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BUILDING NATIONAL INSTITUTIONS FOR SCIENCE AND TECHNOLOGY IN DEVELOPING COUNTRIES

Proceedings

from a Workshop conducted by the American Association for the Advancement of Science for the U.S. Department of State, as a contribution to U.S. preparations for the United Nations Conference on Science and Technology for Development.

April 18-19, 1979

Charles V. Kidd, Editor

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IN

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PREFACE

The proceedings of this workshop are the outcome of one of four meetings convened by the American Association for the Advancement of Science at the request of and with financial support from the Department of State. The purpose was to provide ideas for the U.S. delegation to the U.N. Conference on Science and Technology in Development which will be held in August 1979. In this connection, Ambassador Wilkowski who heads the Department of State staff in charge of preparation for the U.N. Conference wanted to attend this meeting but it conflicted with a preparatory meeting for the U.N. Conference (See Appendix C).

The papers are substantial. They contain new ideas and specific recommendations, and the discussion should enhance the value of the papers.

The reader will note that neither the recommendations nor the discussion are comprehensive and tightly organized. The reason for this is that they are the outcome of a conference based upon papers that could not cover the entire field, and at which the participants were encouraged to express their views freely. Spontaneity and vigor were more prominent characteristics of the meeting than was a disciplined search for order and comprehensiveness.

Charles V. Kidd

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I. INTRODUCTORY REMARKS

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The meeting is about institutions and structures - and infrastructures. In preparing for this meeting, I had to consider for the first time the meaning of "infrastructure", a term for which I have had until recently an instinctive aversion. Since I had no precise understanding of the meaning of the word I looked it up. It means: "The underlying foundation or basic framework as of a system or organization." That is direct and simple. Yet in practice the word often seems to mean so many things to so many people that it lacks any meaning. But I have solved the problem for myself by speaking of infrastructure only in connection with some specific center of interest. In this case, the center of interest is science and technology, and the infrastructure consists of the institutions which we shall be discussing. If the center of interest were economic development, the elements of infrastructure would be quite different. Indeed, science and technology can be considered as part of the infrastruture for economic development, along with such things as communications, roads, bridges and transportation. There is no such thing as infrastructure in general, unrelated to any focus of attention. Any institution or activity can be a primary focus of attention in one context and an element of infrastructure in another context. This may be where many people start, but the idea that the content of infrastructure is determined by the subject under discussion and that any given institution,

activity or structure can be either a primary goal or part of an infrastructure, came as a clarifying light to me.

Now with this terminological byway explored, we can consider the substance and purpose of the meeting.

One of the first questions is the rationale of centering attention on institutions. This approach creates an obvious problem because structures exist to carry out functions that are in turn determined by national goals. It is impossible to discuss structure rationally without having goals and functions in mind, so there will be frequent mention of the purpose for which institutions exist. But the focus of the discussion will be on institutions.

Establishing an administrative entity is sometimes equated with and substituted for action. It would be an obvious error to assume that the establishment of an administrative structure for science policy would automatically produce sound policies. This point has been made by the Secretary General of UNCSTD, who has correctly pointed out that:

> The solution to the problems being dealt with by the Conference should not be sought in purely institutional formulae...I myself emphasized the artifical nature of purely institutional formulae, for in point of fact the problem is essentially one of the political will of Member States, both developed and developing.[1]

However, it would equally be erroneous to assume that political will can in this area become manifest over the long run in the absence of institutions, or that the strength of institutions is irrelevant to the execution of political decisions.

[1] A/Conf. 811 PC/L. 2, 24 January 1978

We shall be discussing a number of institutions for science and technology. The first is institutions for formulating and coordinating national policies for science and technology. The second is institutions, such as universities, research institutes, national industries and private corporations which actually carry out the research, development and training functions. Weiss would correctly add all of those institutions whose decisions markedly affect technology, such as consulting engineering design organizations, central planning agencies and central banks. Moravcsik provides a useful taxonomy of institutions, people and problems in his opening paper, and Schweitzer's paper elaborates upon that taxonomy and adds some new ideas.

A few introductory words on the policy and coordinating bodies may be in order. As I see it, a number of considerations have prompted a world-wide movement towards the establishment of central organizations for science and technology in national governments. Establishment of a central structure for science and technology is a step towards building indigenous capability in these areas, and could be important for this reason.

As national activities in science and technology become more significant in developing countries, it often becomes useful to have a central point for administering activities related to science and technology -- such as fellowship programs -- which do not fit easily into any single ministry.

Central structures are often useful devices for increasing the effectiveness of communication on research and manpower matters with other developing and developed countries, and with international agencies on matters related to science and technology.

The existence of outside funds from other nations or from international agencies has generated pressures for central science and technology policy bodies. Relatively small amounts of money from these sources have often exerted remarkably powerful influence over the research and development policies of developing countries. The developing countries provide about 90 percent of the total funds for research in the form of basic salaries and operating costs of universities and research institutes, while the remaining 10 percent or so of outside funds strongly biases the lines of research and development effort. In this circumstance, developing countries are well advised to have some means of monitoring and even controlling outside funds. Anandakrishnan amplifies this point.

Finally, effective use of scarce resources requires not only the establishment of priorities but organization and effective mechanisms to carry out the priorities. Science and technology are increasingly recognized in developing countries as activities that must be viewed as valuable and scarce, and that therefore require organization at the national level. Policies relating to the development and use of manpower for science and technology are clearly important and clearly an integral part of overall policy for science and technology.

