degree to which investigation of these stages and systems is included or excluded from the analysis, different conceptual models of the process of societal utilisation of R&D have been proposed and realised in the past. In the following pages, models of implementation and of transformation will be discussed as being relevant to the alternative proposed subsequently which begins to emerge in the light of recent research and theoretical criticism.

4.1 The model of implementation

The model of implementation is based on the assumption that scientific-technological R&D results are produced in the scientific community independently of their utilisation or their potential applicability and are subsequently "applied" to societal goals and practical problems:



Recurrent explanatory schemes and models concerning the R&D process (production of knowledge) and the process of societal utilisation of research results reflect this assumption. With respect to the former for instance, the criteria which govern the generation and control of findings are thought to be internal to science, i.e. they are thought to be exclusively determined by the knowledge and methodology in a speciality field or discipline. (1) In accordance with an exclusively internal view of research production, only research scientists are granted the right to evaluate the quality of scientific results, and science policy is sometimes called for to protect and secure the autonomy of science from "external" influences and institutions. (2) Not surprisingly, this conception often goes hand in hand with a rigid adherence to the distinction between basic scientific research and applied technological research which is equated with the above dichotomy between production and implementation of knowledge. Thus, there is a tendency to regard technological research as ruled by mechanisms of result-production which differ in principle from those of scientific research, and to consider the latter as a necessary precondition of the former. (3) With regard to the more narrow question of societal utilisation of research results the model of "implementation" conceives of the problem as one of adaptation and

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(1) This conception can be linked to Max Weber's notion of "Wertfreiheit" (value-neutrality) of scientific research according to which the "internal" process of result generation is not influenced by "external" value judgements, etc. However, Weber recognised that the overall research theme can be chosen in accordance with societal needs, which points to the second model outlined below.

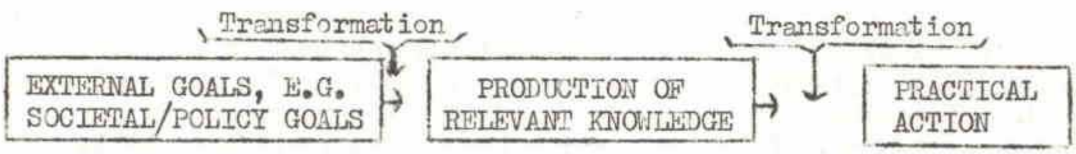
(2) Thus, in a recent article on dominant problems of research policy, one of the tasks of orienting and governing research is defined as follows (Radnitzky 1976:374): "With respect to the evaluation of quality of results, science is autonomous. If one wants scientific progress, one is forced to respect this autonomy. Organisationally this means that the relative independence of research vis-a-vis science-external bodies has to be secured ... It is one of the tasks of rational science policy with respect to orienting science to secure on an organisational level the independence of research from science-external bodies which is necessary to guarantee that the evaluation of the quality of scientific results will be exclusively left to science itself". (Italics and translation from German by the Authors of this paper).

(3) In accordance with such a conception, the previously mentioned study (Radnitzky 1976:383) claims that all important technological innovations originated from previous development in basic sciences - a thesis which in the light of recent historical studies must be regarded as at least controversial (See Stichweh 1977). Furthermore, the author asks that in applied research at least a minimum of "scientific" quality be required, which implies that the criteria and procedures of the applied sciences do not regularly meet the standards of a "science" (375).

adaptability of scientific findings to a practical situation, and identifies the relevant mechanisms as those of communication and application of results. Studies of "implementation" policies, research into the diffusion and adoption of innovations are often based on such a model.(1) The model matches the situation of information in search of a use, equally described as "knowledge-driven" or as one of "knowledge/technology push". There is by now sufficient evidence to suggest that the more effective modes of societal utilisation of R&D must be associated with the opposite situation of demand pull, and must recognise the fact that utilisation is a process which starts before research efforts are initiated and not only after it has been completed.(2) Consequently, predominant conceptions of societal utilisation of R&D substitute a model of interrelation of science and societal practice to the simple scheme of "knowledge-implementation", and they emphasise rather than minimise the role of external influence.

4.2 The model of "transformation"

The model of "transformation" in contrast to the former "implementation" model conceives of the process of societal utilisation of R&D in terms of an input-output model in which some "external" goals are "internalised" and transformed into scientific descriptions of the issues at hand, which are then examined within the R&D system (production of relevant knowledge). The results of the examination are eventually translated back into practical action "external" to the R&D system. In the simplest version of this model, only the relationship between external goals and the production of relevant knowledge is analysed. In the typical case, translation into practical action is given additional attention:



Lazarsfeld describes what he calls the "bare minimum" of the "utilisation cycle" in terms of the above double question of transformation: "How is a practical

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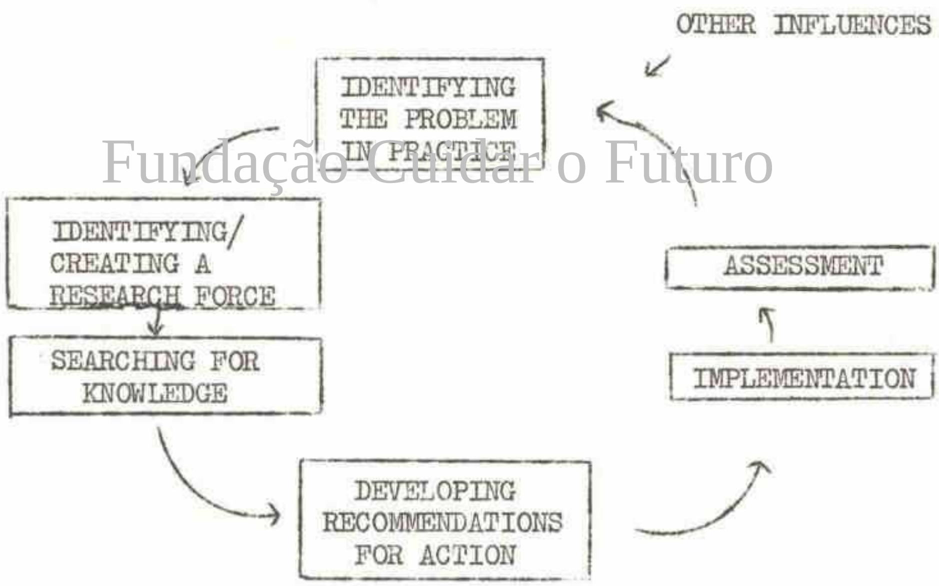
(1) See for example Havelock and Mann (1968) and Havelock (1973).

(2) Evidence comes from the way effective research "utilisation" was achieved during the Second World War when there was a nexus of political, military, industrial and scientific interests. Quantitative evidence is available from studies of successful and unsuccessful innovations on the economic market (e.g. Marquis 1969, Utterback 1974, Gerstenfeld 1976), and from studies tracing the interaction between science and policy which showed identification with a research effort and influence on its conception before the execution of a study to be a good predictor of the degree of utilisation of results (Knorr et al. 1978, ch. 8-12).

problem translated into search for pertinent knowledge?" and "How is the unavoidable gap between knowledge and action bridged by additional considerations so that recommendations can be produced to help with the solution to the problem at hand?" (1) In more elaborated versions of the model, the process is described as follows: (2) "A need or deficiency is recognised; the extent of the problem is assessed and its causes diagnosed; basic or applied research is conducted or retrieved to find ways of ameliorating the problem; technology is invented or improved - either "hard" technology in the form of devices, or "soft" technology in the form of programme and human services; institutions are created or modified to provide the technology or services". In elaborated mappings of the process of utilisation of scientific and technological research in terms of a model of "transformation" the number of steps which surround the linkages between the external world and scientific production of knowledge are increased, and sometimes a self-regulating mechanism is built into the representation: (3)



(1) Cf. Lazarsfeld and Reitz (1975:55).

