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RIKARD STANKIEWICZ

Social Processes of Utilization of Scientific Knowledge

A Theoretical Essay

INSTITUTE FOR STUDIES IN RESEARCH
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A Theoretical Essay

P R E F A C E

This essay on the social utilization of scientific knowledge was written by Rikard Stankiewicz during his assignment at the Institute for Studies in Research and Higher Education in 1978. Stankiewicz is a sociologist of science at the Research Policy Program of the University of Lund.

In this study the focus is on the absorption capacity of the users with respect to scientific information. It is suggested that lack of scientific competence at the top level of management is at present a main bottleneck in government as well as in business.

We hope this essay will provide a useful survey of the literature in this area of science policy studies and stimulate the theoretical discussion. Both empirical surveys and practical science policy will benefit from an improvement of the theoretical analysis.

Oslo, desember 1979

Sigmund Vangsnes

CONTENTS

SUMMARY

The society's ability to derive full advantage from its investment in R&D activities depends on three factors:

a. The relevance of the knowledge which the R&D system produces. The policies related to this factor are concerned with the improvement of the direction of R&D activities.

b. The adequacy of the means of transmission of knowledge from its producer to its users. Related to this are the policies for the effective dissemination of scientific information.

c. The ability of various categories of users to assimilate and apply the available knowledge. Related to this are the measures to upgrade the scientific competence of the users.

In the past the attention of science policy makers tended to focus chiefly on the first two of the above factors. As long as the utilization of science was confined mainly to a few well defined spheres of technology (military, industrial, medical, and agricultural), this restriction of perspective did not cause major difficulties. The users of science in the above mentioned areas have traditionally had highly developed ability to absorb scientific inputs. The science policy makers could therefore take that ability more or less for granted.

However, the rapid expansion of the scope of application of science which occured in the industrialized countries, especially since the middle of sixties , has changed the situation considerably. The ambition to bring science into virtually all aspects of social life created new forms of demand for scientific knowledge and new categories of users of science.

Not surprisingly, the above developments were accompanied by intensified tensions and conflicts between the users of science and the scientific community. The difficulties were particularly noticeable in such areas as environment protection, social welfare, and urban planning - to take a few examples. The conventional reaction to those difficulties was to demand policies for more effective steering of the R&D effort and/or for improved communication channels between science and the new categories of users.

It is argued in the present paper that such policies alone are not sufficient. The central proposition advanced here is instead that the main bottle-neck in the social utilization of science today is the limitations on the "absorption capacity" of many of the potential and actual users. These limitations cannot be overcome by either increased control of science or by improved communication channels. The investments in the total R&D system are bound to quickly reach the level of rapidly diminishing returns

unless they are supplemented by measures aiming directly at improving the users' ability to assimilate and apply the knowledge which is being produced.

The analysis of the intellectual aspects of the process of utilization of scientific knowledge - described in the middle part of the paper - leads to the conclusion that the users' absorption capacity depends largely on their own ability to identify and articulate their goals and needs. In other words it is the users themselves who are most capable of evolving the intellectual framework within which the externally produced knowledge can be effectively incorporated. The poorer such framework, the less will be the users ability to assess the relevance of the knowledge produced externally, to influence the production of such knowledge and to "translate" it into the users' own language. Own analytical/research capacity is therefore the precondition of effective utilization of external sources of knowledge. In relation to the world science and technology system, this is just as true of a small country as it is of a business firm, a government department, a political party, or a small interest group.

The "absorption capacity" of the users can be predicted from the degree to which they possess the following four characteristics:

1. The expectation and acceptance of change which reflects the user's intellectual alertness to and readiness for analytical effort and information search.

2. The recognition of the importance of the analytical functions within the user's organization. This involves, among other things, treating such functions as distinct aspects of the staff (rather than line) organization, the allocation of resources and prestige to the personnel involved, etc.

3. The development of the user's own research capability. This can be seen as an extension of the user's general analytical capacity and may assume a variety of forms ranging from relatively routine monitoring of the user's activities and environments to sophisticated long-range investigations. Such activities help to assess the quality of the analysis on which the user's policies are based, to close various knowledge gaps and specify the knowledge needs which can be satisfied by external sources.

4. The motivation to maintain high intellectual standards of the personnel/membership. Such standards depend both on the quality of formal training of the personnel and on the heterogeneity of their professional and scientific backgrounds.

5. <u>The active strategy for maintaining permanent or quasi-permanent links with external research environments</u>.

The users of science differ greatly in the degree to which they pcsses the above listed properties. The last part of the paper deals with a variety of factors which account for these differences.

One of the chief reasons for the varying levels of absorption capacity is, of course, the differences in the material resources at the disposal of various users. However:

- the availability of resources is not the only determinant of the actor's absorption capacity; given sufficient motivation even resource poor actors can significantly improve their ability to use science; this is especially important since
- not all the features of absorption capacity need be prohibitively expensive: relatively cheap changes in the user's organization, recruitment policies, etc. may lead to significant gains in his analytical capability;
- relatively small investments in the improved absorption capacity may, under favorable circumstances, result in strategic information gains;
- the recognition of the importance of own analytical capacity may result in pooling of the resources of poorer actors in a manner similar to what happens in the economic and political spheres.

Indeed the difficulties in effective utilization of science are by no means confined to the resource poor social actors. Some of the most often debated problems of utilization of science are those concerning powerful organizations such as government departments, political parties, trade unions and the like. This suggests that the institutional and organizational factors are at least as important in determining the user's absorption capacity as are the material resources. The paper discusses some of these factors in relation to three kinds of users: the economic enterprizes, the government and the so-called "voluntary organizations."

Industrial firms are characterized as relatively effective utilizers of scientific knowledge. This is related to the high level of "scientification" of most industrial technologies to the competetiveness of economic actors and to the flexibility of their organization. In so far as there exist some outstanding problems of utilization of science in industry (other than the ones related to macroeconomic factors) they reflect the tendency towards technological inertia in "mature" industries, and the relative lack of resources in certain (especially small) enterprizes. The paper discusses various measures aiming at overcoming these difficulties.

However, the main thrust of the analysis presented in the paper is towards the problems facing governments and their various subsidiaries. These problems, far more acute than those found in industry, have to do with three general properties of governmental agencies:

1. the complexity and fluidity of the situations with which they are dealing - which makes it difficult for governments to develop sufficiently many-sided intramural analytical/research capabilities;

2. the high level of bureaucratization of their organization - which does not generally create an optimal organizational and psychological climate for intellectual activity; and

3. the crucial importance of the ideological aspects of their intellectual perspectives; such ideological aspects are the potential cause of disruptive conflicts between the claims of the scientific and the political authority.

The above considerations imply that a government's policies aiming to increase its capacity to utilize scientific knowledge must be substantially different from those adopted by industry. The present paper contains a discussion of a number of options open to government agencies, and concludes that the effectivenes with which they can absorb and adapt the knowledge produced by the R&D system, will depend largely on the way in which they organize their advisory systems. Arguments are presented in favor of a clear cut institutionalization of the scientific advisory functions in government. Such institutionalization should make an explicit distinction between the advisory roles which are essentially political and the expert roles which are, at least ideally, non-political.

The factors affecting the absorption capacity of the voluntary organizations (political parties, trade unions, interest groups, citizen associations, etc.) are very poorly understood today. This is partly due to the fact that the voluntary organizations themselves have been rather slow to recognize the problem. Another reason is the fact that the knowledge needs of such organizations in many respects are different in character from those of the government and of industry. For instance, the voluntary organizations are seldom involved in technology development or extensive monitoring research. For this reason they generally do not need any permanent research capacity. Their functions are of a more evaluative and critical character and consist to a large extent in the moblilization of counter-expertise in the crucial areas of application of science and technology. Because their organization is less formalized than that of the government, they do not generally need an insitutionalized advisory system. The success of voluntary organizations in the performance of their evaluative-critical functions depends rather on their ability to solicit free collaboration from the scientific community. The extent and fruitfulness of such collaboration depends nevertheless on the availability of material resources and appropriate organizational arrangements. Some of the proposals and experiments designed to improve the voluntary organizations' ability to acquire and effectively apply scientific expertise are described and discussed.

I UTILIZATION OF SCIENTIFIC KNOWLEDGE: THE PROBLEM AND ITS BACKGROUND

The problem of effective utilization of scientific knowledge is as old as science itself. It has been addressed by all major theorists of science policy from the time of Bacon until the present day. Yet the intensity with which it has been debated and the nature of attempts to solve it have varied greatly over time. Today we are experiencing a period of renewed interest in the problem of social application of science. It manifests itself in a variety of ways. The frequency of public inquiries into various aspects of the problem undertaken in different countries has increased greatly during the last 15 years. Examples of such inquiries are the Heyworth report (1964) and the Fulton committee report (1968) in Britain, Forskningsrådsutredningen in Sweden (SOU, 1977), the NSF's report "Knowledge into action" (1969) in USA, the OECD report (1977) on the utilization of the social sciences, to take just a few. Other studies are in progress or planned. UNESCO, for instance, considers sponsoring an international project in the area. In the United States a special research unit has been created (CRUSK at Michigan) to deal solely with the mechanism of utilization of knowledge. In Norway several separate inquiries have been undertaken to illuminate various aspects of the problem. Along with such "utilitarian" analyses, there has been a remarkable renascence of general scholary interest in the social impact of science. (See, for example, Holton & Blanpied, 1976).

What is characteristic of this activity is not only its intensity but also its broadness. Compared with the earlier periods there seeems to be a great preoccupation with the impact of science outside the traditional military and industrial spheres and with the role of the social sciences.

Another manifestation of the renewed interest in the social utilization of science is various policy measures and institutional innovations. These range from comprehensive reform plans such as those indicated in the Rothchild report (1971) or SOU (1977), to more specific programs such as the RANN, Science for the Citizen, and Public Understanding of Science, in the United States. The creation in Norway of a special research council to deal with science for societal planning can be taken as an especially interesting illustration of the trend.

What are the causes of this reawakened interest in the utilization of science? What are the roots of our dissatisfaction with the situation as it is today?

One simple answer to these questions might be that, unable to sustain further growth of investment in science, the societies become more concerned with the efficiency with which the present investments are exploited. There is certainly some truth in this explanation, yet it can hardly be the whole truth. In order to arrive at a satisfactory diagnosis of the present situation we need to see it in a historical perspective.