All of these considerations lead me to the conclusion that these central structures have important functions to perform, that more of them will be founded, and that their significance will increase.

Yet we all know that the organizations in many countries are weak and disconnected from centers of power, and that they operate under severe handicaps. Some observers think that some research councils should remain weak as a means of curtailing their ability to do harm. Organization and coordination can, if not done carefully,

stifle research. Instead of forming a much needed bridge between science and technology on the one hand and administrative entities and politicians on the other, institutions can form a bridge for an invasion of science and technology by politics and by the less productive manifestations of bureaucracy. I am sure that each of us can cite instances where these things have happened.

I hope that we can discuss these matters in some detail. What are the sources of weakness? How can the significant functions that they are supposed to perform be performed better? I also hope that we can consider what the United States can do - if anthing - either to help countries establish appropriate structures, or to make them more effective.

Turning from policy oriented to operating institutions, which are by all odds the most significant ones, there are private and public instrumentalities. In the private area, the transnational corporations are significant institutions, but other smaller enterprises are also important. Robert Cotton, Charles Dennison and Warren Keegan will discuss the transnational corporations.

A particularly important characteristic of structures for science and technology in developing countries is the pervasive absence of an organized approach to the difficult problem of acquiring, adapting, developing and diffusing technology. The transnational firms are by far the most significant organizations so far as transfer of technology is concerned. National councils for science and technology are typically poorly equipped to deal with national interests in this field. Bodies for approving investments and licenses exist in most countries, but this is only part of a total program for securing, modifying and diffusing technology most effectively.

I know of the Andean pact effort and of the Mexican and Brazilian efforts to secure technology on more favorable terms, but there must be other models in other parts of the world.

It would be interesting to explore the reasons for the scarcity of effective domestic governmental organizations designed to help developing countries cope more effectively with the acquisition, development and diffusion of technology. There are many possible explanations:

1. The problems are often best solved outside governmental channels, and the most effective governmental policy may be "hands off."
2. The central importance of effective technology for developing countries has risen to prominence so recently that there has been insufficient time to establish effective institutions.
3. The problems associated with more effective use of technology in developing countries are so diverse that no one institution can serve as an effective focus.

There are no doubt additional considerations and I hope that they are brought out in the discussion.

My view at the moment is that over the next decade or two the establishment of institutions for more effective acquisition and use of technology will be one of the most significant structural developments in developing countries. I hope that this view will be confirmed, modified or rejected in the discussion.

One of the most significant and debatable areas of infrastructure for science and technology is that of institutions for education and training. An even more intensive debate concerns the role of universities. For example, what roles related to development can they play effectively? Should they be made more effective, direct agents

for economic development? Is so, how? How are the research, service, and educational roles of universities to be reconciled? K.N. Rao will analyze questions such as these. In addition, he will present an interesting and specific analysis of types of developing countries and activities appropriate to each.

The last item on the agenda, but not the least significant, is the relationship between national institutions, international organizations and the transnational firms. Here the focus will be not on the functions of international organizations as such, but on the relationships between national and outside organizations. Dr. Anandakrishnan's paper is on this subject, but he also has some wise observations on domestic institutions.

Finally, all of the judgment expressed by speakers in papers and by other participants during the discusssion are personal and do not necessarily represent the views of the organizations with which the members of the group are affiliated. Similarly, the recommendations are simply codified expressions of individual judgments on which there was a consensus within the group.

II. RECOMMENDATIONS FOR ACTION BY THE UNITED STATES

Ambassador Jean Wilkowski asked the group to present recommendations for consideration by her Office and by the U.S. Advisory Commission for the U.N. Conference on Science and Technology for Development. The proposals which follow are drawn from the papers and discussion at the meeting. They represent a general consensus although there was not complete agreement on all points. Since the suggestions are drawn from a number of sources, they differ in scale and in manner of presentation. The suggestions fall in three groups -- proposals for action by the United States, suggestions for action by developing countries to which the United States might contribute and suggestions for objectives to be sought by the United Nations Conference on Science and Technology for Development (UNCSTD). They are presented in that order.

The papers themselves contain many sound general recommendations in the form of suggestions as to how the problems of development should be analyzed and approached. The Ramesh, Weiss, Kamenetzky paper, for example, stresses explicitly the seldom emphasized point of the vital importance of taking into account the full range of relevant "non R&D" institutions which often influence the amount, characteristics and rate of diffusion of technology more than those institutions with R&D missions. Such significant ideas cannot be translated into "action items," but they are often more influential than specific, limited proposals. For this reason, the recommendations of the workshop in a full sense can be understood only by reading the papers.

A. Respect the Goals of Developing Countries

Developing and developed countries should set their own priorities and these should be respected. Cooperation is possible when there is reasonable correspondence among these goals. Industrialization and generation of jobs are important on the agenda of most developing countries. Overemphasis by the United States on its priorities -- for example, basic human needs and dangers to the global commons -- to the exclusion of other goals -- such as creation of an industrial base and more efficient processing of natural resources -- will be viewed by many developing countries with suspicion if not antagonism.

B. Establish an Institute for Scientific and Technological Cooperation

The sense of the conference was that the United States had not used or helped developing countries use science and technology with full effectiveness as tool for economic and national development, and that collaboration with the more advanced countries in particular, in activities involving science and technology had been inadequate.