(2) Cf. Pelz (1977:5).

(3) The scheme is adapted from Lazarsfeld and Reitz (1975:48). For more elaborate schemes of the process see Havelock (1973).

The conception ties in with a producer-consumer model of the relationship between scientists and their political, economic or social counterparts, a model which matches the frequent situation of contract-research from which it seems to originate. (1) Analysis proceeds along distinctions of different roles, concerns and value orientations of producers and customers, distinctions which are restricted to singular characteristics of the social sphere. (2) Phrased differently, emphasis is on the interaction between two systems (the "external", societal, political or economic system of the nation concerned and the "internal" R&D system of science and technology) whose modes of operation and production (decisions in the political system and discoveries or inventions in the case of R&D) are not themselves made part of the analysis. Despite the fact that external influence on R&D is recognised (through societal goals or practical problems demanding an answer from scientific and technological research), the question of how external variables materialise in R&D - the very question of "transformation" - is not in itself investigated. (3) This "black-boxism" (4) with regard to the production of knowledge can be associated with the separation between economic production of goods and their circulation which is characteristic of many

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(1) Lazarsfeld, for instance, had a vital interest in government and other "clients", and many of his own research efforts were carried out under contract.

(2) The most prominent of these characteristics are norms and value orientations. They can be traced back to Merton's influential work on norms and values conducive to science (originally 1942, see 1968, ch. 17-21). Differences in value orientation between scientists and other workers are often cited in research on scientists in industry or other non-professional organisations, together with problems of adaptation and resistance to organisational requirements. See for example Scott (1966).

(3) This has to do with the fact that the up-to-recently dominant functionalist approach to science studies defined its topic as the social system of science and its functional mechanisms of internal organisation and control, thus excluding cognitive processes of research production and external factors as more or less irrelevant. It was only after Kuhn's theory (1962, 1970) had been absorbed, and mostly in European studies of science, that a redefinition of the study of science occurred which considered cognitive and external variables as of vital interest.

(4) See Whitley (1972).

modern societies. (1) It marked not only research into the question of societal utilisation of R&D, but social studies of science in general up to very recently. (2) Needless to say, this black-boxism will have to be overcome if genuine insights into how societal utilisation of R&D has worked - and may work in future - are to be gained.

4.3 A proposed alternative : the model of "societal utilisation" of R&D

The authors propose as a working framework for the study of the societal utilisation of R&D an alternative model, based on some relevant conceptual approaches appearing in the literature. The transition between the model of "Transformation" and what could be called the model of "societal utilisation" is marked by recent conceptions in which the interaction between external societal factors such as societal needs and wants, and the national R&D system (factors internal to the production of knowledge) is made the focus of study in its own right. (3) According to these conceptions, external goals are transmitted into R&D through principles and directives which orient national development, i.e. principles which determine the extrinsic objectives of R&D, the criteria for evaluating the successfulness of R&D efforts, and what counts as a "solution". More concretely, there is a transformation of societal goals into R&D policy programmes and budgets, and finally into projects on the side of the societal system which is matched by a similar transformation on the side of the R&D system. Here, relevance criteria deriving from societal goals are concretised in terms of directives for research-orientation (R&D objectives) and for the allocation of R&D resources; and finally into guidance for overall scientific/technological development. (4)

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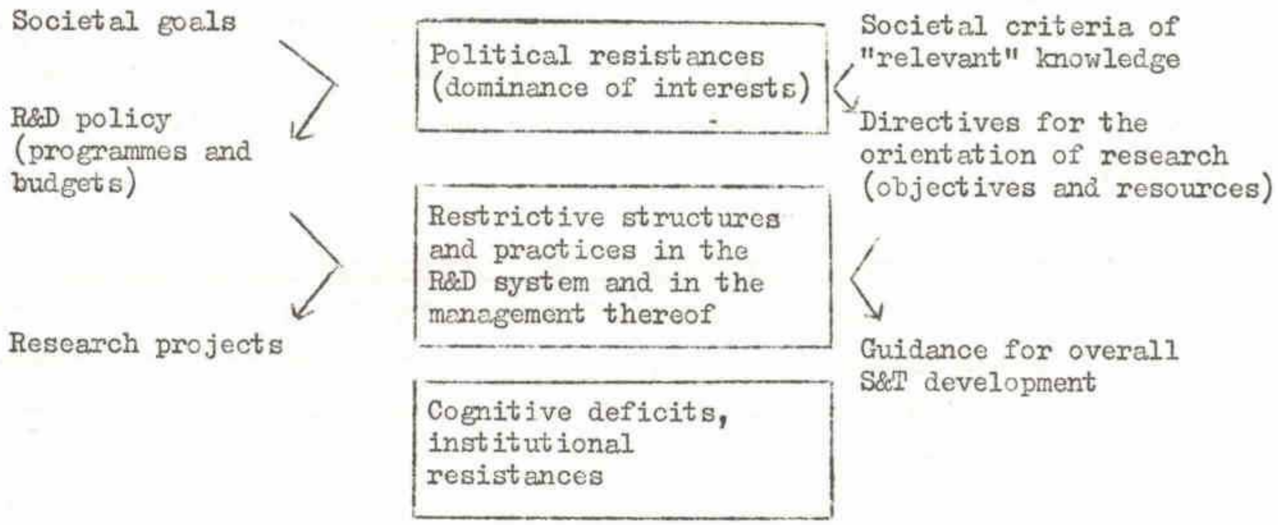
(1) Luhman associated the assumption that knowledge is applied after it has been created independently the distance between economic production and distribution in bourgeois economy (1977:24). It appears that the argument holds more generally for the tendency to conceive of external and internal, social and cognitive variables as operating independently and separately.

(2) In programmatic form, the criticism of black-boxism appears first in the literature of the early seventies, e.g. in Whitley 1971 and Weingart 1972.

(3) Cf. Küppers and Weingart 1977, Weingart (1976), ch. 1, and Y. de Hemptinne, 1972 (Document UNESCO/NS/ROU/234).

(4) The following figure is derived from the scheme offered by Küppers in a recent presentation of a paper on the issue. See Küppers and Weingart 1977, p.2 ff.



In contrast to previously mentioned conceptions, the "societal utilisation model" includes, inter alia, "an analysis of the R&D system at the level of system requirements, and of the processes of institutionalisation. Differentiation into scientific fields and institutional resistances are thought to systematically relate to the cognitive (scientific) development of knowledge in a given area. With respect to the performance of R&D, no differences between "basic" and "applied" research are postulated, a hypothesis supported by historical data mentioned before.