In the early stages of the development of science policy (that means up to the late 1950s) there was remarkably little concern over the problem of utilization of science taken as a separate issue. The focus of attention of the policy makers and the public at that time was on a limited number of strategic R&D objectives chiefly in the military and national security areas (atomic energy, aerospace and electronics). One of the main characteristics of the technologies in these areas was that they have grown out of science. The organic system of link between the relevant scientific, technical and political communities operated quite smoothly. Contributing to this harmony was the fact that in many countries the system has been shaped in the years of the WW II, i.e. at a time of mobilisation of science for defense.

The problematic nature of the utilization of R&D became fully apparent first in the 1960s when the main thrust of science policy became directed towards the promotion of economic growth. Studies of the differential contributions R&D was making to the growth of various industries, the investigation of "technological gaps", and analyses of the innovation process generally brought to light a variety of economic, political, organizational and institutional factors affecting the civilian utilization of R&D. Certain pioneering studies, such as IIT (1968), and Sherwin & Ibenson (1967) showed that scientific knowledge, especially in the basic fields, filtered only slowly into practical application. These time gaps have been variously interpreted by such scholars as for example Derek de Solla Price (1965) or Johnson and Gibbons (1974). Other studies focused on the fact that the utilization of science depended on many things in addition to the availability of knowledge. Ben-David (1968), for example, argued that Europe's technological disadvantage vis-a-vis the USA stemmed from the absence of entrepreneural incentives rather than from the inferiority of European science itself. Thus within the space of a few years there developed a new scholary field dealing with the impact of science on technological innovation. The activity in that field reached certain maturity with the publication of Myers and Marquis' "Successful Industrial Innovation" (1969), Pavitt's "Conditions for Success in Technological Innovation" (1971) and OECD's "Technological Gaps" (1970). The results of these studies influenced substantive science policies. However, their focus - mainly on the industrial sector - continued to be relatively narrow.

Yet it was precisely at that time (late 1960s and early 1970s) that a significant change in the situation started taking place demanding a broader perspective on the social utilization of science. There occured a major restructuring and extension of the scope of science policy. The older philosophy of science-policy which placed emphasis on the military-strategic and economic-growth objectives came under attack from the critics who demanded greater restrain on technological innovation, and argued for the formulation of more comprehensive social objectives for the R&D effort. This change of mood, while bringing with it som excesses and naivety, resulted in important substantive shifts in science policy. Perhaps the most representative document heralding these shifts was the so-called Brooks Report (1971). On the practical level the significant tendency was the trend towards sectorization of sciency policy. The concentration on comprehensive sectorial objectives implied marked extention of the area of application of science. While in the past the application of R&D was confined to relatively well defined areas, the new approach postulated a scientific dimension in virtually every sphere of social activity. Quite suddenly the number of areas in which one would expect interaction between science and users increased dramatically. This change in the expectations is probably the best explanation for the feeling that the level of utilization of science was inadequate. It was also in this context that the role to be played by the social sciences began to receive increased attention - as witnessed by such publications as NSF (1969), Lyons (1969), NAS (1968) and many others.

The tendencies described above were amplified by certain parallel developments.

One of the major signs of the changed relationship between science and the public has been the increasing politicization of many research & technology issues. The environmental movement, the nuclear energy debate, the recent DNA controversy, as well as the public clashes over various other "superstar technologies" generated a wave of public involvment in science & technology without a parallel in the past. Although the extent of that involvment and its forms varied greatly from country to country, it is obvious that a new kind of societal demand for scientific knowledge has been created. Along with the emergence of new voluntary organizations focusing on various aspects of science & technology (for example: various environmentalist groups, consumer organizations, associations such as The Council for Science and Technology, etc,), the scientific and technological issues have gradually become a growing concern for the political parties, trade unions and the like.

Furthermore the politicization of science policy has led to controversies over the differences between various social groups concerning their ability to use the existing R&D resources. The concept of "resource poor group" has thus been introduced into the science policy debate. It is hard to find a better exemplification of the belief that science can and ought to be related to every aspect of social life.

The ambitious objectives assigned to new science policy placed high demands on both the scientists and the users. The resulting frustrations were caused by both the exaggerated expectations of what could be done and the relatively novel character of some of the emerging issues. It is against this background that the flurry of activity of which we spoke at the beginning of this chapter must be seen. The conceptual and practical diffuculties encountered in this activity call for reexamination of some of the premisses on which they are based. The present paper is meant as a contribution in this direction.

II THE PROCESS OF UTILIZATION OF SCIENTIFIC KNOWLEDGE

A. Alternative approaches to the problem of utilization of scientific knowledge

Before continuing our analysis, we must clarify the meaning of the concept of "utilization of science", since it lends itself to several different interpretations. Difficulties of definition arise from the fact that the application of scientific knowledge to practical affairs involves a sequence of stages. For the sake of simplicity we can distinguish three such stages:

1. The incorporation of scientific knowledge into the cognitive framework of various users*). That means that the user's definition of his/her situation is changed in some measure. leading to some modifications of attitudes and behavior.

2. The creation of various devices, processes and practices which embody the new knowledge. In other words: the development of technology.

3. The diffusion and use of the technologies which embody some elements of scientific knowledge.

Ideally the analysis of social utilization of scientific knowledge should encompass all the above listed stages. However, in the context of science policy it is the first two stages that are crucial, and it is on them that our analysis will focus.

Of stages 1 and 2, it is the first which is both more inclusive and logically primary. Normally, before a piece of scientific knowledge is incorporated into a certain technology it must become a part of the cognitive framework of the person or persons who develop that technology. Moreover, there are various kinds of application of science which are not technological as, for instance, when research is used in generating policy-relevant descriptions of the state and dynamics of various natural and social systems. Indeed, such non-technological applications of science contribute considerably to the contemporary problems of utilization of science.

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*) The concept of "user" is a relative one. One and the same person can in principle play the role of both the producer and the user of knowledge. Note also that in the context of the present paper the term "user" is usually used to denote various social organizations and institutions also referred to as social actors.

For these reasons I shall define the term "utilization of science" as the process of incorporating scientific knowledge into intellectual perspectives of social actors. This process may but does not have to lead to the creation of specific technologies. The utilization of science involves, in other words, not only the modifications of the means of social action but also of its various cognitive premisses.

Given the above definition of the utilization of science one is able to distinguish three main kinds of factors affecting the process. These are:

1. The degree of relevance of the knowledge produced,
2. the effectiveness of the communication between the producers and the potential users of knowledge; and
3. the capacity of various categories of users to absorb the knowledge produced and to embody it in relevant practices.

Each of these three factors is important in its own right. They also tend to interact and, for that reason, may be difficult to separate. Nevertheless their relative importance may vary from time to time and from context to context.

In this paper I shall discuss in some detail the approaches to social utilization of science related to the second and third of the factors. The question of achieving the necessary degree of relevance of scientific knowledge would extend the scope of the present analysis to encompass the entire science policy. That is obviously impossible. Instead, we shall restrict ourselves to the discussion of the utilization of scientific knowledge which has already been produced, even though some reflections about the problems of steering scientific research will be called for as we proceed with our main theme.

Of the two remaining approaches, the one which emphasises the process of communication between the producers and the potential users of science is particularly common today. Its popularity may be related to the fact that it promises a technical, and therefore relatively uncontroversial, solution to the problems it addresses. It has been discussed in many recent documents such as, for example, SOU, 1977:55, Gustafson, 1976, NSF, 1977, and Bozeman et al., 1978.

The "communication approach" places emphasis on the transmission of knowledge/information from "producers" or "users". It tends to view this transmission as problematic and proposes various measures to facilitate it. It assumes that scientific knowledge is not utilized because the costs of finding and acquiring it are too high. If we cut these costs subtantially, the utilization is bound to increase. For example, an easy access to a national research project inventory should cut the costs which various users incur in trying to find research groups working on problems relevant to them.

The logic of the argument is quite compelling and there is little doubt that various measures to facilitate the communication between the producers and users of scientific knowledge should produce positive results which are at least commensurate with their costs. It is, however, doubtful whether these results would make a decisive difference for the overall situation. My reasons for pessimism are as follows.

The communication approach is based on the assumption that the users can define their problems with sufficient precision such that the available knowledge which is pertinent to these problems can be easily identified After the relevant knowledge has been identified, the user's problem is either solved or the exact "knowledge deficit" is defined so that appropriate research processes can be initiated.

The difficulty with such a simple view is that the practical problems are not always precisely defined. In fact, it could be maintained that the solving of "well defined problems" is but one of several aspects of utilization of scientific knowledge - a mere tip of the iceberg. It generally occurs only after several other preparatory steps have taken place. Such steps involve the articulation of "practical problems" in terms of the methods and concepts of relevant research fields. Once this process of articulation has occured, the communication between the producers and users of knowledge will be smooth at least generally. And conversely, whenever serious problems of utilization arise, we are likely to discover the absence of conceptual convergence between the producers and the prospective users of science. In such cases the costs of communication per se will be minor compared with the cost to the user of assessing the relevance of the information transmitted. The absence of clear criteria of relevance will make it difficult to devise a system which distributes information with the necessary degree of selectiveness. If, on the other hand, such criteria are available the users will tend to acquire information they need without any intermediaries. In a country of a moderate size the identification of all non-secret research answering to some reasonably specific description is a matter of a few telephone calls.

In an earlier NAVF working paper (NAVF's utredningsinstitutt: Rådgivning og formidling - noen momenter til diskusjon om behovet for økt kontakt mellom forskning og samfunn, arbeidsnotat U-nr. 5/1977) a distinction has been made between four types of situations depending om whether or not the users' problems are well defined and whether or not there exist professional environments specialized to deal with such problems.

Another classification (partly overlapping with the above) can be based on the degree of relevance which various fields of research have for a particular situation and on the degree to which that situation has actually been described in terms of the concepts prevailing in those fields. Combining these two dimensions yields the following classification.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">R&D fields according to potential relevance to some specified user</td></tr>
<tr><td>High relevance</td><td>Low relevance</td></tr>
<tr><td rowspan="2">The degree of articulation of the user's problems in terms of the R&D fields</td><td>High level of articulation</td><td>I
The mature area of application</td><td>II
The area of misuse of science through misrepresentation of the user's problem (spurious relevance)</td></tr>
<tr><td>Low level of articulation</td><td>III
The area of under-utilization of science</td><td>IV
The area of acknowledged irrelevance</td></tr>
</table>

The above table oversimplifies the reality but is helpful in defining the problem we are going to deal with. The general position taken here is that the communication approach to the utilization of R&D works best in a situation of type I. This kind of situation is exemplified by the most well developed science-based technologies.