The most significant recent institutional development affecting the use of science and technology for development by the United States is the proposal to establish a new Institute for Scientific and Technological Cooperation. Further discussion of the Institute brought out these points of general agreement:

1. Prompt enactment of legislation establishing the Institute would be in the national interest;
2. It is important that the Institute have a substantial degree of autonomy with and diverse support from a strong advisory group or governing board;
3. Foreign nationals, with understanding of an experience in both developing and developed countries and with independence from their governments, should serve as members of such a group,

following the successful precedents set by other developed countries;

4. The new Institute should place heavy emphasis on long range institution building and on continuity of support for carefully selected areas of emphasis, as contrasted with short range support of a large number of projects.
5. The new Institute must be established under circumstances which establish its capacity to recruit a substantial proportion of the staff from universities, industry, other countries and other non-federal sources on a revolving basis.
6. While a new organization with specific capacity to use science and technology more effectively for development promises to add substantially to the capacity of the United States to collaborate with developing countries, it would be well to understate rather than overstate its potentialities because developing countries have in the past found that the United States has promised more than it has delivered.
7. The ISTC should rely on the tremendous potential for transfer of technology from two sources -- smaller firms in the United States and experts in community action in the United States.

C. Use Non-Governmental Organization More

So far as the United States is concerned, cooperation with developing countries in building institutional capacity should be based to a substantial degree on non-governmental and quasi-governmental organizations. Institution building almost always involves delicate internal political problems. Organizations such as universities, foundations and professional societies

are often better equipped to work in such an environment than are official agencies, and they should be called upon more by the U.S. government.

Some inherent limitations of governmental channels further emphasize the essentiality of informal relationships. Governmental relationships tend to be means of expressing national interests as these are interpreted by governments. Those interpretations of national interest are quite different from national interest as defined by scientists. To a degree never achieved by national governments or by the United Nations, science is an international enterprise. Scientists tend to interpret national interest in terms of a cooperative effort to advance knowledge, and this is an approach to relations between developed and developing countries that should strongly complement efforts in a governmental framework. Moreover, the governmental approach is often in practice the uncoordinated total of the policies and programs of a number of semi-autonomous agencies. This complicates the task of collaboration through government. These realities are additional reasons for greater emphasis on non-governmental channels as agents for collaborative efforts.

D. Expand Manpower Development Efforts

A theme reiterated in a number of papers is the significance of the development of manpower as a prerequisite to economic and national development of developing countries.

Concern for manpower development and utilization is inextricably tied with all aspects of institutional development. Since educational institutions in many developing countries are now increasing their output faster than demand, demand-oriented strategies ought to receive more emphasis.

Over the past decades, the U.S. has been closely involved both in institutional development in the less developed countries and in the education and training of large numbers of foreign nationals in U.S. educational institutions and in government laboratories and industry. Not just enlightened self-interest but also the broader humanitarian and cultural concerns of the nation require that such activities continue, but be adapted to meet changing needs, capacities and aspirations of the developing countries. Collaboration in development is a two-way street with opportunities to learn and to teach. Artificial barriers to the free flow of people in search of knowledge and understanding is ultimately counter-productive.

The following are some specific initiatives that are worthy of consideration:[1]

1. Improve Capacity for Manpower Planning and Supply and Demand Forecasting.

   The U.S. has through its aid programs given much attention to the questions of employment and unemployment in the developing countries. The focusing of these concerns on the critical areas of science and technology is a pressing need. Assistance to LDC efforts could take several forms depending on the country and problem area:

   (a) Creation of cadres of manpower analysts in appropriate institutional settings in the LDC's to improve such things as methodologies of manpower forecastings, wage

[1]Based on suggestions by Rao, Schweitzer and Useem, as modified by discussion.

and salary surveys, research on occupational choice and information on employment opportunities;

(b) Establishment of manpower data banks and promotion of annual assessments of high level manpower.

(c) Support for "state-of-the-art" review of manpower needs in specific problem areas and in critical occupations.

(d) Collaboration with central bodies such as research councils in high level manpower analyses and in the general area of science and technology policy analysis.

2. Study of the Characteristics of Scientists and Engineers

Too little is known about the characteristics, working environment, values, motivation and productivity of scientists and engineers in developing countries. More extensive research on these matters would benefit both developing and developed countries.

The current debate over the goals of development, and over the contributions of science and technology to these goals, led to the suggestion that the United States urge the United Nations to sponsor research on the aspirations of the poor, the social aspects of the development and use of technology and the psychological and social aspects of the motivation of urban and rural workers.

3. Manpower Development Through Collaboration

Efforts are needed to refocus U.S. collaborative programs for manpower development in light of new needs perceived and articulated by the developing countries themselves. Illustrative

actions might include:

(a) Inter-university collaboration in research and curriculum development.

(b) Promoting regional networks in which U.S. universities would be included.

(c) Programs to enable U.S. professors to teach and do research overseas.

(d) Collaborative arrangements in sub-professional technology programs.

(e) Increased emphasis on management education and especially the management of technology-based enterprises.

(f) Transfer of knowledge and experience in the organization and management of student loan and scholarship programs.

(g) Transfer of experience in education and training for women and other disadvantaged groups in technology fields.

(h) Promotion in U.S. universities of curricular and non-curricular initiatives to adapt programs for the special needs of developing country students.

4. Stress Training of Technicians

In considering the development of manpower, there was a consensus on the point that training of technicians ranked in importance with the training of scientists and engineers. The thought on this subject that emerged is the need to elevate the social status and prestige of technicians and institutions for training them and to make training more directly relevant to actual job requirements. In many countries, young people would rather be

an unemployed university graduate than an employed technician.