The "societal utilisation" model thus theoretically attacks the problem of the black box of "research activity" as such (performance or execution of R&D), yet it does so by defining its project in terms of the distinction between social and cognitive, internal and external variables of the R&D activity proper; this, in itself, obviously needs empirical support and increased theoretical justification. According to what was said in the paragraph on scientific fields, the concept of scientific competence conveys at the same time connotations of social authority. Thus, cognitive approaches and attitudes within scientific research must be seen at the same time as social strategies within the competitive struggle of the scientists and institutions active in a certain field or discipline. (1) In addition, evidence emerging from observational studies of certain scientific laboratories suggest that there is no core of internal "scientific" decisions about R&D which could in principle be exempted from societal (or external) considerations. (2) It also seems that selections made "a priori" between alternative approaches do not unequivocally determine procedures which follow later on in the research process.

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(1) Cf. Bourdieu (1975) and the studies cited below.

(2) Cf. Latour and Woolgar (1978); Knorr (1977).

With regard to the above conception this means that one cannot expect to identify a hierarchy of decision criteria which can be partitioned exclusively according to the cognitive-societal and internal-external dichotomies and which would definitely specify the process underlying the question of research. Rather, one might have to associate different kinds of scientific products (such as a gas law or a method of protein separation) with various modes of carrying out research in different *contexts* (defined as cognitive and social) and at the same time with *societal goals*, which cannot be reduced to a simple set of parameters whatever their range and generality. Defining a "context" or a "field" should allow for the *indeterminacy* of individual research-decisions which one encounters in the laboratory. In addition, it should allow for the "*generativity*" of scientific action in the sense that choices are not made under external constraint (i.e. restricted by some set of criteria), but that they are also generated in the process of doing research.

Societal utilisation of R&D is thus understood as the production of research results in a context which is at least partly determined by the conditions governing prevailing scientific practices. Since science proceeds by intentional change, it may be useful to conceive of this context as constantly fostering *differences* to occur between what is the case and what appears to be possible. The creation of a scientific fact that has practical relevance can be equated to the realisation of some such possibilities. The difference produced by the emergence of a new scientific fact in the prevailing contextual situation determines the value of the finding and measures the change of state of the context or field. Differentiation and institutionalisation of contexts - in science marked by the emergence of professional associations, if specialised journals, of positions, etc. - must be associated with selective change of state in a scientific/technological field. Some of our knowledge and intuitions with regard to the characteristics of these contexts in academic research have been discussed above, but clearly more will have to be said about them.

Let us dwell, for a moment, on the fact that the models outlined above not only exist in the form of implicit or explicit conceptions (models) of the process of societal utilisation of R&D which underlie publications or the discipline in the relevant literature; they also exist in the societal *practices* concerning R&D. Thus the idea of putting existing scientific knowledge to some practical use - for which it had (or had not) been specifically developed - without a definite connection with those concerned by the findings, has led to many efforts toward societal utilisation of R&D; (1) and the procedure underlying the second model described above can be observed in most cases where research is carried out on a customer/contractor basis. Depending on the interests and awareness of producers and customers of R&D results, various degrees of elaboration and sophistication of procedures will be observed. (2) Finally, it seems that the model of "societal utilisation" was present in the case of the (partly basic!) military research during the Second World War where, according to available data, the integration of political, industrial and scientific efforts cannot be captured in terms of input-output models. (3) The same model also adequately describes the current situation in many technological fields. In the latter case it can be easily made apparent that more than one kind of utilisation may be present simultaneously. Thus phenomena of institutionalisation in a technological speciality may increase the distance to actual practical needs, say in an industrial enterprise, and give rise to the same kind of gaps encountered in contract research projects concerning the social sciences.

It may be tempting to associate different historical epochs with the predominance of one or the other of these modes of application of research results. Thus the model of "implementation" and the attempt to draw a rigid distinction between basic and applied research in terms of the motivation of researchers and of their management, design and execution, or of the practical significance of the results obtained, might be related to the "ivory tower" situation which appears to have characterised much of scientific life up to the Second World War. In contrast, the model of "transformation" seems to capture

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(1) The "Research and Development Laboratory Management Knowledge Utilisation Study" done at CRUSK (Havelock and Mann 1968) investigates this mode of utilisation.

(2) For example, the data of Caplan (1975) on the political utilisation of social science reflect such a model. For a general discussion of the increasing use of contract research in daily practice see Radnitzky and Anderson (1970).

(3) See Hirsch (1971:241 ff).

the spirit of increasing instrumentalisation of R&D for economic, political or social goals as mediated by the policy system, i.e. by science and technology policy since the Second World War. There was, for sure, instrumentalisation before that time, but it had mainly occurred at the level of the industrial enterprise. (1) As implied earlier, all three modes of utilisation of R&D are currently applied to various degrees in different practical situations; yet not all three modes are equally effective modes of utilisation. It is likely that some mode of re-contextualisation operates in cases of highly effective societal utilisation of R&D, and that it will be imperative to reach an understanding of this process, if societal utilisation of knowledge is to be improved at all. It will be argued below in more detail that a thorough understanding of the concrete societal decision-making mechanisms, as well as the relevant political context which carries through the societal utilisation of knowledge, will also be necessary. It was previously suggested that the study of existing modes of societal application of the scientific approach will have to be supplemented by an analysis of the ethical-normative aspects of such application, and this refers to both, the what and the how involved in the utilisation of new knowledge, i.e. it refers to the desired goals as well as to the modalities of application. In the following discussion of societal aspects of R&D utilisation, the development of an awareness of this normativity will be traced as it can be observed today, and its implications spelled out for a study on the societal utilisation of R&D.

5. Societal Aspects of Utilisation of R&D

5.1 The interrelationship of science and society

The discussion and implications of the model of societal utilisation of R&D presented in Section 4.3 can now be expanded from the complementary perspective of society. Although so-called "externalist" orientations of national R&D systems are gaining ground even among non-Marxist scholars interested in the science of science, theoretical and empirical analyses focus primarily on the factors extrinsic to science which determine or influence the orientations of scientific development, the setting of problems, or the objectives of research.(2)

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(1) For an overview of this development and a tentative assessment of the future situation see Salomon (1976).

(2) For a recent review of the emergence of "externalist" approaches see S. Blume (1977).

As such, although "society" has now been admitted into the analytic picture, the focus in market economy countries is still mostly on one-way relationships between R&D and Government (or between science and society) primarily from the perspective of the implied consequences on science and scientific researchers. Alternatively, scholarly interests in the changing role and effects of science on society have been mainly pursued in the tradition of macro-societal and economic analyses, which in turn tend to largely ignore the role played by the internal structures of science and of national R&D systems as such. (1) Parly because of the slow convergence of these alternative approaches, explicit studies on the feedback relationships between R&D results and the structures, processes and mechanisms of actual societal utilisation thereof have been rather limited. The relative scarcity of research in this area is undoubtedly also partly due to the fairly recent emergence of public concern with the broader societal usefulness of scientific and technological research.*

From a societal perspective, science, technology and the related R&D can be viewed in different ways: as a social process, a social product, a powerful factor of socio-economic development and progress, etc. Science can be also seen as a historically determined social phenomenon rooted in the way of life of societies, and a conditioning factor of their well-being. As such scientific and technological research is intimately interrelated with the production of goods and services on the one hand, and with the value system and economic and political organisation of a given society on the other. (2) Moreover, the more recent history of the interaction between science and society shows that R&D has become closely and rapidly interrelated with technological advances in production. The results obtained in basic research are becoming rapidly transformed into products, processes and technical devices, and immediately channeled into productive enterprises. For example, scientific knowledge is increasingly used not only in designing machines, synthetic chemicals, etc., but for the designing of production processes as a whole in pilot plants, which allows for subsequent direct and immediate application as a single turnkey "package". Interaction

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(1) Extreme examples of this approach make even basic-applied science distinctions exclusively in terms of relations to production; see Stölting (1974).