In the situation of "spurious relevance" (type II) effective communication will, if anything, worsen the situation. As an example one can take the attempts to apply eugenics to social problems at the beginning of the century.

It is the situation of type III, however, which - in the light of what was said in the first chapter, - is of particular interest today. It comprises all the cases where potentially useful knowledge is not exploited because the corresponding problems have not been defined in its terms. What is needed in such cases is a creative act of changing the user's way of perceiving his/her situation. Consequently the focus of analysis must move from the process of communication as such to the users, their motivation and their ability to engage in the necessary process of intellectual innovation. In this chapter I shall outline a framework in which such an analysis may be conducted.

One of the main tools of this analysis will be the concept of cognitive system. After presenting this concept in the next section I shall proceed to discuss the process of utilization of science defined as transfer of knowledge between two cognitive systems. The social mechanisms involved in such transfers are then examined and the notion of user's " absorption capacity" introduced.

B. The organization of knowledge: cognitive systems

1. Scientific fields and disciplines as cognitive systems

There exists a substantial and rapidly growing body of knowledge on the subject of scientific change. During the last 20 years there has occured an enormous increase in the sophistication of our views on the emergence and evolution of scientific theories, their diffusion across research fields and their functions in directing every-day scientific activity. Since Kuhn (1962) it has become difficult to maintain that the piecemeal replacements of "bad" hypothesis by "better" ones is the only mechanism of scientific progress. We are now more inclined to recognize that science is an entity composed of many interdependent intellectual layers, some of which show remarkable stability over time. Without necessarily becoming a Kuhnian one can say that intellectual disciplines form cognitive systems containing the following elements:

- Some set of fundamental concepts defining the ultimate features of the studied phenomena,
- some notions of how these phenomena can and ought be studied/known (heuristic rules)
- some manipulative procedures (technologies) for acquistion of data and testing of propositions
- some range of causal/predictive generalizations and
- a body of descriptive information emphasizing certain crucial facts about the nature.

The pace of the changes taking place at any level of the system is limited by various constraints operating at its other levels, the mutual dependence of which gives the cognitive systems coherence and accounts for its resistance to external steering and manipulation.

When a certain cognitive system dominates a research field it constitutes - in Kuhn's terminology - that field's paradigm. In the fundamental sciences the strength of a paradigm depends on its fruitfulness in promoting the growth of the explanatory/predictive knowledge - that is to say: on its relevance from the point of view of internal scientific values.

Generally, it could be said that a cognitive system constitutes an intellectual articulation of certain underlying values. These values determine the content and form of the system. Thus the dominance of the heuristic*) values of explanation and prediction in the natural sciences has induced their practitioners to evolve knowledge systems without regard to immediate practical considerations. In their theory of "finalization" Böhme and his collaborators (1973) pointed out that during the period when the heuristic potential of a given paradigm has not yet been fully exhausted, the research field guided by that paradigm tends to be very resistant to external (extrascientific) direction. It is only when the paradigm has been heuristically perfected and offers neither intellectual challange nor guidance that the extrascientific considerations become increasingly important in determining the direction of work of the scientists.

The above description of the cognitive systems in fundamental sciences reflects an ideal situation rather than empirical reality. In practice the heuristic values guiding the scientists tend to be intermixed with economic, political, religious, or personal ones. This notwithstanding, the differences in the degree to which distinct types of values determine various cognitive systems are large enough to justify the above "ideal type." Let us now consider two other variants of "cognitive systems" reflecting different value premisses.

2. Applied sciences and technological fields as cognitive systems

While the systems of knowledge produced by the fundamental sciences have been a traditional focus of philosophical, historical and sociological analysis, comparatively little effort has been devoted in the past to the study of practical knowledge. There has been a tendency to view the so-called applied fields and technologies as either mere derivatives of the fundamental sciences, or else to define them as "arts", i.e. traditional systems of instructions for the achievement of various ends. Fortunately, in the recent years, there has been some change in these attitudes. Thus, there is a growing preference to view technologies as

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*) Heuristic values are those the pursuit of which is necessary in order to progress to reliable knowledge. They are formulated both with reference to the desirable qualities of knowledge (for instance: objectivity, clarity, consistancy) and to the procedures used in acquiring knowledge (for instance: explicitness, replicability etc.).

coherent intellectual systems with a developmental logic of their own. For example: Johnson (1972) has suggested that many crucial technological changes can be analysed as a series of design paradigms succeeding each other. Similar views were expressed by Skolimowski (1969) and Toulmin (1972). Krohn and Schäfer (1976) described the emergence of agricultural chemistry as a coherent intellectual field with a "paradigm" of its own. Wartofsky (1976) emphasized the need to view medicine as a genuine cognitive system which is not reducible to a number of biological sciences even though these sciences have been crucial in the process of articulating the values underlying the medical theory and practice.

This new sophistication in the treatment of applied sciences and technology promises better insight into the process of utilization of scientific knowledge (see, for example, Lyton, 1977) and, hopefully, better understanding of the means by which it can be directed. However, the approach needs to be extended to yet another kind of knowledge: that of specific social actors.

3. The cognitive system of social actors

Scientific fields produce well systematized explicit descriptions of their cognitive systems. Although less pronounced, the same tendency exists in the applied fields and even in technology. The cognitive systems of specific social actors, on the other hand, tend to be implicit rather than explicit, private rather than public, concrete rather than abstract, spontaneous rather than formalized. All that makes them intangible and accounts for their neglect by the theorists of knowledge.

Nevertheless such systems exist and play important roles. Every social actor whether individual or collective (organization, institution, etc.) evolves a system of beliefs which determine his/its "definition of situation" and guides subsequent actions. Such a system contains a set of fundamental concepts and beliefs about the ultimate features of the world in which the actor acts; a variety of "theories" about the causal relations which relate these features to one another; certain heuristic beliefs which determine the strategies which the actor uses while seeking new knowledge; a certain amount of descriptive information about the "state of affairs", together with some notions about the potential for beneficial/detrimental change of that state; and, finally, a certain amount of "know-how" about the means/techniques through which the actor's situation may be changed and controlled.

In short, the cognitive systems of actors have structures which are analogous to those of scientific fields. However, rather than being based on systematic "research" they tend to be rooted in the actors' accumulated experience. In addition they often contain strong traditional elements reflecting the history of the institutions or groups to which the actors belong. The stability of such systems depends also on a number of other factors, the most important of which are:

- the interdependence of the cognitive levels, the mechanisms of which are, on the whole, the same as in the cognitive systems of scientific fields,
- the complexity of the underlying values, which generally will be greater than in the scientific or technological fields, and
- the social constraints reflecting the political, ideological and organizational determinants of the actors' intellectual perspectives.

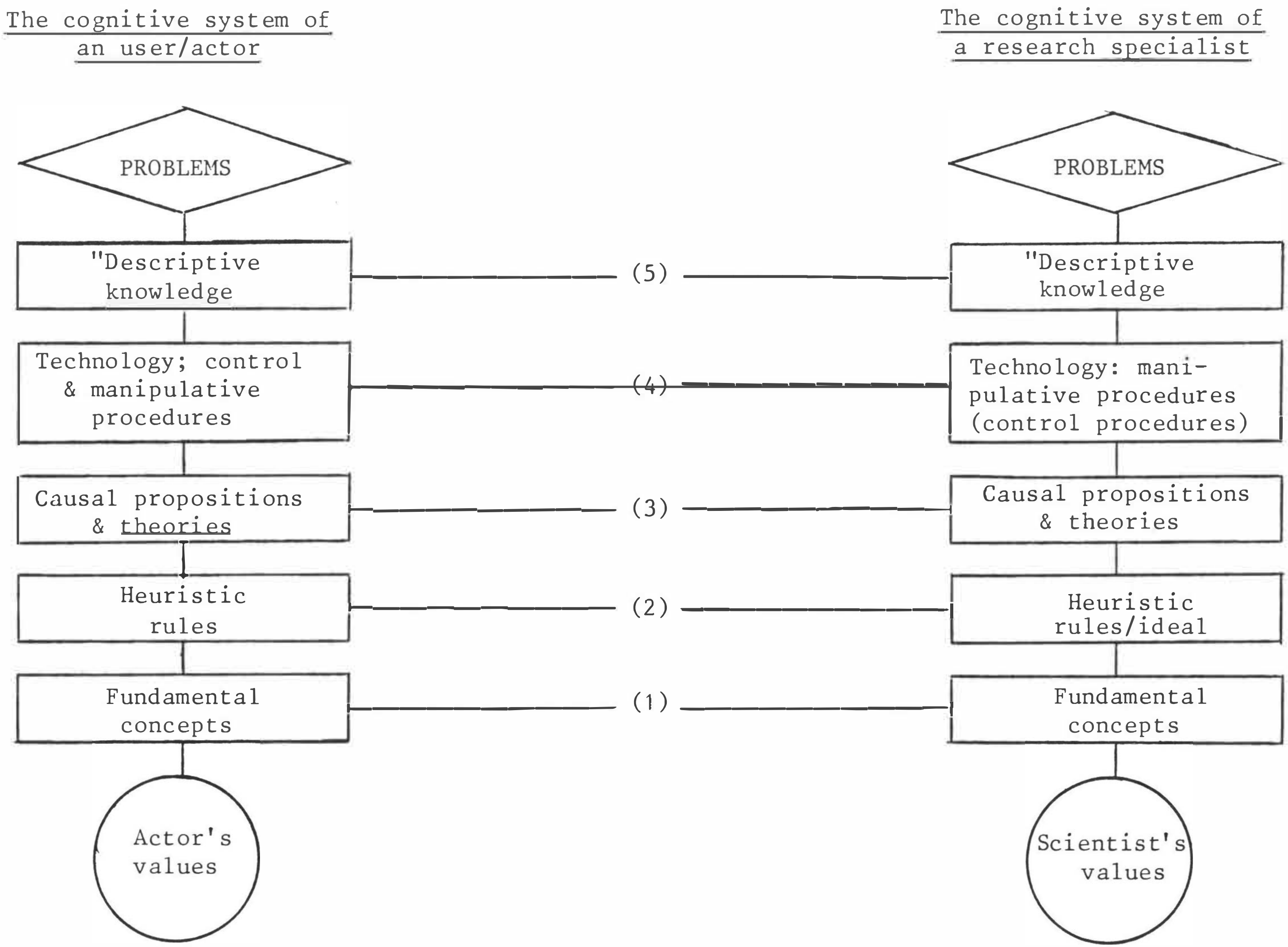
The fact that the cognitive systems of social actors are only rarely fully spelt out results in their often being disregarded in the discussion of the utilization of science. This is unfortunate. The attempts to communicate new knowledge to an audience may fail because the communicator has no understanding of the intellectual background against which the information he imparts will be judged. An interesting illustration of this effect has been presented by Nypan & Vaa (1974) who analysed the difficulties encountered by the agricultural extension services in Tanzania. The extension officers failed to realize that successful introduction of new techniques required not only an adequate description of the techniques themselves but also a systematic attempt to change the "local theory" of agricultural praxis. Such "theory" should be viewed as "an autonomous system of norms and cognitive standards of what is appropriate and why this should be so in a given community of farmers." Unless the "local theory" is taken into account, the information supplied by the extension workers will tend to bounce off, or will be misinterpreted by the addressees.