5. Revive the SEED Programs

Revive the program for sending individual U.S. scientists and engineers to laboratories in developing countries. (This is the program, Scientists and Engineers in Economic Development, administered by NSF and recently abolished.) The program has been repeatedly evaluated and found to be a very successful low-cost program. The Department of State should take the lead in sorting out whether AID, NSF, or ISTC should assume responsibility, but this success story should not be allowed to die.

6. Improve Programs for Foreign Students in the U.S.

(a) No Diluted Engineering Courses for Foreign Students

Foreign engineering students are typically required to undertake unpredictable and often unprecendented tasks. A high premium is placed upon initiative, responsibility, ingenuity and adaptability. Rigorous training in basics is the best way to inculcate these characteristics. Curricula diluted to meet what are mistakenly interpreted as the needs of foreign students are no favor to the students. At the graduate level, there are well known means of linking work to conditions and problems in the home country. These include writing theses on indigenous problems.

(b) Counsel Prospective Foreign Students More Effectively

The International Communication Agency should strengthen its student counseling services throughout the developing

countries. Given the myriad of universities and colleges in the United States, the optimum matching of prospective students with the most appropriate schools will never be achieved. However, a little advice can go a long way in reducing obvious mismatches. The problem is further confused as a number of U.S. institutions of dubious standing expand their recruitment programs in the developing countries.

7. Use the Peace Corps to Upgrade Secondary School Science and Technology Teaching

Critical to the upgrading of science and engineering education at the university level is an upgrading of the quality of technical preparation at the secondary school level. The Peace Corps, which has been retrenching under the basic needs philosophy, should show greater flexibility and should expand its programs for the teaching of science and mathematics in secondary schools. The need is acute and the United States is well equipped to help fill the void.

8. Train "Jacks of All Trades" for the Urban Poor

The United States should support efforts of developing countries to train people who are capable of translating technologies into forms usable in poor rural areas and capable of eliciting and developing the ideas of villagers.

E. Improve Communications

It is generally agreed that the flow of scientific and technological information both within and to developing countries is inadequate, but how the flow can be made more adequate is controversial. The conferees agreed upon these general policies:

1. Increased attention should be paid to the flow of information field by field and problem by problem. Large, general purpose automated information storage and retrieval systems designed to provide information on many topics on demand to developing countries are expensive and ineffective.
2. Multiple formal and informal channels should be used to convey information -- the telephone, visits, consultants, journals and specialized information systems.

The group also reached a consensus on three specific proposals for the United States.

1. Establish a New Journal of Scientific and Technological Information for LDC's

   The United States, with the International Communication Agency taking the lead, should consider producing a new publication -- a Journal of Scientific and Technological Information -- directed to developing countries. The journal would publicize the existence of organized sources of information on science and technology in this country, describe the problems and opportunities in securing access to technological information, present information on

important topics -- such as particular strengths of individual higher education institutions in the United States -- in special issues, review articles with citations on the state of technology in selected areas, and book reviews. Such a journal should complement existing publications (e.g., Interciencia). It would not only present needed information but would be a tangible demonstration of the willingness of the U.S. to share information.

2. Enhance the Effectiveness of Existing Science and Technology Communications Networks

There are throughout the world many effective networks for transmission of information on science and technology. The United States could collaborate in making these more effective, with a large return from a small investment. Initiatives in this area could include support for regional and national science and technology associations and especially those concerned with technology matters. This is best done through central bodies in the developing countries and with the help of U.S. professional associations. Increased support for U.S. participation in international conferences is needed to sensitize and inform members of the U.S. private enterprise, and governmental and academic communities regarding the real needs and aspirations of the developing countries in the contemporary context when concepts of interdependence and autonomy are strangely at odds with each other.

3. Appoint Regional Science Attaches

Regional Science Attaches should be assigned in Southeast Asia and West Africa. The Department of State has little capability to keep abreast of science and technology developments in these two areas. A number of agencies and sponsoring technical programs in the regions, and the countries of these regions are anxious to strengthen their ties with the U.S. If ISTC comes into being, the situation will be even more chaotic. The "Billings model," involving a broadly experienced professional with a small budget for travel grants, that was so successful in Taiwan, would return significant dividends.

F. Promote Collaboration of U.S. Institutions with Relevant LDC Institutions

Science and technology institutions with varying interests and capabilities exist in almost all developing countries, with well established links to counterpart organizations in the industrialized countries. Similarly, large amounts of modern technology are in place throughout the world, often dependent on foreign sources for spare parts and maintenance. While many of these existing links need reinforcement and there is an expanding need for additional linkages, the initiation of new collaborative linkages must be sensitive to current international patterns lest well motivated additional efforts become counter-productive.

Collaborative efforts between relatively well developed science and technology institutions can often be very inexpensive -- perhaps

involving only a few airplane tickets. However, considerable time patience may be required to build up understanding among collaborators. During this formulative period -- usually measured in years -- interruptions in a developing relationship due to political or other factors can easily negate earlier progress. Of course, if institutional capabilities do not exist in both countries as the base for collaborative activities and institution building is required, the time and cost involved increase significantly, and the importance of uninterrupted interactions becomes a paramount concern.

The most fruitful types of collaboration are those that are designed to provide direct technical benefits to all of the participating institutions and individuals. Publication of joint research reports or joint development of products or processes soon after the initiation of a collaborative relationship can provide a good stimulus not only to the participants but also to the institution providing financial support for the activities.

International networks of collaborating research institutions have become an increasingly popular approach to solving problems of concern to many countries. These networks can be very effective when focused on quite explicit problems, when there is strong demand for their research products, and if political and bureaucratic interference is minimal. A frequent concern is that such networks can become easily separated from the on-the-ground problems in country-specific situations.