* In short, the "usefulness of science".

(2) See e.g. Berka (1977).

between R&D teams and the productive enterprises has become more rapid and continuous. Elaborate technologies are developed — including information technology — to coordinate extremely complex organisational and science-based industrial processes. (1) In other words, one speaks increasingly of the "scientific-technological revolution" wherein R&D has come to be viewed as an intrinsic part of a country's production force. (2) The accelerated rate of interaction between R&D and society on the one hand, and the rapid quantitative and qualitative developments in science and technology itself, on the other, have resulted in the fact that today R&D intensively absorbs society's human, financial and material resources. Thus the growing expenditures involved in the production of knowledge have greatly stimulated external interests in the orientations of scientific and technological research. The growing concerns with the allocation of scarce resources has brought to the foreground the economic profitability of investments into science. Scientific and technological research became increasingly conceived in terms of "consumption" versus "investment". (3)

In the more advanced societies, until the 1960's, societal efforts — articulated through policy structures — primarily focused on attempts to determine science's contribution to the growth of the Gross National Product and on giving the priority to branches of knowledge and spheres of research that can relatively quickly yield large economic returns. (4) However, as was pointed out in the "Introduction", in the 1960's there came a change in the attitudes both within the scientific community and in society in general. There arose a growing awareness of the fact that although science is a significant factor in the development of production, the measure of the need for science only partially depends on the solution of current production problems, and to a much larger extent on society's long-term aims. Scientific and technological research began to be perceived by some as a "tertiary industry" whose operations are to be directed to a variety of societal needs. (5)

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(1) For a summary of some characteristics of science-based production and its implications, see Bodington (1977). For discussions of the concept of scientific-technological revolution, see e.g. Richta (1969) Man, Science and technology (1973), Afanasyev (1975).

(2) Obviously scientific results are utilised increasingly also in other societal sectors, besides material production. Examples of utilisation of science, in the so-called non-productive sector are the applications of medical sciences to the development of health services, the utilisation of social sciences in the development of social indicators and the planning of educational systems, of juridical sciences in state administrative machinery, etc.

(3) See, Shils (1968).

(4) See, Ben David (1962), Denison (1967).

(5) Toulmin (1966).

At the same time voices of warning began to be heard about how the concentration of scientific and technological research on short-term, narrowly defined positive effects may give rise to serious negative or possibly even catastrophic side effects. (1)

5.2 Reorientation of societal expectations from science and technology

The place of science in the human world has been a question occupying mankind for a long time. Already in 1919, Max Weber was concerned with the discrepancy between modern scientific orientations and the sphere of other human values. In his essay on science as a professional occupation he pointed out that the fate of our times is characterised by rationalisation and intellectualisation, and above all, by the disenchantment of the world. (2) The accelerated developments in science and technology and some of their ill-fated consequences in more recent times have made the role of science (in fact, of R&D) an increasingly commonly voiced problem. Especially during the last two decades the ability of scientific and technological research to cope with the long-term basic problems faced by mankind became increasingly questioned. With the growing crisis faced by many advanced societies, on the one hand, and with the increasing economic and social discrepancies between the developed and developing countries of the world, on the other, the optimism of the so-called "economic growth era" became replaced in some quarters by pessimistic disillusion. In the western world, this was channeled into "anti-science" movements. The "counterculture" critics of science and technology have spoken out against "the technological society" and the "mechanistic imperative" to "apply every piece of knowledge in every possible way, whether or not its applications are health-giving for human beings, or preservative of the non-human world in which we have to live". (3)

The uneasiness which manifested itself in some countries during the 1960's and which found expression in blaming the rapid progress of science and technology for creating a world that can no longer perform its basic functions gave way to more rational analyses. There came a growing awareness of the fact that the problem lies in another direction, i.e. in the inadequate dynamic application of the potential of science and technology. (4)

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(1) These concerns became "formally" expressed e.g. in the 1971 OECD Report: Science, Growth and Society, ed. by H. Brooks.

(2) Wissenschaft als Beruf (1922).

(3) Needham (1976). For the antiscience and counterculture movement see e.g. S. Cotgrove, "Anti-Science", New Scientist (1973) and T. Roszak, The Making of a Counter-Culture (1971) and Where the Wasteland Ends (1972).

(4) Richta (1977).

There consequently arose a gradual change in societal attitude towards science, technology and their potential impacts on the life of man. Science and technology policy structures began to pay more systematic attention to the fact that policy decisions must go beyond assessments of science's contribution to the attainment of immediate economic profitability and strive towards examination of the extent to which R&D in science and technology fulfills more complex social functions. The role of science and technology began to be reconceptualised in terms of their contribution to the solution of urgent societal problems with due respect of the principles governing the conservation and rational use of nature and of its resources.

5.3 Values and goals in science policy decisions

Worldwide recognition of the societal role of R&D in science and technology has brought a new emphasis in evaluating the claims of research and on the question of how to efficiently direct R&D and the application of existing scientific and technological knowledge to desired ends. The notion of "desired ends" already implicitly contains the assumption that societal goals and ways of utilising scientific and technological research are as such important in their social and human consequences, and that these "desired ends" cannot be inferred from science/technology itself. It therefore follows that any in vivo evaluation of the societal utilisation of R&D is ultimately and essentially normative.

Although the notion of "societal goals" is essential to any analysis of societal utilisation of R&D, a precise definition of such goals is difficult to agree upon. From the point of view of societal expectations placed upon science and technology, goals may be defined as "over-arching objectives or ends, which serve in part to direct one or more field of research, and of which individual, or groups of scientists, need not be explicitly aware". (1) Such goals are established usually as a result of a complex set of social and political processes (such as planning and budgeting for science and technology) which involve dynamic interaction between interest groups and actors that may - or may not - include also direct scientific interests. For example, van den Daele, et al. have extensively shown the varying degrees of determination by societal and scientific authorities involved in the establishment or "transformation of political into scientific goals". (2)

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(1) This definition is adopted from the one used by R. Johnston and T. Jagtenberg (1977).

(2) Van den Daele, et al. (1977).

However, the precise content and processes and mechanisms in the establishment of goals are a function of the prevailing social relations, and as such need to be determined by concrete studies. Some of the most striking illustrations of the process of goal determination can be seen e.g. from studies of the Manhattan Project, [(1)] the Apollo Mission, [(2)] or the US Cancer Programme. [(3)]

New goals may arise for a variety of reasons. The perception and normative definition of a societal problem that requires scientific "solutions" may come from a variety of sources within any given society. An awareness or formulation of a problem may come from the sphere of the institutionalised political or governmental structure (e.g. administration), some part of the organised public realm (e.g. trade unions), the more diffuse and less institutionalised sectors of society (e.g. "the public"), or even from the sphere of R&D itself. [(4)] From a more international perspective, societal goals of science and technology may arise from a shift in the structural interdependencies among countries or regions of the world (e.g. The Third World), or from an international awareness of issues of global concern to humanity (e.g. the environmental crisis, earthquake prediction, drought or famine forecasting, etc).