Our societies are full of "local theories", i.e. actor-specific cognitive systems. One of the major reasons for the difficulties in the application of scientific results is that such results often do not fit into the "local theories" of the user and that this fact is disregarded. The problems of this kind can be minimized if we recognize that <u>the utilization of knowledge involves interactions between distinct cognitive systems.</u>

C. <u>The intellectual aspects of the transfer of knowledge between two cognitive systems</u>

On the next page the reader will find a schematic representation of interchanges between two cognitive systems. The systems are seen as similar in structure (levels) but distinct in content and in underlying values. Each of the systems consists of levels discussed in the preceding section plus an additional component: problems.

The ease with which exchanges can occur between the systems will depend on their "conceptual correlation." Such correlation is high when there is a great degree of overlap/correspondence between levels 1 - 5 of the two systems. The limiting case is when the systems are identical in all respects except for the underlying values and - consequently - problems.


The cognitive system of an user/actor
The cognitive system of a research specialist
PROBLEMS
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(5)
Technology; control & manipulative procedures
(4)
Technology: mani- pulative procedures (control procedures)
Causal propositions & theories
(3)
Causal propositions & theories
Heuristic rules
(2)
Heuristic rules/ideal
Fundamental concepts
(1)
Fundamental concepts
Actor's values
Scientist's values

Much of the literature on the relations between science and the society is concerned with the mechanisms through which conceptual bridges between cognitive systems are built. One of the recent contributions to this literature is especially relevant from our point of view. Böhme and his collaborators (1973) advanced the "theory of finalization" of science according to which the pattern of utilization of science is a function of the development stages of scientific fields. The authors accept Kuhn's views about the stages of scientific evolution. They assert that before reaching the paradigmatic stage sciences interact freely with various social users chiefly because they lack a firm commitment to any single conceptual system; the usefulness of such sciences may, however, be limited by their immaturity. Once a single paradigm becomes dominant, it gives its field a compelling internal logic, thus making it less easily influenced by external considerations.

In fact, during the paradigmatic stage, the "conceptual correlation" between the scientists and the extrascientific users may actually diminish. Once, however, the heuristic potential of the paradigm has become exhausted, the underlying intrascientific values are no longer capable of generating significant research problems. When this happens, the field becomes gradually reoriented towards extrascientific values and the applied problems derived from them. Science which has reached this stage is defined as "finalized"; it can be exemplified by, for instance, the field of classical mechanics which today has mainly engineering significance. The "finalized" sciences can be regarded as the cases of very high conceptual correlation between theoretical and practical fields of knowledge.

The theory of finalization advanced by Böhme and his collaborators accounts for the process of transforming the fundamental fields into applied fields through injecting into the cognitive systems of the former the values and problems of the latter. There is no doubt that such processes do take place, although perhaps in a less clear-cut manner than the finalization theory suggests. However, it cannot be claimed that the theory accounts for all or even the most important processes of social utilization of science; nor was it the intention of its authors that it should do so. The most common pattern of application of scientific knowledge is instead the reverse of what happens in the case of "finalization": the utilization is achieved by injecting the cognitive system of the users with various elements of the cognitive systems of science (such as concepts, methods, heuristic strategies, etc.). This kind of transfer can occur at any stage in the development of scientific fields although it is obvious that, other things equal, a more advanced science will have more to offer than a less advanced one.

The interaction between two cognitive systems can be viewed as a self-stoking process: the greater the frequency of exchanges between the systems the higher becomes their conceptual correlation; and - conversely - the higher the conceptual correlation the easier and richer the flow of knowledge between the systems. Simplifying things greatly we can divide the whole process into the following major stages:

1. The stage of sporadic interaction; it may be characterized as follows: The conceptual correlation between the systems is very low; their practitioners "speak different languages", have different heuristic commitments, pursue problems which, from the other's perspective, appear irrelevant and esoteric, and so on. Yet despite that apparent disconnection, there may occur spradic exchanges between the systems. Individual concepts, facts or techniques discovered/evolved within one of the systems find their way to the other. The examples of such exchanges are numerous: we all use bits and pieces of information derived from fields of knowledge with which we are largely unfamiliar.

Characteristic of such exchanges is that they cause little disturbance within the receiving cognitive systems. This is especially true of the transfers of technology. The acquisition of artifacts or occasional utilization of some expert skills seldom involves an immediate challenge to the user's cognitive system. To take a crude example: one does not need to know anything about electromagnetism to operate a transistor radio.

The exchanges between the cognitive systems at the stage discussed here are infrequent, largely spontaneous and therefore unpredictable. Consequently it is difficult to envisage systematic policies for their promotion. The occurence of such exchanges is chiefly the function of the frequency and quality of social encounters among the representatives of various cognitive systems. Sharp distinctions between scientific, technological, business, political and other sub-cultures slow down the process; cultural heterogeneity and interaction can be expected to promote it.

2. The stage of systematic interaction. The sporadic intellectual exchanges decribed above may eventually lead to the recognition by the users of new cognitive needs. With the borrowed technology there often comes the need to maintain, adapt and evaluate it; the technological "black-boxes" have to be open, new dimensions of knowledge have to be incorporated into the users' cognitive system. Indeed many technologies have very definite connections with specific fields of science. It is quite striking how often they consist of adapted and improved experimental set-ups which have been originally devised by some researchers for theoretical reasons. Examples are the X-ray apparatus, radio, nuclear fission, or any of the thousands of chemical processes. In such cases the link between the technology and the underlying scientific theory is particularly obvious.

The cognitive impact of "borrowing" of technologies depends on many things. One of them is the relative maturity of the technology at the time of transfer. Young technologies are often "messy" and require in-depth understanding of the processes involved. For instance, the successful operating of the early radio-sets required a physical insight which, as the technology progressed, became increasingly superfluous. Indeed some aspects of the resistance to technological innovation may be related to the fact that in their early developmental stages some technologies put great intellectual demands on their users.

The transfer of research methodologies have similar effects. Examples of such transfers include the use of social sciences (for instance, surveys) for social monitoring purposes or the application of various chemical and biological observation techniques in environment control. Just as in the case of ordinary technology transfers, the absorption of heuristic techniques may at first appear to be free of any deeper intellectual implications. However, in the long term this kind of transfer will open doors for the flow of more fundamental ideas. Indeed, many scientific tools are so heavily "theory loaded" that they must be viewed as excellent carriers of "theoretical infections." This is greatly amplified by the fact that the transfer of heuristic techniques is often accompanied by moving the scientist into the user's environment.

These and related processes serve to establish the relevance of specific fields of scientific knowledge to specific areas of social activity. Once that relevance has been established a whole series of events is likely to ensue: The training of social actors becomes modified to include some instruction in the fields in question; the mobility of the practitioners of these fields into the user's environment is initiated; consulting the experts from the fields becomes common practice, and so on. Another important feature in this process - at least in its advanced phase - is the development of a mechanism of systematic monitoring by the users of the research front of the source-fields. The history of professional training and praxis in medicine, engineering and agriculture illustrates these points very well.

Characteristic of this stage is that, although the relevance of the source-fields becomes clearly recognized and the user's cognitive system becomes increasingly saturated with the elements originating in these fields, the conceptual correlation between the two continues to be limited in the sense that some of the most crucial aspects of the user's situation cannot be adequately dealt with within the conceptual framework of the source-field. For example, the relevance of chemistry for biology and medicine has been recognized for at least a century. Relatively advanced chemical training has been a standard element in the biologist's and doctor's education for decades. Yet, it is only relatively recently that the genuine fusion between chemistry and the life sciences has taken place in the shape of the still controversial field of molecular biology.

3. The stage of fusion of the conceptual systems. Complete conceptual correlation between two cognitive systems can occur only when the underlying values of one of them are felt to be adequately expressed/articulated in terms of the concepts and theories of the other. I emphasize the word "felt" since I doubt that this is something that can ever be proven in some objective fashion. Even in this restricted sense it is debatable whether a perfect conceptual fusion can ever by fully realized. However, in practice one may come rather close to it. Examples are found in many fields of high technology. Among the social sciences it is economics that comes closest to fusing with the government policy-makers' intellectual perspectives. As Andrew Shonfield (1970) pointed out:

> Economic policy is recognized as a matter for economists, not only in the sense that they are invited to provide expert advice on the means to be employed to achieve specified ends - that would apply to other social scientists in their respective spheres - but also in arguing about the ends themselves. (emphasis - R.S.)

Shonfield's claims may be somewhat exaggerated but they illustrate nicely the idea that I am trying to convey.

The process of achieving a conceptual fusion may be gradual or rapid. It may follow after a long period of interaction between two cognitive systems or may start without any preliminaries. It may be carried out in a very diffuse manner or may be aggressively championed by certain definite groups or individuals. Because it touches the very core or the user's value system it often generates social and psychological conflicts. Although such conflicts do occur even during the other two stages of interaction between cognitive systems, they are less frequent and seldom take the form of ideological battles.

Looking at the apparent harmony between science and social practice in many fields of human endeavour we often forget the conflicts which preceded it. Once the act of articulation of the values underlying one cognitive system in terms of the concepts, methods and theories of another has been successfully completed we become insensitive to its possible shortcomings and blind to alternatives.

Let us take the medical sciences as an example. One of the most important aspects of the development of these sciences, especially since the second half of the 19th century, has been the gradual replacement of a broad (and by modern standards vague) concept of disease and health involving a variety of psychological, social, ethical, and even religious aspects, by an increasingly biological model. The effectiveness of the biologically and chemically based treatment (mainly antibiotics and chemotherapy) has profoundly affected the very philosophy of medicine.

