Science, Technology and the Development Process

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For fully three fourths of the nations of the world, the overriding social and political goal can be stated in a single word: Development. Although the precise implication of this word will vary somewhat from one nation to another, in almost every case, the principal meaning of development lies in an expansion of production and service activities of society in order to improve living standards. Almost without exception, these nations will see science and technology as a major tool for development, but they differ considerably in the particular ways in which they propose to utilize this tool. The broad problem is one of public policies for science and technology and it is this which I propose to examine today.

The specific policy questions involved are such things as: (1) how are science and technology to be supported, and (2) how are they to be utilized for specific problems? (3) What measures are needed to insure effective application of science and technology to social problems? A shorthand phrase to cover these various questions is, what are the public policies for science and technology, and an abbreviation of even this is simply "science policy". This is the phrase that we shall be using in much of what follows.

It is especially appropriate to be discussing the topic, science and technology and development, in Japan since, to almost all of the developing nations, Japan appears as the modern miracle, the success story *par excellence*; the nation, which through application of science and technology, has broken out of the categorization "developing nation" and has moved happily into the category "developed".

But even given the shining example of Japan, the problems which face any developing country are both particular and painful. Broad national goals must be developed, and specific program priorities must be established. These must be done in the face of crippling shortages: shortages of money, shortages of engineers and skilled managers, frequently even shortages of food and essential natural resources. Only a few decades back, it was possible to believe that the verriding requirement for development was quite simply capital, i.e. that given ufficient funds, industries could be developed which would be profitable and aise employment so that efficient and economic growth would thereby be assured. e know better now. We know that in the establishment of priorities and in he allocation of scarce resources, the most careful planning is essential. here must be broad planning in terms of social systems and geographic regions. here must be sectoral planning, for such important areas as agriculture, ndustry, education and public health. In context of this clear and generally erceived set of needs, there is also wide appreciation of the need for ncreased attention to a centrally important non-sectoral activity, namely science nd technology. A partial explanation is that there is a great deal of ommonality and interchangeability in the utilization of scientists, and for the pplication of technologies. Hence, a non-sectoral approach to science and echnology makes good sense. Of somewhat more importance, however, is the act that for almost all developing nations, science and technology equally, cientists and technologists, can be thought of as a scarce resource; a resource hose proper allocation and efficient utilization is of great import. This, it eems to me, is the real reason why the developing nations are increasingly generating xplicit procedures and agencies for the development of science policy.

As we shall see in a moment, the structures used by different nations for the evelopment of science policy differ greatly. However, there is a considerable ommonality in the specific topics to which science policy groups address aemselves. Among the important ones are the following:

(1) Projections of scientific and technical manpower requirements and the development of programs to insure the availability of the needed manpower.

(2) Policies and procedures for the acquisition of appropriate technologies, and for the modification of desirable but not fully appropriate technologies. Note that the phrase acquisition covers both technology transfer from developed nations, and technology which comes from local programs of development and technology innovation.

(3) Policies to insure the proper flow of technology into such important public service sectors as transportation, construction and housing.

(4) Policies for the allocation of scarce natural resources.

(5) Programs for the support of basic science and of long-range applied research in universities and research institutions.

(6) Policies to encourage research and development by private industry.

(7) Policies to insure sufficient research and development in sectors where private industry is often inadequate or ineffective. Examples are: agriculture, transportation, public health.

(8) Encouragement and support of appropriate roles in the development process for universities and other institutions of higher learning.

Needless to say, certain countries will exclude some of the above from their science policy activities, and other countries will add activities not mentioned here. However, there is enough commonality among the national efforts that this list is a fair approximation of what typically constitutes science policy.

I have stressed that an overriding general concern is the application of science and technology to the problem of an increased standard of living. It remains true, however, that science and technology, and policies therefore, relate to many other national goals and priorities, among them education, better health, protection of the environment, military weapons and even questions of national prestige. Given the wide span of possible topics, it is of great consequence to have a far sharper definition than we have so far given as to what is actually encompassed within the category, public policies for science and technology. Otherwise, there is the danger of so much overlap and confusion that "science policy" simply degenerates into "public policy." A particularly useful analysis of this problem was recently made by Prof. John Montgomery of Harvard University and bears repeating here.[1]

1 "Science Policy as an Organizing Principle for Government Action" by John D. Montgomery; presented at the Symposium on U.S. Bilateral Aid Strategies and Programs in Selected Areas of Science and Technology, at Cornell University, May 8-9, 1973.