One fundamental aspect of the understanding of the processes of societal utilisation of science and technology thus involves the identification of the relevant goals as they find expression in the formal "ideology" underlying science and technology policies. While the ideology may not be formally stated as such, it is reflected in the viewpoints and arguments on how science and technology interact with society, how the current state of that interaction is defined, what national importance is given to the development of R&D, what the relative importance is of various branches of science or technology for the achievement of national/societal goals, and what should be done to foster various kinds of research activity. [(5)]

Once formulated, goals are then mediated through different scientific, socio-economic and political considerations that may be expressed at varying levels of generality. The transformation of societal goals into research goals, what has also been called the "politisation of research" may be determined by a variety of societal factors. Dominant and possibly conflicting interest and value orientations may act as structural constraints that selectively determine which societal

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(1) See, e.g. Groueff (1976).

(2) See, e.g. Etzioni (1964).

(3) See, e.g. Goodfield (1975).

(4) See, Weingart (1977).

(5) See, e.g. Gibbons (1972).

goals can be transformed into research goals. In the presence of conflicting interests, the transformation of societal problems into research goals may reflect only an artificial solution to reduce or avoid societal or political conflict without real expectations for potential solutions of problems. (1) As such, not only the pronounced "official" goals, but the mechanisms, structural context and dynamics of the transformation of societal goals into actual research plans, budgets, programmes and projects need to be extensively analysed. (2)

In short, at the societal initiation end of the "utilisation cycle", the processes of the establishment of goals, their content, and their mediation into research programmes need to be understood in real-life societal contexts in order to isolate the factors that determine the success or failure of societal needs and objectives to find expression in scientific or technological research.

5.4 Societally beneficial utilisation of R&D results

A critical scrutiny of the criteria used in decisions regarding scientific-technological solutions to societally relevant problems, implies going beyond analyses of the societal direction of research, realisation of goals in the research process, and the subsequent scientific results, to issues of the practical application (utilisation) of the research results in a societally beneficial way.

It has often been pointed out that the formal links between societal decision-making structures and scientific research present a variety of unresolved problems in organisation and communication. So far satisfactory methods of feeding societal needs and wants into the R&D decision-making processes have been far from sufficiently elaborated and political leaders or decision-makers "continue to feel that their concerns are insufficiently recognised by scientists". (3) (The opposite is also true). Conversely the relations, mechanisms and existing structures for transmission (and often translation) of research results from the knowledge producers to the users of scientific knowledge is also an aspect of the problem of societal utilisation of R&D that calls for systematic study. In this context considerably greater attention needs to be paid to the potentials and

(1) As was shown in Section 3 of this paper, similar constraints may come from the science system itself.

(2) See Unesco with the collaboration of R. Zeida and C. Maestre.

(3) Dahrendorf (1977), p. 79.

implications of various types of "activist" feedback alternatives and the creation of appropriate channels for them. (1)

Organisational constraints and communication barriers are some of the manifestations of the problem of societal utilisation of R&D. However, a critical approach can no longer take the formal pronouncements of the policy structure at its face value, no more than one can take the "value-free" theory of science for granted. One must also go beyond the overt objectives of the societal decision-making structures to the potential or latent intentions of initiating "societally relevant" research programmes. For example, when the political structure defines a certain type of research as a legitimate societal goal and accordingly supports corresponding research programmes, it happens that research is being supported under these covert goals for other purposes, too. Thus, research programmes may be initiated not for the expected utilisation of the actual results but for the side effects such programmes may have, e.g. for economic development, increase in the qualification of manpower, or from an international perspective — to promote certain political or economic policies. Alternatively, the underlying purpose may be "legitimation", i.e. where science is called upon to give greater credibility and power of conviction to political decisions. (2) For example, research programmes may be supported to demonstrate that "something is being done about the problem". Of course all these examples are illustrations of "utilisation of R&D" in some sense or other that cannot be overlooked in analyses of actual (or potential) sources of failure of "societal utilisation" of R&D' stricto sensu as is proposed in this paper. In the above discussion the focus was on the absence of "real" utilisation of R&D results, as a consequence of using research in ways other than the explicitly formulated purpose. One must, however, also consider purposeful non-utilisation. Scientific or technological results — new knowledge — may also turn against the expected "legitimation" or be contrary to the interests of existing power structures. If such new knowledge is made available to the public (or to conflicting interest groups) it may have a "delegitimising" effect on the

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(1) On activist feedback see Pelz (1977), Havelock (1968) and the forthcoming "Guidebook of Survey Research Techniques as Applied to the International Comparative Study on the Organisation and Performance of Research Units" to appear in 1978 in the Unesco series "Science Policy Studies and Documents". The notion of "activist" feedback refers to the active role taken by scientists in promoting the utilisation of their research results.

(2) Weingart calls this the "legitimation purpose" type of societal utilisation of R&D. Weingart (1977).

existing decision-making structure and thereby call into question existing social relations.[1] In the international context one hardly needs to search for examples of selective use or availability of "knowledge" in order to maintain the status quo (for example, the alleged destruction of the "ozone-layer" by the supersonic plance Concorde).

This brings us to the final and most problematic question of societal utilisation of scientific and technological research: <u>for whom is societally relevant research useful</u>? Obviously the term "society" in the foregoing discussion of "societal goals" and "societal utilisation" implies a broader concept of "mankind", "the people" or total populations, both from a national and an international perspective. The extent to which choices about the purposes and intentions for which scientific results are utilised, can be clearly formulated by broad segments of the local or international human community is, however, an open question depending, inter alia, on prevailing and international social relations. This ultimate question of what are the social or international relations that provide an adequate basis for the utilisation of the achievements of science and technology is necessarily beyond the subject of the present paper. The problem can, however, be restated by attempting to define the domains where the societal consequences of research may be the broadest and most significant for the material and spiritual welfare of peoples, and can even decisively determine the destiny of mankind.

6. Global Problems of Societal Relevance and Relevant Research Areas

Obviously it is not possible, and — as will be argued in the next sections — hardly desirable to reach an agreement on all specific problem areas where the societal utilisation of R&D needs attention. As a starting point, however, one can point to some global problems that may be formulated in different forms, depending on the concrete historical context of given societies, but can be said to be of universal concern to all mankind. From a societal point of view these universal concerns can be defined in terms of <u>homeostasis</u>, i.e. the ways in which human beings and societies can regulate and stabilise their living conditions (physical, physiological, psychological, social etc.) so as to make their existence both possible and acceptable. Such conditions are imperative for people to be able to live and develop themselves. Even though the most common and obvious criteria for homeostasis is that of biological necessity, the conditions involved are not only - nor simply - biological.

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(1) See, e.g. Van den Daele, et al. (1977).

And although the origin of the concept is linked with actual biological processes, homeostasis can be considered as a function of society. (1) This social quality of homeostasis is aptly expressed as "course of life" needs — i.e. needs for living in a certain manner. (2)

Although there are different views about which criteria should be used in defining basic conditions for societal homeostasis, the underlying principle in general is that they are connected with the more general notion of welfare. (3) It is primarily in connection with concern about welfare in general and its operationalisation in "level of living" measurements that various organs of the United Nations (especially UNSRID) (4) have evolved a theory based on the idea that men have rather unchanging, general and similar homeostasis patterns. The emphasis in this approach is on international comparability while at the same time it recognises that comparability does not necessarily require complete equality of the homeostatic conditions, but only that those conditions should vary between nations in a known fashion. (5) In the work of UNRISD the level-of-living concepts were explicitly elaborated with reference to the level of satisfaction of needs and wants and of the corresponding component areas thereof;
(a) Physical areas, which include food, housing, health. (b) Cultural areas, which include education, leisure, recreation and security. (6) Although the delineation of these areas has undergone a number of modifications, the central basic components that have remained during the various phases of development were nutrition, housing, health, and education. Today it is generally agreed that concerted efforts to create homeostatic conditions in these areas is both a national and international obligation of all societies. Conversely, it can also be said that the satisfaction of (or the elimination of existing threats to) these principal components of social homeostasis constitutes a major global problem of mankind.