Today the biological-chemical paradigm of medicine constitutes a cultural orthodoxy the critics of which are usually regarded as cranks. In order to observe the pains and vicissitudes of the conceptual fusion in progress we have therefore to turn to the borderline case of psychiatry. A recent article in Science (Engel, 1977) describes the difficulty of fitting psychiatry into the biological paradigm of the rest of medicine. As its author points out one is forced either to eliminate from psychiatry some of its traditional non-somatic elements or else to declare the biomedical concepts of disease as inadequate. Various participants of the often heated debate supported one or the other of these courses. The issue is far from resolved. This is hardly surprising considering the fact that the conflict involves not only knotty intellectual and technical problems but also a whole gamut of social and political ones. The acceptance or rejection of one model of mental disease has a whole range of social consequences including the principles of division of labor between neighbouring professions (medical doctors, psychologists, social workers, etc.), the shape of the professional status hierachy, the need for, and legitimacy of various therapeutic roles in the system, the definition of the role of the patient, the social status of the sick, and so on.

The conflicts such as those described above may lead to temporary disturbances in the relations between the two cognitive systems which are suddenly transformed from being complementary to being competitive. We cannot dwell here on all the intricacies of these processes. It is, however, important to keep in mind that the connections between the intellectual and social conflicts accompanying such a process are two-sided. Not only can a genuine confrontation between paradigms lead to social tensions but also the other way around - the underlying social conflicts are often disguised as confrontations between different conceptualizations of social and natural phenomena. Often it is next to impossible to separate such tensions from one another. This is particularly evident when we look at the policy applications of the social sciences. Many of the conflicts between policy-makers and social scientists stem less from disagreements on specific propositions and methods than from the fact that the scientists, consciously or unconsciously, implicitly or explicitly, challenge the legitimacy of some fundamental ideas with which the policy-makers are identified. The resulting confrontation often reveals the excessive naivety of the scientists, who are prone to overestimate the adequacy of their concepts and methods to the "real-life" problems or get blinded by own ideological commitments. But obviously the fault is not always on the side of the scientists. It is enough to recall the struggles which were necessary to introduce the Keynesian theories and, later, the econometric models into economic policy-making (see for example, Skoie and Steine, 1975). The occasional cases of intellectual arrogance exhibited by scientists toward the politicians and administrators can be easily matched by the cases of anti-intellectual arrogance of the people in power. Embittered by the slowness with which the economic establishment accepted his ideas, Keynes wrote in 1936:

> .... the ideas of economists and political philosphers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed, the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler from a few years back. I am sure that the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas.

The intense frustration, such as that expressed by Keynes, is the plight not only of the social scientists. I have already mentioned the tensions within psychiatry. The bitter controversies concerning the applicability of a biological approach to social deviance around the turn of the century (and even later) serves as another example - although in this case the failure of conceptual fusion can hardly be regretted. As yet another example we can mention the recent debates about the relevance of ecological paradigms to socio-economic planning.

There is an important difference between the stage of fusing of the cognitive systems and the phase when they merely interact systematically. There often exists a point beyond which the application of a science cannot progress - either for technical reasons or because of the lack of legitimacy - unless the user's problems (and ultimately his values) are rearticulated in terms of a given science. Since such rearticulation is often resisted, there arise difficulties in the process of utilization of science which are fundamentally ideological even though they may at first appear technical.

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The above description of the stages of interaction between cognitive systems is of course very crude. In reality the borderlines between the stages defined above are very fluid. Futhermore, within each of the stages one could distinguish many degrees of conceptual correlation between the systems involved. Special properties and problems can be linked with these degrees. All such reservations notwithstanding I think that it is important to keep in mind the general distinctions introduced in this section. The problems of effective utilization of science will differ depending on the nature of the relations between the cognitive systems in question.

Let us now turn to the social mechanisms which bring about the conceptual correlation between cognitive systems, thus creating the precondition of the effective flow of knowledge between them.

D. The social mechanisms of interaction between cognitive systems

1. Factors influencing interactions between cognitive systems

Although exchanges between cognitive systems tend to be self-sustaining, their rate and scope is influenced by a variety of factors. The single most important of these factors is of course the relevance of the source field to the needs of the user. We can attempt to increase that relevance by influencing the direction of research in the source-fields*) - this indeed is one of the main concerns of science policy. We may also try to stimulate the process of interaction between the producers and users of knowledge by improving the channels of communication connecting them. Both these approaches have been widely discussed in the literature of science policy. Let us therefore turn to certain aspects of the problem which, while crucial, receive much less attention.

We take for granted that - other things equal - the level of development of a science determines its social usefulness. Physics today is more useful than it was in the 17th century. The social sciences, we often hear, are too immature to be as applicable to practical problems as the natural sciences, and so on. All that is true. However, the utilization of knowledge involves - as we have seen - interactions between <u>two</u> cognitive systems. Consequently <u>what matters in not only the degree of development of the source-field but also the sophistication and adequacy of the receiving cognitive system.</u> This must be so because <u>it is primarily within the latter that the user's values are identified, articulated and set in relation to his particular situation.</u> Unless these values are defined and made explicit, and the contingencies under which they are to be pursued specified, the assessment of the relevance of the externally produced knowledge is hardly possible. Speaking metaphorically, we can compare the user's cognitive system to a template on which the externally produced knowledge is merged bit by bit and layer after layer. The better developed the template, the easier it is to fit to it the additional bits of knowledge.

The importance of the degree of advancement of the receiving system is easy to illustrate. The applications of chemistry to biology and medicine were not only a matter of chemistry reaching a certain stage of development; they also required prior availability of fairly advanced knowledge of the morphology, physiology and pathology of living things. Before one could inquire about the chemical nature of the gene, the purely biological concept of heredity had to be elaborated. Before the search for reliable biochemical indicators of various diseases could be initiated

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*) The fields of science from which the knowledge which is being utilized originates.

there had to exist a foundation of clinical knowledge about these diseases. The story of application of various natural sciences to agriculture provides further examples, as do the histories of "scientification" of many other industries. (It may also be worthwhile to mention here the role which formalized professional education played in the systematization of various "practical" knowledge systems. This systematization was crucial in making such systems receptive to scientific influence.)

Clearly the receiving cognitive system must reach a certain level of maturity before it can "digest" given inputs from outside. The less developed the system is, the smaller the chances are that its exchanges with the source fields will transcend what we call the stage of "sporadic interactions." This is not to deny that the process is partly circular; the autonomous internal development of the user's cognitive system cannot progress indefinitely without exchanges with external sources of information and ideas. However, the constant effort to develop the receiving system from within is necessary if the cycle of interactions is not to run down. It is therefore important that when discussing the problems of utilization of scientific knowledge we put due emphasis on the following questions:

i. how well developed are the cognitive systems of various categories of users?

ii. by whom and by what means are these systems being developed?

iii. what is the optimum or necessary level of the development of the user's system for it to permit effective utilization of externally produced knowledge?

In order to approach these questions we need to make our abstract model of interactions between cognitive systems somewhat more realistic.

2. The channels of diffusion of knowledge in society

Until now we have considered a highly theoretical situation in which two completely distinct cognitive systems interacted with one another. The systems were distinct in the sense that there was no direct overlap between their underlying values. Of course in reality the situation is far more complicated. The creation of knowledge takes place in a large number of interaction cognitive systems which are based on similar or overlapping sets of values. Furthermore the dissemination of knowledge is carried out by a complex network of units the function of which is to "metabolize" the available knowledge to suit the needs of various categories of users. In our societies this metabolism of knowledge is performed by a host of intermediate agencies of which the most important are:

i. the general educational system,

ii. the professional educational system,

iii. the research contractors,

iv. the consulting agencies, and

v. the open scientific-technical communication system.

Together with the universities, government laboratories and other R&D units within the users' own organization the above listed intermediaries form a complex which is sometimes referred to as the knowledge industry.

The general educational system requires little comment. It creates the foundation on which all other systems of production and distribution of knowledge are based. However, it is the professional education system that constitutes the single most important direct link between most types of science and practical activities. The professions are concerned with identifying, analysing and satisfying certain needs of defined client groups. In so doing they search for new sources of knowledge relevant to these tasks. Such sources are systematically incorporated into the educational curricula of the professionals. The professional schools have proved extremely effective in integrating various strands of knowledge into coherent user-oriented cognitive systems. This ability has been greatly augmented whenever such schools became the seat of research activity. We can be therefore be confident that as the professionalization of our societies progresses, so will our ability to capitalize on the investment in R&D. Nevertheless the professions do have certain important limitations.

It is in the nature of professional education to be oriented mainly towards relatively permanent needs of fairly broad client groups. In addition, the educational process tends to be rather slow in translating the most recent scientific advances into applicable knowledge and skills. It is the function of research contractors to offset these shortcomings by developing stand-by intellectual capability for assessing and solving emerging problems of individual clients. The flexibility of research contractors accounts for their rapid growth. In the United States alone over 450 non-profit R&D corporations have been set up in a single decade (1955-1965). Some of these corporations enjoy world-wide reputation; for example the Jet Propultion Laboratory, the RAND corporation or the Standford Institute. We can include in the same broad category such things as cooperative research institutes, various quasi-independent government laboratories as well as certain profit-oriented R&D firms.

The consultants and consulting agencies represent a somewhat amorphous category which is intermediate between professions and research contractors. Whereas the latter specialize in filling up knowledge gaps by doing original research, the consulting agencies live by selling the available knowledge. In this they are similar to the ordinary professions - an outgrowth of which they often are - but differ in being more up-to-date in highly specialized areas. The consultants often come directly from R&D environments. Like research contracting, consulting is a growing industry. The technological complexity of modern society and the rapidity of change create an attractive market for those who have ideas and expertise to sell.

The last of the five main intermediaries listed above is the open scientific-technological communication system. This system plays a significant role in classifying, organizing and disseminating user-relevant information, especially through the media oriented towards specific professional and technical audiences. However, studies of various categories of users indicate that the importance of formal literature as a means of trasmitting knowledge to the practical users should not be overestimated - at least compared with the other channels and mechanisms listed above (see, among others, Allen, 1977).

In certain sectors of society - such as agriculture for example - the role played by the intermediaries is overwhelming. In these sectors the users (in the case of agriculture the farmers) appear largely free from the necessity of independently assessing and utilizing "raw" knowledge and information and function as mere consumers (often reluctant) of the goods and services produced by the intermediaries.*) This is natural if not for other reasons than on the grounds of intellectual economy. However, excessive reliance on the intermediaries may lead to the failure to develop the user's own ability to analyse his needs and situation. This may be dangerous in the long term. For instance: research contracting in the United States has grown largely in response to the needs of the government. The growing dependence on outdoor research has prompted some critics (see, for example, Nieburg, 1966) to ask whether this development did not significantly limit the government's control over the policy-making process. We shall return to this problem in the next chapter of this paper.