Finally, with regard to funding of collaborative efforts, the world is replete with examples of interesting collaborative programs that foundered because of insufficient financial support. Generally speaking, serious collaborative efforts should not be attempted in the absence of reasonable assurance that financial support would be available if the program develops along constructive lines. Hopefully, the funding would be provided in sufficiently large increments so that the collaborators can spend their time working on substantive problems and not simply searching for additional funding.

G. Support Industrial Innovation in the Developing Countries

Industrial innovation transcends purely research and development activities and includes a variety of activities of private firms and entrepreneurs who assume the risks to bring technical ideas to the market. This is a rather wide field of endeavor and might also include activities to prove innovation in agriculture and social or public technologies. Among the variety of initiatives needed, the following illustrate what the United States could do more effectively:

1. Increase support studies on industrial innovation in the developing countries, including the effectiveness of LDC government approaches to stimulation of technological innovation.
2. Promote cooperation between U.S. small and medium enterprises with similar organizations in the developing countries.

e. Study venture capital availability and support to venture firms and development banks.

4. Analyze technology and manpower factors in large industrial and agricultural undertakings.
5. Study the factor mix in new technologies being considered by the developing countries and policies to optimize them in the context of LDC development.
6. Establish links between low-cost appropriate technology organizations in the developing world and appropriate U.S. institutions.
7. Study how multinational companies can further stimulate industrial innovation in the developing countries, and their manpower effects.

U.S. efforts in the field of industrial innovation tend to be confused by the existence in AID of a program designed to sell the services of U.S. government agencies and educational institutions to developing countries (The Reimbursable Development Program (RDP). This may be in the public interest. However, this objective should not be joined with objectives in the field of international development. Indeed, the two types of objectives can conflict in specific cases. The current situation of the RDP program representing the science and technology interests of the U.S. Government in dealings with middle tier countries, and in doing so giving the clear impression that the other countries must pay for both parties in any cooperative arrangement, needs to be corrected immediately. The program should be transferred to the Department of Commerce.

H. Goals for the U.S. at UNCSTD[1]

1. UNCSTD should avoid urging the establishment of, or actually setting up, new organizations and institutions, national or international

[1] Based upon suggestions by Moravcsik, as modified by discussion.

unless these are significantly different from the existing ones both in purpose and in structure. Organizational manipulations are highly unlikely to contribute to the amelioration of problems of science and technology in developing countries, and can very well result in a worsening of the situation by siphoning away needed manpower and funds and by diverting attention from truly effective remedies.

2. UNCSTD should stress programs involving person-to-person interaction. The value of close working relationships between individuals is often undervalued, and this mode of collaboration is relatively cheap. In addition, those participating in the workshop agreed that an important element of U.S. policy should be "to get more Americans out there;" not as technicians attached to AID projects but a individuals collaborating with scientific and engineering colleagues on research and development projects of mutual interest. Some developmental projects are large by nature and are essential. However, they also tend by nature to be costly and impersonal, characteristics which can be offset by complementary programs stressing collaboration among individuals. (The U.S. program Scientists and Engineers in Economic Development, noted in A above, is an example of such a program.)

3. UNCSTD should find ways of supporting specific programs which enhance the local interaction within the scientists and technologists of a given developing country, as well as the local interaction between scientists and engineers, between engineers and the productive sector, between scientists and science policy

personnel, and between scientists and engineers on the one hand, and the population at large, on the other.

4. Manpower is the key to a creative scientific and technological infrastructure, and quality in manpower development is crucial. Hence UNCSTD should emphasize the support of specific programs which stimulate the creation of high quality indigenous manpower in science and technology.

5. UNCSTD should propose means ensuring that international assistance is made more freely available to the developing countries for the purpose of making scientific and technical evaluations of particular research projects. Such an international network of referees, consultants, and assessors is already well established, in an informal way, within the scientists and engineers in the more advanced countries, and this network is very widely, in fact routinely, used in these countries for the assessment of past research, for decisions to support proposed research or development, and for the promotion and appointment of scientists and engineers. At the moment, the developing countries are, to a large extent, excluded from such a network, and this unsatisfactory situation must be altered.

6. Since there will be extensive discussion of the political aspects of the use of science and technology for development at UNCSTD, the U.S. delegation would benefit from discussion of substantive proposals made by engineers and scientists from other countries -- particularly the developing countries -- who may be at UNCSTD.

III. LOCAL INSTITUTIONS FOR THE BUILDING OF SCIENCE AND TECHNOLOGY IN DEVELOPING COUNTRIES - AN OVERVIEW

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SUMMARY

A. Introduction

B. A Characterization of the Institutions

1. Sectors

Education: schools, colleges, universities, technical training schools, public communications media

Research and Development: universities, governmental research and development centers, industrial laboratories, international centers

Organization: planners, managers, supporting functions (information, repair and maintenance, etc.), professional societies

2. Functions

Aspirational

Operational

Social and political

3. Personnel

Bureaucrats

Hierarchophiles

Accomplishers

4. The Background of the Personnel

Science and technology

Civil Service

Politics

Economics

C. Problems

1. Overinstitutionalization
2. Overformalization
3. Overbureaucratization
4. Civil Service
5. Fragmentation and strife
6. The few and overextended activists
7. Separation from the S&T community
8. Quantity vs. quality
9. Lack of evaluation

D. Suggestions for Action at UNCSTD

(Parenthetical numbers refer to subsections in C.)