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(1) See, e.g. Etzioni (1968).

(2) Braybrooke (1968).

(3) For a thorough discussion of different approaches to definitions of basic needs, see Roos (1973). The concept of homeostasis is wider and more dynamic than the rather static concept of basic needs.

(4) United Nations Research Institute for Social Development.

(5) Report on International Definition and Measurement of Standards and Levels of Living (1954), p.6.

(6) Drenowski & Scott (1966) pp. 13-14.

From the point of view of societal utilisation of science and technology it thus seems that the most urgent issues of effective utilisation concern those research areas or disciplinary domains that can most immediately contribute to the solution of these global problems related to societal homeostasis. These most central impending global problems that require massive research have also been often expressed in terms of the following four "challenges": (1)

1. The population challenge - implying the need for medical and pharmaceutical research for raising health standards, the need for agricultural and related research oriented towards problems of nutrition.
2. The energy challenge - implying the need for research into post - fission nuclear resources and non-conventional renewable sources of energy.
3. The environment challenge - implying the need for development of scientific-technological domains oriented to the development of economical methods of environmental protection.
4. The nuclear challenge - implying the need for research on reactor safety, nuclear waste disposal, and on the geography and economy of the exploitation of nuclear resources.

Similarly in many of the relevant research domains mentioned above, not only greater efforts could be made to channel research to meet the above "challenges", but also there is a need to redirect current paths of development from areas where utilisation has the potential for seriously threatening the homeostasis - or even survival - of mankind as a whole.

Furthermore, the devastating possibilities of nuclear weapons are known to everyone. Mathematical engineering has developed vast computers whose information storage and retrieval capacity has a wide range of significant applications, but at the same time contains the potential of endangering the privacy of individuals. While the potential societal contributions of biology, biochemistry, etc. hardly need to be emphasised, the hazards of biological engineering have been drawn to the attention of the public by the self-imposed moratorium of research scientists which discontinued for a while certain types of genetic experiments.

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(1) See, e.g. Dahrendorf (1977), "Science and Current Global Problems" (1975).

The overriding importance of medical research, too, often pushes to the background the important ethical issues involved in many research areas, such as e.g. those related to transplantations, embryology, and treatment techniques. (1)

In view of what has been said above, it thus seems that one approach, both theoretically and practically justifiable, to the study of societal utilisation of science and technology is to focus on areas crucial to societal homeostasis. Obviously the magnitude of the societal problems, or the urgency of the "challenges" varies from one country to another, and there are undoubtedly also corresponding differences in the research efforts devoted to the various areas. Obviously nutrition and health are currently more universal problems, and of great concern particularly to the nations of the Third World, while the nuclear challenge (from a non-military perspective) as well as the waste disposal and environmental control challenges, are for the moment of more immediate concern to the more industrialised nations. On the other hand, all of these problems relate to all segments of the population within the context of any given country, and the efforts devoted to their solutions as well as the "outcomes" have ultimately implications for the entire international community.

7. International Problems and National Solutions

7.1 The interdependency of societal systems and it's bearing on the question of utilisation of science and technology (R&D)

The global problems of mankind discussed in the previous section underscore the world-wide, international character of the development of present-day science and technology. It is also obvious that the solution of global problems requires the cooperation among many scientific and technological disciplines, the alliance between science, technology and praxis, and interactions between economics and politics. The internationality of certain major societal problems, the internationality of the interdependence of science, technology and society, as well as the international character of the institution of science and of the scientific community as such, all imply that the approach to the study of societal utilisation of R&D should be an international one.

This emphasis on internationality does not mean that very significant differences between countries, regions of the world, or social systems must not be given full recognition. After two centuries of industrial revolution the map of the world shows two types of nations, the so-called developed and the developing — or, bluntly put, the rich and the poor.

(1) For discussions and examples of societal "misutilisation" of science, see, e.g. Needham (1976), Rose and Rose (1976), Enzensburger (1976).

The consequences of the international interdependence in the field of science and technology between the developed and developing countries deserve special attention and should be taken into account with respect to the model proposed in Section 4.3.

The development of science in the developed countries in the past two hundred years is characterised by an approximately exponential rate of growth in the content of scientific knowledge and in the number of scientific personnel.(1) The widespread development of science and technology has markedly transformed the material conditions of life of the peoples of the advanced countries. At the same time the growing disparity in the standard of living in the more economically advanced and the developing countries can be at least partly accounted for by the rapid developments in science and technology in the case of the former. It has been said that in science and technology lies the key to wealth. One can also say that the more advanced countries in general also kept a tight rein on this key. As such, the more advanced countries are to a considerable extent also directing the science and technology of the developing countries.

The role of science and technology in the Third World has only begun to be questioned during the last decades. Today there is a growing awareness that the concentration of science and technology in the more advanced countries seriously affects the position of the developing countries in the world economy. Owing to the historical dependence of the scientists and scientific institutions in the developing countries on those of the developed nations, the role of scientists in the developing countries tends to be marginalised and their scientific and technological goals are alienated from the fundamental needs of production in their own society. (2) While this is partly a reflection of the broader structural dependencies between the more and less economically developed countries, part of the blame must also rest with the international scientific community.

Scientists of advanced societies have been sharply criticised for their prevalent attitude in training scientists from the developing countries by associating them with problems on which they themselves are currently working.

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(1) See, e.g. Price (1961).

(2) Singh, (1977), Rahman (1975), Cooper (1973).

After returning home, trainees usually continue to consider the scientific discipline of their training as their relevant "field", and continue to work on the "foreign" problems because of the prestige imposed by the science of the advanced countries. (1) Thus scientists and science in the developing countries remain linked with the system of science and technology in the developed world whose functional needs and homeostatic conditions are of a different order. On the other hand results of research carried out in the developed countries regarding problems relevant to the developing countries are not adequately transferred or shared. For example, a Norwegian survey of research projects relevant to the developing countries found that for about 40% of the ongoing projects no plans existed for transfer of results to the developing countries concerned. (2)

The problems of the prevailing practices of technology transfer are also receiving increasing attention. (3) The many adverse effects of scientific and technological dependency are well known, and as such can be here only briefly reiterated.

Technological monopolies undoubtedly form one of the central problems. The possession of unique technologies confers monopolistic advantages on the private sector, commonly represented by transnational corporations, where adequate control over the use and adaptation of the technology by the "host country" is often not obtained.

Moreover, the research undertaken by transnational enterprises is highly centralised in the advanced countries, often in the headquarters of the corporations. This implies that the learning effects of research, "learning by doing", are rather limited in the host country. Thus the potentials for building up local innovative capabilities that could be oriented toward more appropriate technologies are further limited.