As Professor Montgomery sees the problem, one should think about public policies for science and technology as principally involved in supplying answers to the following three rather different kinds of questions:

(a) What policy decisions must be made for the effective application of science and technology to specific social needs?;

(b) What kinds of information linkages must be established in order to
.st in the carrying out of the policies?;

(c) How does one insure that the potential clients of new technologies,
.ic or private, are made aware of the new opportunities and respond favorably to them?

Three important levels of decision making are required. At the broadest
el, there is the problem of (1) selection of appropriate technologies for
:icular tasks and programs. At a more specific level, there are decisions to
nade about the (2) implementing agencies to apply the selected technology. Finally,
re are decisions about (3) implementing procedures, including specifically, the
stion of mobilizing support. The first level of decision making is normally
the charter of national agencies for science policy. It is less common for
n agencies to have responsibility for the second, and especially, the third
el of decision making, in spite of the fact that these two levels often
n out to be critical to the success or failure of a given science policy.

A point of great consequence is that in many real-life situations, when
licit attention is not given to the required decisions, inadvertent or
idental decisions will turn out to have been made implicitly. Indeed, it is
too common that a major decision on the application of technology is made
only then, after some time, is it belatedly recognized that accidental
isions about implementation or about citizen involvement have led to serious
itical difficulties.

A simple response to this danger of inadequate or accidental decision making
to say that more information must be provided. However, the problems of how
to whom information is to be provided are clearly critical. It is here that
tgomery introduces the concept of linkages, which are to be thought of
specific information exchange paths which must be established and used if
decision making on science and technology is to be effective. Six linkages
of particular interest: (a) between related public and private agencies;
horizontally, between or among government ministries at the same level of
hority; (c) vertically, within ministries, with pathways which extend
m the decision makers to the final consumers; (d) linkages among the private
ustries and other agencies which utilize science and technology; (e) linkages

commercial linkages with, e.g. multinational corporations.

This is not the place to explicate in detail either the importance of these linkages (which is almost self-evident) or the procedures to develop them. The significant point is that without attention to these linkages, and more generally to proper flow of information, even the best science policies and decisions can be ineffective.

There really are two messages which need to be stressed. The first is that if science policies are to be useful, they must be closely consonant with national goals and priorities. It is self evident, for example, that a science policy which leads to far more effort on research on nuclear energy than it does on agriculture will usually be of questionable merit. Similarly, a science policy in a developing nation which ends up allotting more funds and effort to basic scientific research than it does to applied research must surely be questioned.

The second message is that it is not enough to make sensible decisions on the utilization of science and technology or of scientists and engineers. Attention must equally be given, even at the stage of policy development, to the problem of implementation. It is for this problem of implementation that the information linkages are so overwhelmingly consequential.

At this point, one can reasonably ask, are there particular organizational requirements for the effective development of science policy, or in other words, are some science policy organizations greatly to be preferred over others? The answer is, probably not. If a science policy apparatus is to be effective, it must: (a) have responsibility for policy development in some, preferably most, of the areas listed above; (b) have the staff and budget to permit it to obtain competent analyses of policies and problems in its areas of responsibility; (c) have firm working relationships with the agencies which will ultimately carry out policies; (d) be able to make its policy recommendation in a way as to have significant influence on the political decision making.

Looked at in the light of these requirements, it can be seen that the size and competence of a science policy organization, and especially the character of its linkages with other organizations, are at least as important as the formal structure. Let me illustrate this by pointing to two structures for two developing

The first one is that of the Republic of South Korea, in which much science policy development is centralized in a single agency, the Ministry for Science and Technology, MOST. The diagram below illustrates the structure of this Ministry. Although MOST was established only in 1967, it has become a most significant agency in the South Korean scene. There are several reasons for this. In the first place, its Director has cabinet-level status, and reports in directly to the President. Secondly, the agency has responsibility for a group of important components of the Korean apparatus for science and technology. Specifically, it has responsibility for the Atomic Energy Laboratories, the Korean Institute for Science and Technology which is an applied research institute, and for the new graduate-level university for science and technology, the Korean Advanced Institute for Science (KIST). Finally, MOST has important assignments for planning and policy development and a sizable and competent staff to carry them out. But in spite of these impressive credentials, one may still wonder whether MOST has yet built an adequate number of the information linkages whose importance is stressed by Professor Montgomery. In particular, the linkages with industry, which is after all a principal user of technology, and with the agriculture activities may be less than optimal.