Quite obviously there always exists some gap between the user's needs and the way these are perceived and defined by the intermediaries. The extent of the gap will vary greatly from case to case. It depends on such things as the uniqueness of the user's needs and situation, their changibility, the absence/presence of interest on the part of the intermediate agencies, or even a conflict of interests between the prospective producers and

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*) Of course the intermediaries may also be viewed as users. These concepts are relative. However, the five intermediaries listed in this section occupy a special position, since their chief function is the acqusition and adaptation of knowledge on behalf of external users (clients).

users of knowledge. After all, the professions are not there solely to serve the interests of the clients, they have interests of their own as well. The consultants are prone to oversell their expertise. The research contractors work for those who pay them. The causes of discrepancies between what is needed and what is supplied are manifold indeed.

To diminish such discrepancies we may proceed from two directions. We may try to improve the intermediate system by reforming the professional education, stimulating emergence of new research contractors, promoting new consulting services, etc. But we may also try to improve the user's own capabilities to assess and analyse his situation and needs and to identify the sources of relevant knowledge. The central thesis of the present paper is that the optimal utilization of the available knowledge requires an appropriate mixture of these two strategies. A heavy investment in one without a certain minimum of investment in the other will soon lead to diminishing returns. The user's own analytical capability should not be viewed as a substitute or a mere complement to what is supplied by the intermediate agencies; it should rather be regarded as the prerequisite of effective exploitation and control by the user of the external sources of knowledge.

There is a good deal of evidence pointing in this direction. An example is the studies of cooperative research in industry. Research organizations (brach institutes, research associations, etc.) have been created in the industrialized countries to increase the innovative capacity of small enterprises which as a rule lack own R&D. A study conducted in Britain, one of the countries which has pioneered this approach, showed that the results of cooperative research were largely disappointing. According to the author of the study, Johnson (1973) the government ... "ignored the fact that the small companies rarely have staff of sufficient calibre to identify their problems, apart from applying research results unaided. What has happend is that (the institutes) now derive their main support from the larger firms." The author found also that the institutes did poorly as originators of process and product innovations of commercial importance. These conclusions are quite consistent with what was found in a recent Norwegian study (Bransjeforkningens betydelse, 1977). The study established not only that - whenever possible - the industries had clear preference for R&D done intramurally (that could be explained by the needs of secrecy) but also that the larger firms were clearly more satisfied than were the small ones with the services offered by the branch institutes. This last relationship is in all probability due to the causes described in the quotation from Johnson above. Indeed the general rule in industry seems to be that the use of external R&D resources requires a certain minimum of intramural R&D capability (see, for instance, Freeman, 1965).

An additional illustration of the tendencies described above is the fact that most contract research institutes in industry, are rarely asked to execute complete R&D projects. Instead they tend to provide solutions to various subproblems within larger projects conducted by the clients themselves. This again may be partly explained by the requirements of secrecy but the industry's distrust in the outsiders' ability to assesses adequately the intricacies of its commercial and technical problems is certainly as important.

The consequences of the low degree of development of the user's cognitive system will differ from case to case. The situation in industry need not be fully representative for what happens in government. Still other aspects of the problem may be crucial when we consider political organizations or private citizens. I shall discuss these differences in greater detail in the next chapter. Before doing that, however, let us consider more carefully the concept of user's "absorption capacity", i.e. the ability to identify and utilize externally produced information.

3. The nature and determinants of the user's absorption capacity

The absorption capacity of a user is both the cause and the effect of the level of sophistication of the user's cognitive system. A study of the literature suggests that both of them depend strongly on the following factors*):

i. the user's orientation towards change;

ii. the recognition of the importance of analytical functions within the user's organization;

iii. the development of the user's own research capability;

iv. the motivation to maintain high intellectual standards of the personnel/membership; and

v. an active strategy for maintaining permanent or quasi permanent links with external research environments.

The first two of these factors are related to the organizational culture and philosophy of the users. Social actors differ greatly in their expectations and acceptance of change. It is often observed by organization theorist that the acceptance of change and systematic planning for this change stimulate to analytical effort and information search (see for example Leavit, 1965 and Bozeman et al., 1977). These efforts are then reflected in such things as: the recognition of analytical functions as a distinct aspect of the user's organization (setting up of long range planning units and investigating committees, formalizing policy review procedures, etc.); treating these functions as part of the staff organization

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*) In what follows I shall limit our discussion to collective users such as organizations, institutions, etc. What is said, however, is, at least in principle, applicable even to individuals.

rather than of line organization; allocation of resources and prestige to the personnel involved, etc. The role of such analytical activities is to create a coherent policy-relevant picture of the user's situation. The more sophisticated this picture becomes, the easier it is to identify the knowledge which can help to make its articulation more distinct and practically useful.

The presence of well developed analytical function does not by itself imply the existence of a research capability. However, the latter constitutes a natural extension or outgrowth of the former. It can assume a variety of forms ranging from relatively routine monitoring of the user's activities and environment, through various forms of "operation research" and "system studies" to sophisticated long range programmes. Such activities help to assess the quality of analysis on which the user's policies are based, to close various knowledge gaps and to specify the knowledge needs which can be satisfied by external sources.

Crucial for the creation of requisite analytical and research capacity are the intellectual standards of the personnel. Not only it is important that the personnel should have appropriate professional qualification; they should also - if possible - have some research background in external environments. Gibbon and Johnson (1974) found, for instance, that the problem solvers in industry who had university education, and especially the PhDs, relied much more on the external sources of information than did problem solvers with less education. The mobility of engineers and scientists between research environments is a well documented means of effective technology transfer (detailed discussion of this phenomenon can be found in, among others, Shimshoni, 1970; Roberts & Wainer, 1971; OECD, 1973 & 1974; Allen, 1977 and many others).

The value of acquiring knowledge through mobility of personnel depends on the simple fact that it is generally easier to bring a knowledgable person to where the problems are than the other way around. This is an old truth; in any case it was known to Isaac Newton who wrote in a letter to N. Hawes: "If, instead of sending the observations of able seamen to able mathematicians on land, the land would send able mathematicians to sea, it would signify much more to the improvement of navigation and the safety of men's lives and estates on that element."

The above passage is cited by R. V. Jones (1978) in his celebrated book "The Most Secret War." Jones was one of the key persons assessing the relevance of physical sciences to various aspects of the war effort in Britain during the second world war. His book is a unique document demonstrating the importance of the scientis's immersion in the user's situation as the prerequisite of effective utilization of science.

Earlier in this paper I criticized the tendency to regard the problem of utilization of science as chiefly one of improving the communication system between scientists and practical people. This does not mean that the users should refrain from developing strategies for maintaining permanent or quasi-permanent links with relevant research environments. However, it must be clear that such strategies can work only if the other features of the users absorption capacity are developend to some degree. Examples of such strategies are: exchange of scientists, joint seminars, user support of postgraduate students, various training courses, research contracting, etc. These and other devices are frequently discussed in literature (see OECD, 1973 & 1974; Pavitt and Walker, 1974).

By rating various social actors on each of the above five dimensions of absorption capacity, we can make fairly accurate predictions about their success in utilizing the knowledge produced by the total R&D system. The poorer the actor's absorption capacity, the greater will be his frustrations with the seemingly unresponsive and intractable science.

At this point it may be objected: perhaps it is true that the "absorption capacity" is crucial for the effective utilization of science. But this capacity depends above all on the user's access to resources. What about the poor users? Isn't it they who suffer most from the problems discussed here?

It is certainly true that the poorer the user, the more difficult his situation will be. However, we should qualify our pessimism by pointing to the following considerations:

- the availability of resources is not the only determinant of the actor's absorption capacity; given sufficient motivation even resource poor actors can significantly improve their ability to use science; this is especially important since
- not all the features of absorption capacity need be prohibitively expensive: relatively cheap changes in the user's organization, recruitment policies, etc, may lead to significant gains in his analytical capability;
- relatively small investments in the improved absorption capacity may, under favorable circumstances, result in strategic information gains;
- the recognition of the importance of own analytical capacity may result in the pooling of the resources of poorer actors in a manner similar to what happens in the economic and political spheres.

It is important to keep in mindthat the difficulties in effective utilization of scientific knowledge discussed in the first chapter of this paper are by no means confined to the resource poor social actors. On the contrary, the most often debated problems are those concerning the rich and mighty, such as government departments, political parties, trade unions and the like. This paradox can be resolved if we recognize that the institutional and organizational facors are at least as important in determining the user's absorption capacity as are their material resources.

III SOME FACTORS AFFECTING THE UTILIZATION OF SCIENTIFIC KNOWLEDGE BY THREE CATEGORIES OF SOCIAL ACTORS (BUSINESS FIRMS, GOVERNMENT, AND VOLUNTARY ORGANIZATIONS)

A. General Observations

There are hardly any systematic investigations focusing directly on the ability of social actors to absorb and utilize externally produced knowledge. For this reason the analysis presented here will have to be general and tentative. Three broadly defined categories of social actors will be considered:

i. the economic/productive units (chiefly business firms),

ii. the agencies of government, and

iii. the voluntary organizations (political parties, interest groups, trade unions, etc.)

I have chosen these categories because they differ strongly among themselves on several crucial dimensions including: the nature of their cognitive needs, patterns of organization, social role, etc. The categories form a sort of continuum. As we move from the economic units towards the voluntary organizations, the relative importance of the development of coherent intellectual perspectives and of articulating central social values increases at the expense of the concern with specific technologies.

Each of the three institutional categories of users may be subdivided into subgroups according to the level of their resources. This will be done as we proceed.

Most of the present chapter will be devoted to the second of the categories: the government. This is natural, since the expansion of the scope of application of science, which was discussed in the first part of this paper, affected primarily the government. In addition, as we shall see, it is in government that the institutional and organizational obstacles to the effective utilization of science are particularly visible. By comparison, the situation in the economic sector seems to be fairly straightforward. The relatively restricted space allotted in this chapter to the voluntary organizations reflects the fact that the recognition of their role as users of science has been very slow and, consequently, there is little empirical knowledge concerning it. This does not mean that this category of users lacks importance. On the contrary, as pointed out earlier in this paper, the public involvment in science and technology through voluntary organizations has created a new type of social demand for scientific knowledge. The importance of this demand is likely to increase as the technological complexity of our societies grows.