The technologies transferred are often inappropriate for the "receiving" country. Entrepreneurs are interested in new products precisely because they are a source of quasi-monopolies. This places a strong emphasis on such new product-creating technologies that may be often less optimal from a societal point of view. Not only may these types of transferred technologies focus on "inappropriate" products from the point of view of societal relevance, but are also generally designed to meet the requirements of high-income consumers and as such promote values conducive to even greater social inequalities.

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(1) Rahman (1975).

(2) Researching Relevant to the Developing Countries (1975).

(3) See, e.g. Employment, Growth and Basic Needs (1976); Science and the Future of Man in European Society (1976).

Technology is also often transferred without regard to the socio-economic structure of the receiving countries. The technology transferred by the more advanced countries is almost by definition capital intensive, whereas in terms of the relative availabilities of capital/labour, the less advanced countries would perhaps require labour intensive techniques in some economic sectors. Thus the adoption of inappropriate technologies not only has low societal relevance, but may also have such negative social consequences as unemployment and maldistribution of income. One dramatic example of this can be seen in the case of the "Green Revolution". (1)

Not only is the direct transfer of technology of advanced societies advocated for the developing countries, but it is also sometimes assumed that the scientific infrastructure and scientific "culture" models in current practice in the more advanced societies are of universal validity. In the name of assumed cultural and institutional obstacles to the development of science in the developing countries, the models of development, organisation and institutionalisation of the science base prevalent in highly industrialised countries are sometimes urged upon the developing countries regardless of variations in the cultural, traditional or structural needs and resources. (2) The automatic transplantation of science organisation models - which Unesco carefully shuns - implies, among other things, that the same values, goals, and problem orientations embedded in the prototype infrastructure are also imposed. (3) This may be one of the contributing factors that draws the developing countries - sometimes at their own request - further into the international system both normatively and often also economically.

In the above discussion of science and technology problems within an international context the emphasis was put upon the so-called developing countries, following the traditional division of the world into a dichotomy which is highly artificial and grossly underrates the existing heterogeniety with respect to socio-economic and scientific-technological resources and types of social systems prevailing among the developing countries. Of course, the same might be said about those nations that are thus classed in the "developed" category. The focus on the developing countries here is simply to illustrate the relevance of international socio-economic, political and scientific-technological interdependencies for the societal utilisation of R&D, with examples where the consequences can be

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(1) See, e.g. The Third World and Scientific and Technological Progress (1976).

(2) See, e.g. Herrera (1973, Ramasubban (1977).

(3) For a case study that serves as a good example, see Hill (1977).

seen in the most extreme and concrete forms. Obviously many of the problems, mechanisms and consequences of scientific-technological dependency vis-a-vis the dominant international system are not to an equal extent characteristic of all the developing countries. On the other hand, neither are e.g. the problems of technological transfer and transnational corporations unique to the so-called developing countries. To various degrees, some of the issues here discussed are applicable also to the so-called advanced countries with different levels of socio-economic, scientific-technological resources or levels of science-base development. As such, the simple developed developing dichotomy tends to divert attention from the potential relevance for the societal utilisation of R&D within a broader spectrum of the countries. In this respect, it seems that it would be analytically more fruitful and appropriate to conceptualise the international community in terms of a firstcomers-latecomers continuum reflecting the historical development of science and technology of given societies. (1)

7.2 National alternatives: the concept of "ethnoscience"

The theme developed in the foregoing section has the obvious implication that, along with international aspects, an equally strong recognition needs to be given to the concrete, unique societal contexts wherein the interaction between societal factors and science and technology takes place. Within the international community two strategies of science and technology development may be defined: imitation by adaptive transfer and that of endogenous development based mainly on self-reliance. The former lays stress on maximum importation of exogenous technology and science, while the latter consciously utilises both (appropriate) foreign and indigenous science and technology. (2) For reasons outlined in the previous section, the imitation model of science and technology development may be one of the significant factors hindering effective societal utilisation of research results. As such, the potentials of the self-reliant endogenous model needs to be more systematically explored.

The strategy of self-reliant endogenous development in science and technology brings to the fore the potentials of ethnoscience. The idea of ethnoscience has been introduced in connection with approaches that concentrate on development of technologies that are best suited to a given natural and societal environment. (3)

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(1) Tsurumi (1977).

(2) Tsurumi (1977).

(3) Ibid., (1977). Examples of indication of conscious attempts towards the strategy of self-reliant endogenous development and creation of ethnoscience are the science and technology policies pursued in various sectors by India and the People's Republic of China.

The concept of ethnoscience can be however expanded to include the utilisation of the existing unique traditional and cultural knowledge resources that have evolved in specific national contexts, both in the orientation of research efforts and in the creation of the scientific infrastructure. From the point of view of the societal decision-making processes, this approach implies the exploration of the specific structural needs and potentials of existing societal institutions serving as mediators in the process of developing societally relevant research, and in the application of the results thereof. In short, the concept of ethnoscience lays stress on the formulation of science and technology policies that concretely define the interaction between science, technology and society within the local context of relevances and possibilities.

7.3 Implications for research

In the foregoing pages an attempt was made to trace some of the interrelationships between science and society, and some of the implications for the societal utilisation of scientific and technological research. Underlying the whole approach is the basic assumption that there is on the one hand, an urgent need for a more efficient utilisation of science and technology in a socially more beneficial way, and on the other hand, that there exists at present, both within the political/governmental spheres and in the community of scientitific researchers, inhibiting barriers and/or misunderstandings in this regard. Moreover, while distinctive features of differing socio-economic systems must be recognised in a study of this kind, these distinctions do not rule out the existence of common aspirations and interests with regard to societal utilisation of R&D. As such an international comparative study on the societal utilisation of scientific and technological research could contribute to the understanding of the processes described above, and point to improvements that could be made for a better utilisation of R&D in a manner beneficial to man and human societies. However, while both the existing body of scientific-technological knowledge as well as the globality of certain urgent and basic problems facing mankind argues in favour of an international perspective, at the same time the role of different strategies and societal contexts also puts emphasis on the necessity of detailed studies within the concrete framework of given countries.

8. Design and Methodology for Concrete Research

8.1 The conceptual framework

The argument made above for combining international comparison with a recognition of the specificity of decision-making structures and problem areas in individual societies is not without consequences for the research design, and for the methodology of a study on "societal utilisation of R&D". Clearly, an in-depth case study approach by country will be called for to deal adequately with the relative uniqueness of societal structures, and clearly these case studies will have to be carried out within a common conceptual framework as suggested by the model outlined in Section 4.3, in order to ensure international comparability of results. To start with the latter, let us stress that it is the conceptual framework which determines the kind and character of the proposed in-depth research. In the foregoing pages, some of the more general questions referring to these conceptual dimensions have been outlined in greater detail. To summarise and exemplify some of the concepts which must orient a comparative approach, let us reiterate the necessity to study not only the interaction between the scientific and technological R&D system on the one hand and the societal or political system on the other, but also the mechanisms and processes internal to both areas. With respect to science and technology the notion of a field (or discipline) has been outlined, which provides the social and cognitive context for the generation of research results; with respect to societal systems reference was made to the necessity of studying concrete and relevant decision-making structures. In both cases, the dimension of diffusion vs. concentration of interests and responsibility should play a crucial role in determining the type and effectiveness of societal utilisation of scientific and technological research. Similarly, the degree to which these interests are negotiable or rigidly adhered to will have a bearing on the question of societal utilisation of R&D. Phenomena of resistance and evasiveness of scientists in respect of societal or practical demands can be linked to their prevailing purely scientific interests as well as to the characteristics of a field in which these interests are embedded. Needless to say, similar obstacles are encountered among the conflicting interest groups of society and the decision-making structures and agencies responsible for, or interested in, societal utilisation of R&D. Furthermore, barriers and constraints characterising restrictive structures (rather than reaction of individual actors) will have to be added to the picture. These phenomena alert us to the potential role played by the degree of institutionalisation of a speciality field, a particular organisation, or a policy decision-making process, as well as to the question of "finalisation" (see above) and the bearing it may have on the possibility of achieving societal utilisation of R&D. From a different angle, the problem of societal utilisation of R&D requires an analysis of the origin and mediation of research goals in the process of "transformation" which may start in science as well as in the societal system, and which may eventually end up in practical applications. This process of "transformation" of contexts linked to re-interpretation was tentatively conceived of as depending on local constraints and relevances. Alternative societal strategies for research - such as imitation by adaptive transfer, self-reliant, endogenous development, or the development of an ethnoscience appropriate for local or national problems and solutions - can be seen as different degrees and versions of re-contextualisation. The primary function of the first stage of a study of the societal utilisation of R&D would be to develop, elaborate, and concretise concepts such as the ones mentioned above and to tie them together in a coherent theoretical framework as an analytic tool of research as sketched out in Section 4.3. While this framework needs to be specified in advance, its detailed formulation will depend on the unique characteristics of individual societal settings.