1. New organizations (1)
2. Generalities vs. specifics (2)
3. Person-to-person programs (3,4)
4. Local interaction (5)
5. Manpower, quality (6,8)
6. S&T community (7)
7. Evaluation (9)

A. INTRODUCTION

The purpose of this note is to offer a very brief summary of some aspects of institutions in developing countries, connected with the building of science and technology. The aim is to assist the U.S. delegation to UNCSTD in formulating effective action at that conference.

This note will be concerned with institutions participating in the creation of science and technology. Institutions directly involved in technological products (patent offices, ministries of industry, trade

centers, etc.) will be covered by other summaries presented at this workshop.

B. A CHARACTERIZATION OF THE INSTITUTIONS

The institutions will be described along four dimensions: The sector in which they belong, the functions they strive to fill, the motivations of their personnel, and the educational and professional backgrounds of their personnel.

1. Sectors

On the whole, institutions pertaining to the creation of science and technology in developing countries can be sorted into three sectors: education, research and development, and organizational. A given institution might very well belong to more than one sector.

Education

In this category we find, first of all, elementary and secondary schools which are supposed to offer the rudiments of science and technology and should also arouse interest, enthusiasm, and commitment toward science and technology on the part of at least some students.

On a more advanced level, we find colleges and universities, technological institutes, and technical- vocational schools, the primary functions of which should be the creation of specialists in science and technology, and the providing of the necessary scientific and technological ingredient in the education of students in science-related or technology-related professions (e.g. nurses, positions in

transportation and communication, officials in ministries of commerce, of health, of agriculture, etc.)

Finally, this category should also include a much-neglected aspect of education in science and technology, namely the mass communication media which are to bring elements and aspects of science and technology to the masses. Newspapers, radio, television, community centers, and others are part of this. Of the three groups mentioned above, this one requires the most improvement and enhancement in developing countries.

Research and Development

With occasional exceptions, research and development takes place in developing countries in four types of institutions:

a. Universities and institutes of technology. Compared to the situation in the more advanced countries, universities and institutes in most developing countries engage in little research and development. The aims of these institutions are generally not formulated in terms of research being a primary function, but they are instead considered as almost exclusively teaching entities. Correspondingly, the practice of generous government research grants awarded to university personnel is not at all common in developing countries. In the sciences, the little university research there is tends to be "basic" in motivation, and the technological

development activity also tends to be somewhat abstract and remote from the users. There are some exceptions, especially in agriculture, when a research institute is associated with certain university departments (e.g. the relationship between Ahmadu Bello University in Zaria, Nigeria, and the adjacent Institute of Agricultural Research).

b. Governmental research laboratories. In many developing countries these are highly visible, at least in an organizational sense, and consume the lion's share of the research and development expenditure of the country. Their professed purpose is to engage in applied scientific research and technological development. In many cases, however, applied scientific research (i.e. the creation of new scientific knowledge with technological applications in mind) is minimal, and the laboratories are almost exclusively engaged in low-level technological manipulations based much more on trial and error than on the systematic utilization of scientific knowledge. There are exceptions to this state of affairs (e.g. KIST in South Korea, the Leather Institute in India, the Rubber Research Institute in Malaysia), but they are relatively few in number.

c. Industrial research laboratories. These are very rare in developing countries, compared to practices in the more advanced countries. Industries owned locally (by

the government or by private capital) have not developed the tradition for such research and development, and often utilize derivative technology for which, they think, research and development is no longer needed. On the other hand, industries which are subsidiaries of foreign or multinational companies almost always rely on research and development performed at the headquarters of the mother company in a different country.

d. International research centers located in the developing country. These are relatively few in number. In addition, they are, not infrequently, too preoccupied with the research activities to build extensive and functional ties with the scientific and technological community of the country in which they happen to be located. Some examples of these centers are the International Institute for Tropical Agriculture in Ibadan, Nigeria, the International Institute for Rice Research in Los Banos, the Philippines, and the Asian Institute of Technology outside Bangkok, Thailand, the latter being also an educational institution. The quality and level of research activity in such centers tends to be quite good, sometimes in stark contrast with the national institutions located in the same country.

Organization

These are institutions which are concerned with the planning, the management, the support, and the logistics of

scientific and technological activities. Among them are ministries, councils, and other foci for science and technology, commissions of atomic energy, of agricultural research, of industrial research, etc. and supporting organizations like centers for scientific and technological information, workshops, stockrooms, and maintenance facilities for research and development equipment, etc. Finally, there are the professional societies, that is, organizations which at least nominally belong to the local scientific and technological communities themselves, and are concerned with meetings, journals, and other communication channels.

2. Functions

The functions perceived by these organizations follow from the motivations and justifications for undertaking science and technology, as viewed by the developing countries, and from the fabric of the social and political context in which these motivations must be realized. Although the functions are spread over a wide range, they can be summarized under three headings.

The first, and perhaps strongest, function is what might be called aspirational. The state of underdevelopment of a country (or of any groups of people or even of an individual) is considered detrimental, intolerable, humiliating by the country (or the group, or the individual) not only (and in fact not even primarily) because it reflects material poverty, but because it closes options and choices, because it implies a de facto colonial status in which everything that happens in the country (culturally, so-

cially, economically, artistically, scientifically, etc.) is determined from abroad, and because the feeling of accomplishment, the pride of achievements, the exhilaration of being a pioneer and leader, are frustrated. In other words, the country is void of purpose, aim, and aspirations, since the country's fate is determined by factors and forces external to it.