B. The economic/productive units

The process of utilization of science in the economy has been a subject of intensive research for decades. There are now available several comprehensive reviews of what we know about technological innovation; see, for instance: OECD, 1979; and Freeman, 1975. This abundance of literature might suggest that the economic utilization of science is a major problem today. There are certainly many perplexing questions about the ways in which the R&D system can best be used to promote economic growth. However, compared with many other sectors of society, the economy tends to emerge as an extraordinarily effective consumer of R&D. There are several reasons for this.

The main link between science and economic units is specific technologies. Modern technologies constitute well developed cognitive systems. As such they are effective in helping their users to identify relevant sources of knowledge. The competetive pressures under which business enterprizes operate in market economies make them change-oriented, which encourages investment in knowledge. Free from direct public scrutiny, they can steer clear of ideological controversies and rely on informal channels for communication with the scientific community. These and similar factors create both incentives and opportunities to develop high absorption capacity. Recruitment strategies, development of intramural R&D capabilities, efforts to promote continuous contacts with external research environments are among the most important policies aimed at this objective.

In so far as there exist some outstanding problems of utilization of science in industry (other than those related to macroeconomic factors such as the business cycle, market structures, patterns of international competition, and the like), these are related mainly to:

- the technological inertia of certain "mature" industries, and especially,
- the relative lack of resources in certain (especially small) enterprises.

The level of research-orientation varies greatly from industry to industry. Pharmaceutical, air & space, electronic and instrument industries tend. For obvious reasons, to be research intensive. Most firms belonging to these industries have high absorption capacities. The situation is often quite different in the so-called traditional industries like pulp, mining, ceramics, and the like. The latter tend to depend less on science-based innovation and for this reason often fail. to develop professional and intellectual capabilities necessary for vigorous interaction with science. When suddenly exposed to competition from unexpected R&D based innovations they are often slow to make the necessary readjustments. This phenomenon is illustrated by the effects of computerization on the machine industries in several countries including the United States.

The concept of technological inertia is, of course, relative. The phenomenon is by no means confined to the traditional industries. In fact, it often arises from the earlier success in the application of science to technology. As a result of such success, the established notions of technological relevance become so entrenched in the mentality and organization of the enterprises as to make them incapable of spotting and of exploiting new opportunities.

Nevertheless the importance of technological inertia as the cause of low absorption capacity of economic units must not be overstated. Once the efficacy of a new technology and the relevance of the bodies of knowledge related to it has been established, an industry's ability to develop the necessary absorption capacity is largely a matter of resources. It is therefore the problem of firm size and financial stregth that is crucial.

One of the main determinants of the absorption capacity of industries, their intramural R&D capability, shows extremely skew distribution. In some countries such as Holland, more than half of all industrial R&D is concentrated in five firms. In others, such as Norway, the concentration is considerably lower but still significant. Although the correlation between investment in R&D and firm size is by no means perfect, it is sufficiently strong to expect negative relationship between the firm size and innovativeness. This expectation was confirmed by, among others, a study conducted in Britain by Freeman, 1972.

An obvious way of offsetting the deficiencies in the R&D capability of small firms is to develop some form of collective research. In the preceding chapter I have discussed the limited-success which such attempts have had in the past. Their main shortcoming, said, was that they underestimated the importance of the user's own analytical capability in the process of direction and utilization of external research.

There are of course instances in which certain forms of collective research have been successful. The situation in agriculture is probably the best example. In economic and organizational terms, farms tend to be very small units indeed. To expect them to evolve the capacity to apply science unaided is, in the overwhelming proportion of cases, Utopian. The success in organizing effective agricultural research depended not on the turning of farmers into scientists but on the development of a triple system of interconnected intermediaries: professional scools, specialized research institutes and well organized consulting and extension services. The development of the system was facilitated by the energetic involvment of agricultural interest organizations and the government.

The question is then why similar systems have not been organized in other production areas where small units dominate. The answers to this question will vary from case to case. However, two factors seem to play an important role in most instances: (1) the nature of the competition among the economic units in question and, even more important, (2) the relative homogeneity/heterogeneity of their technological needs. Agriculture is a good example of high level of homogeneity. The technical problems of farming are the same for large groups of users, which makes centralized research effort economic. The small industries on the other hand tend to have very specialized product profiles and are therefore far more individualistic in their needs.

There is very little that can be said about the possible remedies to such problems without going into the specific characteristics of individual industries. This cannot be done here. The aim of the above discussion was to emphasize the fact that the availability of resources is probably the single most important factor determining the absorption capacity in the economic sector. This is not necessarily the case with other types of users.

C. The government

As indicated at the beginning of this chapter, the problem of utilization of scientific knowledge by industry tends to be simple compared with the problems arising in the political institutions generally and the government in particular. However, when concerned with the latter we must make a distinction between the legislative and executive agencies of government, the function of which is to set up goals, norms and standards of control, and the subordinate agencies which are mainly concerned with production of goods and services in the public sectors (health service, postal and telecommunication services, specialized control agencies, etc.). The latter do not differ drastically from the ordinary economic units discussed in the section above. For this reason we shall exclude them from the present analysis.

The special problems affecting the legislative and executive branches of government depend largely on three factors:

i. the complexity and fluidity of the situations with which they are dealing;

ii. the high level of the bureaucratization of their organization; and

iii. the crucial importance of the ideological dimension on their cognitive systems.

The growing complexity of modern societies poses two kinds of cognitive problems for governments. Firstly, it demands an extremely broad scientific and technological expertise. This makes the maintenance of own R&D capacity difficult - one cannot create such capacity on all fronts simultaneously. Secondly, the very fluidity of the situation - resulting from unexpected events and pressures - makes the task of anticipating the R&D needs very difficult. These problems make the governments somewhat reluctant to commit large resources to maintain own stand-by research capability.

The second factor - the bureaucratic structure of governmental departments - adds to this reluctance. As pointed out earlier, the effective utilization of R&D capability depends on treating it as a staff-function responsible directly to the leadership of the organization. In government, this implies side-stepping the bureaucratic hierarchies of civil service, a difficult problem both because of the general tendency of bureaucraties to resist such attempts and because of the special feature of the governmental organization: the division between the political and the administrative/executive functions. Consequently the tendency seems to be either to diffuse the R&D and analytical capability throughout the bureaucratic hierarchy, which is likely to have a paralyzing effect, or to insulate it by delegating it down the hierarchy to the specialized technical agencies or by relying on ad hoc investigative committees. A by-product of these tendencies is an intellectually unattractive climate which has negative consequences on the recruitment of scientists into the machinery of government.

The third - and perhaps the most important - factor obstructing the development of effective absorption capacity within the governmental structure has to do with the public ideological aspects of knowledge. We have said that the actor's cognitive system represents an intellectual articulation of his values. In a political context this implies both a preference for describing the situation in terms of a special set of concepts which are meaningful to the actors' constituency and a committment to certain substantive beliefs and presuppositions. Since such cognitive systems are anchored in political and administrative context, any major changes within them may lead to political difficulties. For these reasons the presence of highly autonomous scientific expertise within the government may be politically problematic. The view that scientists and experts supply neutral facts which are used as mere raw materials of the political process is hard to accept. It applies only when the political actor's definition of a situation has been so completely saturated by the intellectual perspectives of a given scientific field that very specific and strictly technical questions can be put to the scientist. This means - to use the terminology introduced in the preceding chapter - a very high level of conceptual correlation between the scientists and the users. Such levels are seldom attained. When a scientist is brought in not merely to answer very specific questions but also to diagnose and conceptualize the situation, the chance of collision with the politician or with a civil servant is considerable.

The above factors tend to weaken the government agencies' analytical capabilities, which in turn has a negative effect on these agencies' ability to absorb and apply the externally produced knowledge.

Lacking own effective R&D capabilities, the governments and other political actors feel compelled to place considerable demands on the external R&D systems - primarily the universities. (These demands go usually much further than those raised by industry.) For example: one of the main themes of recent science-policy discussions in Sweden was the choice of strategies for the establishment of appropriate links between the R&D system and various sectorial agencies. Most of the strategies under discussion (Steverin, 1976) involved measures for increasing the influence of sectorial agencies over extramural research rather than for improving the absorption capacity of these agencies. Reflecting on these strategies one wonders whether they were not based on the same one-sided philosophy as that which led to the founding of collective research in industry. For the question is: how realistic is it to expect the scientists outside the government agencies to assess correctly the specific cognitive needs of these agencies? While the history of collaboration between governments and external research environments contains many success stories, the tensions and irritations are at least as common.

There can be little doubt that such tensions and irritations are at least partly the result of insufficient articulation of the cognitive needs of governmental agencies. Lacking the intuitive understanding of the problems faced by the users, the scientists have difficulties in living up to the expectations placed upon them. Even when the original statement of the user's problem seems clear enough, there is no guarantee that the researcher and the user will remain on the same "wave-length" throughout their relationship. Success in research depends to a considerable degree on the ability of the investigator to modify and redefine the problem as he proceeds. Without a really deep understanding of the user's needs such a process of redefinition is likely to lead the investigator away from relevant solutions. This danger is reinforced by many other factors.

The scientists who are not bound by the institutional loyalities of their counterparts inside the bureaucracy, will claim autonomy in their approach to the problems to be investigated. In fact, if they come from the academic environment, they are expected to claim such autonomy by their scientific peers. This often leads to a kind of righteous insensitivity to the actual need and constraints of the users.

There exists a considerable literature dealing with these factors. Most of it focuses on the special problems of the policy-application of the social sciences. (See, for instance, Komarovsky, 1975; OECD, 1977; Sinclair & Jenkins, 1970; Russell & Shore, 1977; - A recent study by Baklien (1979) gives a number of case descriptions illustrating the extent of mistrust and misunderstanding between the Norwegian sociologists working on policy-oriented projects and the potential political users of the results.) However, these difficulties are by no means confined to the social sciences, as witnessed by the recurrent controversies in the areas such as nuclear energy, environment, or food control.

In pointing to these problems I do not wish to suggest that the governments should give up efforts to exploit extramural R&D potential. On the contrary, one should strive to maintain close and diversified links with the external research environments. However, the successful exploitation of such links requires the improvement of the government's absorbtion capacity. The question is: how can this be achieved?