8.2 Design for an international study

The preliminary conceptual framework outlined above puts emphasis on in-depth and detailed analysis of processes and mechanisms within and between the Governmental/political system on the one hand and the scientific/technological R&D system on the other, in the process of a purposeful societal utilisation of R&D. In other words, it will be necessary to undertake in-depth studies of existing modes of social utilisation of science and technology which focus on the decision-making process in both the application (praxis) and the R&D system that produces the research results. Furthermore, since societal utilisation of R&D is conceived of as process starting already before the research is actually initiated in the laboratory, case studies which trace such processes will be called for, with a view to identifying and analysing the progressive selections that are made over time, and to assess their consequences in terms of societal utilisation of R&D; and also with a view to identifying the alternative ways of R&D and practical applications that have been ruled out by the actual decisions. Both direct observation and on-the-spot interviewing as well as more indirect sources of data such as written documents bearing on the processes and mechanisms in question will be the primary source material of such a study, supplemented by historical or other existing analyses.

For the theoretical and practical reasons apparent from the foregoing discussions, in-depth case studies should focus on societally relevant problem areas. Both the urgency of the problems involved and the international comparability features built into the research design suggest that an exploratory study could focus on societal homeostasis in the target areas of nutrition, health, waste disposal and environmental control. The universal urgency of these problems makes research programmes in such areas in all countries equally relevant, while the nature of the problems should permit relatively high accessibility to external observers of both the governmental policy-making (including decision-making) structures and the corresponding R&D sub-systems.

By orienting the case study approach toward areas conditioning societal homeostasis rather than toward traditional disciplinary or institutional partitions, it will be possible to achieve the flexibility that is necessary to deal with the complexity and societal singularity of the issue. By tracing the relation of problems and goals in the research process in a variety of structural contexts, comparability of contrasting modes of societal utilisation of R&D within a common framework of goal-relevance will be afforded. While the focus of the study should be on in-depth case studies, the latter should be supplemented by other sources of relevant information. Thus, in order to obtain an overall picture of the mutual and/or conflicting expectations, interests, perceptions of goals and modes of societal utilisation of R&D held by the community of scientific researchers, by governmental policy-making systems and by the more diffuse group of utilisers of research results, a matched sample of research scientists, of governmental policy makers and relevant utilisers of R&D results, should be interviewed on the above questions. Such a survey should also provide some insight in the formal (official) or implicit human values and societal goals held - or envisioned by - the governmental/political spheres, by the community of scientific researchers and by the utilisers of the R&D results. Both standardised and open-ended questions might be used to examine the same topic in order to allow for unforeseen frameworks, governing the behaviour of the interviewed actors, to emerge and thus to allow for an evaluation of the validity of responses. Finally, in order to fully interpret the information obtained from the case studies and surveys, additional secondary material such as historical or statistical data should be analysed within the concrete historical context of the given society wherein the study is undertaken.

Due to the focus being placed on the gradual development of a conceptual framework and to the suggested methodology, the research design has a necessarily loose structure. As such, in order to maintain progressive conceptual and analytic comparability, a mechanism for continuous coordination of the international study among the participating countries should be established. Moreover, the research design should make provisions for consultations among both researchers undertaking the study in the participating countries, as well as with other scientists working in the target research areas of the study.

9. Alternative Suggestions for Action

In view of the foregoing discussion, the suggested action can be perceived in terms of the initiation of a comparative study on societal utilisation of R&D including the communication and dissemination of the results of the study to an audience of interested parties.

9.1 International study on "societal utilisation of R&D"

The study should be undertaken as described in Section 8.2, in three or more participating countries. This study should be conducted according to the following principles:

(a) for reasons outlined in Section 8.2 it is suggested that the countries participating in the study undertake case studies in the target area of societal homeostasis (for example in the fields of health, nutrition, environmental control, waste disposal);

(b) in order to provide for the maximum accumulation of knowledge and experience, it is suggested that the countries participating in the study should belong to differing socio-economic systems and various levels of scientific-technological development.

9.2 Organisation of the studies

In order to maintain comparability and at the same time ensure in-depth concrete information about the unique features observable in different countries it is proposed (1) that an International (Cross-National) Research Project be launched, carried out by national research teams financed by national governments or bodies to whom government can delegate authority; and (2) that some agency be appointed that would have the responsibility for the coordination and management of the project. The organisation of such an International Research Project could be developed along the following alternative lines:

(a) one of the countries interested in the project could take the initiative to undertake such an international study in cooperation with one or several similarly interested countries, possibly in the context of existing bilateral or multilateral agreements. In this case one of the participating countries would assume the responsibility for coordination and management of the International Research Project and for communicating the results of the study to the international community.

(b) alternatively, one or more interested countries could secure the cooperation of some non-governmental international scientific research organisation active in the field of science, which would act as the coordinator of the project. The cooperation of Unesco might be obtained in the form of subvention allocated under the Organisation's Participation Programme.

(c) or else, the initiation, coordination and management of the international study could be undertaken by an international intergovernmental organisation such as Unesco, actively concerned with science and technology within the framework of its own Programme and Budget. Entrusting the Unesco Secretariat (Division of Science and Technology Policies) with the coordination and managerial responsibility for the project would provide the necessary international conditions of objectivity, and would also give it intergovernmental recognition. Such a role moreover fits into the framework of Unesco's missions in the fields of science and technology policies; the project would also benefit from the experience gained previously by the Unesco Secretariat in monitoring and coordinating the International Comparative Study on the Organisation and Performance of Research Units.

In this connection it should be recalled that the General Conference of Unesco, at its 19th Session in 1976, has approved, within the programme of science and technology policies of Unesco, the undertaking of exploratory studies on the social utilisation of R&D. Unesco thus has the responsibility of securing multilateral interest and participation in the international study by three or more member states. The organisation could further act as coordinator and manager of the International Research Project, if requested to do so. This alternative naturally implies that the Unesco Division of Science and Technology Policies be provided, one way or the other, with the appropriate human, financial and other resources that such an undertaking requires.

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