This aspirational motivation of development does not, of course, directly appear in national development plans, because it is not part of economics, and such plans are, at best, purely economic documents. It does appear, however, in political speeches, in the behavior of and conversations with officials in the country in the United Nations and other world bodies, and it is also reflected in the de facto way science and technology are organized, performed and utilized in developing countries.

In this context, engaging in science and technology becomes symbolic of the country's having come of age, having joined the community of nations on equal footing. From this point of view, what matters is the act of participating in science and technology, the activity of organizing, the process of putting up buildings, the involvement in making plans and in setting up institutions, the opportunity to award degrees, bestow titles, and prepare policy documents. The actual output of science and technology is secondary in the framework of this aspirational motivation.

The second function of scientific and technological institutions in developing countries is operational, that is, the direct promotion of the production of scientific and technological results. This is the function that is primarily in the minds of the inter-

national and bilateral assistance agencies, and this is also the one which appears, on the surface, in the national development plans. It involves the promotion of scientific and technological education, the maintenance and stimulation of scientific and technological manpower, the providing of the supporting environment in which scientific research and technological development work can be undertaken productively, and the fostering of interaction between science and technology, between technology and the country's productive sector, and between scientists and technologists on the one hand, and the population as a whole, on the other. One might say that this is the pragmatic function of such institutions, the one that is designed to produce relatively tangible, concrete, and to a large extent material results.

Finally, the third role of scientific and technological institutions is social and political, in the sense that they have to serve as spokesmen, advocates, and propagators of the interest, of the needs, and of the products of the scientific and technological infrastructure of the country. They must create an understanding of what science and technology are and what they are not, generate public support (both moral and material) for their activities, and then transfer the products of science and technology to the rest of the country.

It is not difficult to see that these three types of functions are quite different and in fact potentially contradictory. Action which appears advantageous for one function might very well be judged detrimental from another one. This conflict of aims, func-

tions, and directions is more severe in a developing country, where science and technology have not become so firmly embedded in the fabric of the country, than in the more advanced countries which have lived with the scientific and technological revolution for several centuries.

3. Personnel

Institutions are primarily manifestations of the motivations, aspirations, qualifications, and devotions of the people in them. The success of any institution is determined mainly b the manpower wihin it. Formally similar institutions will perform in drastically different ways depending on the characteristics of the human ingredients in them. Thus we must survey these characteristics.

Human motivations are generally complex, and it is virtually impossible to pinpoint one single motivation behind a person behaving, acting, and thinking in a given way. This is true also in the case of the manpower of institutions in science and technology in the developing countries. Yet, we can summarize the types of motivations in terms of three headings, granting at the same time that a given person generally has an admixture of all three motivations, with varying weights attached to each.

I will call these three motivational types bureaucrats, hierarchophiles, and accomplishers.

The bureaucrat is motivated by being part of an orderly system. He takes pride in his participation in such a system, especially if it is large and has high visibility. His primary con-

sideration will be to live up to the rules of the system, which in fact are transfigured, in his eyes, into goals rather than means. In many developing countries the civil service system is well developed and constantly increasing, and the members of this system tend to have strong strains of the bureaucrat in them. At his best, the bureaucrat provides reliable support for the transaction of routine matters. On the other hand, the bureaucrat finds it difficult to deal with unusual occurrences, with new types of activities, with matters which, by their very nature, are not easily amenable to the application of formalized rules.

One generally thinks of bureaucrats in the context of administrative offices, but the type can just as easily appear in educational institutions, as a teacher of science who presents well set, formalistic lectures, unchanged over the years, and demands the smooth, well prescribed, and accurate reproduction of those lectures on examinations. Or, our bureaucrat can also take shape in the person of a researcher in a governmental research laboratory, who contributes in an orderly way to work on research problems that were selected on the basis of being next on the list of problems that have not been solved before.

The second type I would like to call a hierarchophile, that is, a person for whom life consists of a long ascending staircase, with the aim being to rise through the grades of this hierarchy, and success being measured by the number of rungs one has passed on the way. To the hierarchophile, the nature of the staircase is of secondary importance, and he is likely to accept the obstacle course as it was laid out for him by others, by tradition, or by

other factors. Colonial regimes in the 19th and the first half of the 20th centuries were particularly successful in creating such hierarchies, and their shadows continue to be cast on the aspirational structure of people in the developing countries even today. But indigenous social structures, especially when old, static, and emphasizing stability, are equally good in setting up such aspirational staircases.

The third type of person is the rarest, and at the same time the most crucial for development. Let me call him the accomplisher. His aim is to create new things, to accomplish something, to be able to see something that before his intervention was not there. I do not mean to imply that the accomplisher is always an altruistic and self-effacing soul, and his creations always significant, functional, and operationally effective. On the contrary, at his worst, he might be a grandiose self-adulator who produces white elephants with no utility other than serving as a monument to himself. But at his best the accomplisher is _the_ person on whom practically all development hinges. To be sure, he, by himself, cannot change the world. But he can supply the ingenuity, the talent, the devotion, the inspiration, and the enthusiasm to carry others with him to bring about changes in the direction judged productive and significant by the hindsight of subsequent generations. Virtually everybody who has had extended contact with science and technology in developing countries can pinpoint individuals in various countries who are such accomplishers, and on whose character

much of the development in that country depend. Accomplishers come on various levels, some having a large influence over a whole country, others affecting only their own institutions, disciplines, or immediate environments. Among them, one can mention as a few of the many examples, Bhabha of India, Usmani of Pakistan, Sabato of Argentina, Nayudamma of India, Riazuddin of Pakistan, Saavedra of Chile, Ndili of Nigeria, Odhiambo of Kenya, Munroe of Guyana, or Wijesekera of Sri Lanka.