There exist several obvious ways of improving the analytical capacity of governmental agencies. Essentially, they are the same as those applicable in industry. Increased recruitment of scientists into the governmental bureaucracies is one of them. The assignment of a lager and more distinct role to the policy analysis units inside the government machinery, another. Building up, whenever possible, of own R&D capability, a third. These and similar measures are necessary as the foundation on which more elaborate and specific policies can be based. Yet, however important, the above measures cannot guarantee the government a contact surface with the producers of knowledge which is broad enough to cover all the diverse cognitive demands of the policy-making process. To fill these inevitable gaps, the government agencies have to rely on the existence of the appropriate advisory machinery.

The problem of scientific advisers has been the subject of debate for decades. Among the influential contributors to this debate one finds Brooks (1964), Don K. Price (1965), Cronin & Greenberg (1969) and Gilpin & Wright (1964). The increasing intensity of the debate is hardly surprising. Speaking of the American situation Brooks (1964) pointed out:

> "The function of giving scientific advice to the federal government has begun to assume a professional status, and a hierarchy of part-time advisory groups has emerged that parallels bureaucratic hierarchy within the structure of government."

This assertion is fully confirmed by Cronin & Greenberg's comprehensive analysis of the presidential advisory system in the United States. Similar, if less dramatic, trends can be observed in other countries. Their universality should, nevertheless, not be overestimated. The ease with which the advisory functions can be introduced into the governmental machinery depends strongly on the particularities of constitutional traditions. However, there also exist certain more general difficulties which deserve attention.

Although the presence of advisers in government is as old as government itself, the enormous growth of the advisory system and their "scientification" is comparatively recent. In fact this growth has been so rapid that the role of scientific advisers in the government has not been fully clarified. Some of these ambiguities, which are the source of frustrations and tensions, come into focus when we consider the similarities and differences between the role of "expert" and that of "adviser" proper.

There are two fundamentally distinct ways of utilizing science in the policy-making process. The first consists in employing scientists as the sources of arguments in the formal decision situations; the other as the sources of insight in the informal preparatory stages of the policy-making. The roles of experts and advisers are related to these two situations respectively. One of the fundamental obstacles to effective utilization of scientists in government is the frequent lack of proper separation between these two roles.

According to Brooks (1964), the main function of scientific advisers is:

> "To analyse the technical aspects of major policy issues and interpret them for the policy-makers, frequently with recommendations for decision and action. At highest levels this often involves the analysis of policy issues to determine which issues are political and which can be resolved on a technical or scientific basis."

Consequently, Brooks continues: " ... specific expertise is only a small part of the scientist's role as adviser."

In the terminology used in this paper, the role of adviser is to help to articulate the user's (politician's, administrator's) cognitive system rather than merely to supply the user with some set of discrete facts. Such a role presupposes an informal and intimate understanding between the scientist and the politician/administrator. In fact, it is a political role par exellence.

Unfortunately there is a strong tendency to down-play this political aspect of the advisory function in favour of the expertaspect. This is understandable since the popular image of a scientist is primarily that of an expert. And so the politicians/administrators tend to overemphasize the expertdimension of the scientist's role only to discover that what they often get from the scientist is unsolicited political advice disguised as objective scientific analysis. This often leads to politically embarassing situations. There exist many case studies describing this phenomenon. Margolis (1972), for instance, has found that the disagreements among technical experts involved in decisions concerning the choice of various weapon systems by the U.S. government depended to a very limited extend on the differences of opinion about ascertainable technical facts and to a high extent on the experts' opinions on broader issues outside the scope of their specific expertise. The problem of insufficient separation of the technical and political aspects of scientific expertise has been discussed also by Nelkin (1975), Clark (1974) and McRea (1976) - to mention just a few.

The tendency of the politicians and administrators to inflate the expert roles of scientists is often reinforced by the scientists themselves. First of all, the role of expert is more in keeping with the academic self-image than is the role of political adviser. It is also an excellent cover for the exercise of conscious or unconscious personal influence in political matters.

Such tendencies are usually easy to detect where the social sciences are concerned, but are often visible also in the natural sciences and technology, as demonstrated in the literature cited above.

Occasionally the inflation of the role of expert breeds conflict between the scientific community and the polity. The politicians/administrators respond to what they regard as the illegitimate encroachment by scientists on their reserved domains by developing all sorts of strategies to keep the scientific expertise in "its right place" or at least at arm's length. The standard features of these strategies include: non-response or overt indifference to what the scientist says; complaints about "academism", incompleteness or untimeliness of the advice; selection of experts who are not likely to cause trouble; fragmentation of issues, etc. (A rather entertaining analysis of these strategies was given by Clark (1974) who studied the use of experts in the controversy about supersonic transport in the United States.) These kind of attitudes breed, in turn, bitterness and even hostility on the part of scientists who feel manipulated and exploited. The net result is the breakdown of mutual confidence and cooperation.

The less analytically prepared and specific the problems which are handed over to the scientific experts, the larger the areas of potential conflict between the scientists and the politician/administrators. The expansion of the advisory role of scientists is the means of decreasing these dangers, since it enables the politicians to stay in control of the political dimensions of the problems requiring the use of scientific expertise.

In order to strengthen the advisory function in government one has to institutionalize it and make its political character explicit. (For instance: the advisers' appointment should be viewed as political rather than administrative.) This may require various adjustments both on the part of government bureaucracies and on the part of the scientists themselves.

There is much evidence that the process of institutionalization of the scientific advisory system is in progress in many countries, at least as far as the executive branches of governments are concerned. The legislative branches tend to lag behind this development but even here there are hopeful signs. Once again, it is the United States that seems to be in the forefront of development. According to B. Caspar (1977), in 1973 there were only two PhDs and only a handful of other persons with significant scientific backgrounds on the permanent congressional staff in Washington. In 1977 there were more than 50 staffers with PhD in science and engineering on the Hill. This dramatic change has been brought about partly as the result of action taken by several professional organizations who organized special fellowship programmes to send scientists and engineers to the Congress. But more significant was the need felt by the legislators to balance the executive's massive advantage in terms of access to scientific advice. Another important factor was the need to imporove the congressmen's ability to deal with the growing influence of the "extramural" scientific and technological experts on the legislative process.

Of course the above stated arguments for the strengthening of the advisory machinery of the government institutions do not imply downgrading the role played by the formal non-partisan expertise in the policy-making process. Quite the opposite: the more penetrating the scientific advice on which the policy proposals and counterproposals are based, the easier it becomes to identify meaningful areas of factual disagreement or ignorance, and it is in such areas that the available expertise can be legitimatelt and effectively used. The formal use of the scientific expertise is also necessary as a means of public control over the influence of the advisory systems whose loyalities are, after all, chiefly to the political actors they serve.

Let me conclude this dissension with yet another qualification, the expansion of the advisory function in government is easy in societies with large scientific communities. In such societies the pool of scientific expertise is large enough to allow sufficiently rapid turnover of the persons occupying the advisory roles and guarantee the continous availability of expertise which is not linked to the political establishment. In the societies with small scientific communities - as is the case in many small countries - the expansion of the advisory system may lead to too strong linking of the scientific community to the government. This is a dilemma with no obvious solution.

D. The Voluntary Organizations

By voluntary organizations I mean here such things as political parties, trade unions, other types of interest groups, citizen associations of various kinds, etc. Until recently very few such organizations showed much interest in the problem of utilization of science. However, the rapidly progressing politicization of science and technology is gradually changing their attitudes. The concern with the deterioration of environment, the multiplication of technological health hazards, the nuclear energy debate, the uncertainties associated with the introduction of other "super-star technologies", the social and economic complexities of planning and social reform activities, makes it increasingly difficult for the voluntary organizations to perform their functions without getting themselves involved in scientific and technological issues.

One of the reasons for the slowness of the above process is the traditional weakness of the absorption capacity of the voluntary organizations. As in the case of government, such organizations tend to be involved with too broad and too rapidly changing sets of problems to be able to rely on own R&D capabilities. If anything, their situation is even more difficult, since as a rule their resources are extremely limited. Another complicating factor is that some of them fear that by creating powerful internal scientific-technological expertise, they will allow the center of intraorganizational influence to shift from the political agents to the "technocrats." It seems, for instance, that the fear of technocracy is strongly accentuated in the Norwegian trade unions.

However, one must not overemphasize these difficulties. In the first place, the cognitive needs of the voluntary organizations are rather different from those of government or industry. Since they are seldom involved in technology development or in extensive monitoring research projects, they have no need for permanent R&D capacity. Their functions are of a more evaluative and critical character, and consist to a large extent in the mobilization of counter-expertise in the crucial areas of application of science and technology. Such organizations play also an important role as the champions of novel intellectual perspectives which challenge the established intellectual orthodoxies.

The success of voluntary organizations in the performance of the above mentioned functions will depend to a considerable extent on their ability to solicit free cooperation from the scientific community. However, even more formal approaches such as the setting up of investigating committees, are of great importance. Indeed it is vital that such organizations recognize clearly that the production of knowledge, or at least a systematic analytical activity must become one of their functions, since it is unrealistic to expect that the knowledge which is of special relevance to them will always be produced without their own participation. It is my feeling that it is the lack of recognition of such an analytical function that constitutes the main factor hindering the voluntary organizations from taking full advantage of of the society's investment in science.

There is, however, one more condition which must be fulfilled if the social utilization of science via voluntary organizations is to be fully effective. This is the creation of appropriate social fora. During recent years various suggestions have been made for the establishment of such fora - the idea of science courts is but one of them. One of the most comprehensive proposals has been submitted by the Council for Science and Society (1976) in Britain. It envisages - as a complement to the existing science-policy mechanisms - the creation of publicly founded but independent of government Technology Implications Commissions. The purpose of such commissions would be to permit sophisticated public debate on the scientific and technological issue.

Before finishing, let me add one more thing. In the course of the discussion presented in this paper, I have assumed the scientific community to be an essentially passive agent. I was concerned with the factors which diminish the user's ability to absorb whatever science seems to offer. This had led to the neglect of one extremely important mechanism of the social utilization of science: the direct impact which the scientist can have on the public opinion. By this I do not mean the various prizeworthy attempts at popularization of science. I refer rather to the attempts on the part of individual scientists or groups of scientists to communicate to the public some fundamental perspective on one or another issue of social importance, a perspective which conflicts with the current orthodoxy. The brief history of the environmental debate contains many examples of this kind. The economists have frequently fought their battles with the governments by going to the public. The importance of Keynes' press campaign to gain political support for his new revolutionary approach to economic policy is a good example.

Such "going-to-the-people" is a scientist's ultimate weapon in the effort to have his/her viewpoint taken into account in the formulation of public policy. In a democratic system this is, at times, a potent weapon. However, the discussion of this aspect of the social utilization of science falls outside the scope of the present report.

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