A very different arrangement, but also one where science policy development seems reasonably well integrated into decision making and program implementation, is to be found in Colombia. The structure, however, is quite different than that of Korea, and is far more pluralistic. The diagram below gives some sense of the arrangements within Colombia. The important thing is that a number of more or less parallel agencies, the National Planning Department, the Ministries for Education and Agriculture, COLCIENCIAS, ICFES, all have important responsibilities for the development and application of science policies. From the standpoint of decision making, the Planning Department is probably the most significant of the policy agencies. For direct support of science and universities, ICFES is the central agency. For broad support of scientific research and for studies on the utilization of science and technology, COLCIENCIAS is probably the most important agency. With a decentralized structure like this, it is of great practical significance that the linkages between these several agencies be close so

Hence, although the overall structure is much more diffuse than in South Korea, the effectiveness of the agencies in developing science policy and their influence on decision making appears to be comparable to that of MOST in South Korea.

This comparison of two rather different but effective national structures for science policy development strongly suggests that some of the most important requirements for effective utilization of science and technology in development are not to be found in the organization charts. Whatever are the formal structures, the effective science policy agencies will be those which (1) have a clear understanding of the national goals and the characteristics of their societies, which (2) are well integrated into the overall decision making processes, which (3) have able people and which (4) have sufficient funding to be able to carry out the needed studies. Finally, and most importantly, they will have established and will strive to maintain the close linkages between themselves and the other involved agencies so that information flows freely, decisions are reached promptly and implementation may be treated as a vital element of the entire process. Note also that if a science policy effort is to remain effective there will need to be continuous attention to the problems of linkage and information flow. After all, priorities change, people change and governments change, all of which means that the needed linkages will be in a constant state of flux and change.

If science and technology are to be effectively applied to the development process, it will clearly be necessary to obtain the best efforts of a number of skilled planners, knowledgeable scientists and experienced economists and engineers. This can be a problem since this sort of person is almost always in short supply. This brings me to my final topic, which is the great importance of persuading the universities of the developing nations to undertake much larger roles in the application of science and technology to development.

The universities have a good deal to offer. In the first place, some of the best talents in science and engineering are to be found in the universities. Secondly, the universities are typically to be found in the significant regional centers of countries, i.e. they often are in a better position to understand and work with local and regional groups than are agencies of the central government.

'inally, the active involvement of the universities and their faculties in the development process will almost inevitably be reflected in the instruction which they give their students and hence, will contribute importantly to the sensitizing of the new generation of scholars to the problems of development.

Unhappily, however, bringing universities actively into the development process is typically neither automatic nor easy. University faculties are often overworked and poorly paid, with little time for research. Research facilities are often minimal. Organization by discipline-oriented departments -- chemistry, sociology and the like -- sometimes makes it difficult to establish the kinds of interdisciplinary, applied study efforts which many problems of development require. Even so, many individual scholars do already work on development problems, and in selected areas, e.g. agriculture, many universities have substantial efforts. The universities themselves can help here by encouraging and supporting still other research efforts on the development process. However, the principal initiatives for expanding these university programs and especially in providing financial support for them will almost surely need to come from the national governments. The implication therefore, is that here is a science-policy problem in itself, how effectively to bring the talents and efforts of university faculties to bear on problems of development?

Fortunately, there already exist some interesting models of what universities in developing nations can contribute. The Universidad del Valle in Cali, Colombia, appears to be a good example of a university which is effectively involved in development programs. The Universidad del Bahia in Bahia, Brazil may well be on its way to being a second example, and there are doubtless many others.

So far in this analysis I have said virtually nothing about the role of the <u>developed</u> nations in this problem of utilization of science and technology for development. This omission was deliberate. I am convinced that the first essential task is for the developing nations themselves to outline their own national goals and objectives, to set up science policy structures which fit their needs and political systems, and finally to bring in university scholars and similar people in ways which are consistent with their social pattern. Agencies of developed nations and the specialized international agencies can be various nations have done. However, the ultimate initiative for serious study of the uses of science and technology must be that of the developing nation itself. Once the developing nation has established its goals and set up an appropriate structure, opportunities for effective collaboration with developed nations and with international agencies are very great. In addition to interagency collaboration, collaborative programs between universities in developed and developing nations can be important and effective. Comparative studies, involving several nations, can be usefully made of effective policies and procedures. Exchange programs of technical people can assist in training and in the interchange of experiences.

For all these programs, the unity of science, which is our theme, has a special meaning and offers special opportunity. Traditionally, scientists of the world think of themselves as members of an international community. They speak the same scientific language, understand each other's problems, and have experience in collaboration in joint research programs. This same unity of science can and should be applied to problems of development. Here is a great challenge to the scientists of the world, and it is one which we should all be eager to accept.

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