4. The Background of the Personnel

Having tried to describe the various motivations of the personnel in the scientific and technological institutions of developing countries, let me now summarize their professional and educational backgrounds. Here again, mixtures of backgrounds are most likely to occur. The backgrounds can be classed into four groups.

First, some of the personnel has background in science and technology. This background may be just formal, that is, a degree in science or technology without having ever "practiced" either science or technology. In other cases, the background may be more extensive, involving even distinguished accomplishments in scientific research or technological development work. In the developing countries it is even more difficult than in the more advanced countries to distinguish these two types from each other, since in the former the holding of a degree counts more, seniority is respected much more, and prominence in scientific bureaucracy is equated to being a distinguished scientist or engineer. For somebody who is active

in science and technology it is rather easy, even after just a few minutes of personal acquaintance with the person, to tell whether he is an experienced scientist or engineer, or just a degree holder who afterwards switched into administration. To the uninitiated, however, such a distinction may not be immediately clear.

The second type of background is that of civil service. As mentioned earlier, civil service is a very prevalent way of life in many developing countries, and can be a very desirable career option for even the marginally educated. Typically, the background of a civil servant would be that which is called a "generalist" nowadays in the United States (i.e. a person who knows nothing about many things). Specifically, in the sciences and in technological matters, the background of a civil servant would be especially weak, matching a similar situation in the more advanced countries which, in part, prompted C.P. Snow to write his Two Cultures. Even more specifically, a civil servant would be unaccustomed to quantitative thinking, would be mystified by the process of creating results of science and technology, and would not be favorably inclined toward claims by scientists and technologists that creative activity in these areas has its own rules and needs that may not match those of the more common occupations in the country.

A particularly detrimental feature of civil servants, again paralleling a similar situation in the more advanced countries, is that they will feel insecure and unsure vis a vis technically

educated persons, and that scientists and technologists, on the other hand, a priori and based on what might be called "class prejudice," are likely to regard civil servants with suspicion and as inferiors.

The third type of person important in institutions of science and technology in developing countries is the politician. Needless to say, much is to be gained for science and technology through the presence of politicians favoring and understanding science and technology, and specific examples in a number of countries could be named to support this assertion. These examples would always point at great politicians, with statesmanship, vision, skill, and breadth of horizon. On the other hand, the domination of science and technology by small, partisan, and fumbling politicians implies great dangers, not only in diverting science and technology from their legitimate aims to serving as footballs in political squabbles, but also by dragging science into partisan political conflicts and thereby depriving the development of science and technology from the continuity and stability that they need and which can only be secured by an apolitical composure in the midst of political instability and of the alternation of extreme political regimes. A good example for such a detrimental effect of politics on science and technology can be found in the majority of the Latin American countries, at least at one time or another. In most of these cases both politicians and scientists are to be blamed, the former for barging into science, and the latter for

giving higher priority to their partisan political activities than to their service to the building of science and technology.

Finally, the fourth type of background found among the personnel of science and technology in developing countries is in economics. This background is most prevalent in institutions of organization, and particularly in planning institutions. It is a curious although understandable feature of the national development plans of developing countries that while they nominally include an extremely broad spectrum of elements in science, technology, art, culture, sociology, philosophy, religion, psychology, economics, and many other aspects of life, they are almost invariably composed of economists and are viewed in an almost exclusively economic light. As a result, economists have a considerable influence on institutions of science and technology. At the same time, the treatment of technology, and especially of science, in economic theory is still rather rudimentary, in that the short term connection between scientific and technological activities and economic production remains unarticulated. This gives rise to a number of problems and distortions in the treatment of science and technology in developing countries.

C. PROBLEMS

In this section, an extremely brief list is given of some of the most important deficiencies of the institutional structure of developing countries in science and technology.

1. Overinstitutionalization

Developing countries tend to have a very much heavier institutional structure than is warranted by the size of their scientific and technological manpower and efforts. Extensive planning bodies, research institutes set up regardless of the availability of manpower to do such research, universities founded in the absence of qualified faculty for instruction, grandiose central documentation centers organized when even the simplest scientific and technical journals are missing from the ordinary libraries, are some of the hallmarks of this situation. It is unfortunate that some bilateral and international assistance agencies have greatly encouraged such a proliferation of premature and stillborn institutionalization. Such overinstitutionalization is a result of the aspirational motivation for science and technology, but it hinders the operational function.

2. Overformalization

The institutional structure of science and technology tends to be overly formal, concerned with appearance and structure rather than essence and output. For this reason, much of the emphasis is on planning, much less on decision making, and very little on implementation. Universities tend to regard science education as a formalized ceremony aimed at the awarding of a degree. This trait is also a consequence of the aspirational function of these institutions but it hinders the operational function.

3. Overbureaucratization

Institutions tend to be overburdened by rules and procedures.

This bureaucratization hinders the functional practice of science and technology and also robs science and technology of some of its talented practitioners who are forced to spend much of their time in the quagmire of these rules and procedures.

4. Civil Service

In many developing countries scientists and technologists are placed within the civil service. The result of this is a lack of recognition of the talented, the outstanding, and the energetic, and science and technology are straight-jacketed into a system which is rigid, pedestrian, and unresponsive to the special needs and structures of the different types of activities it encompasses.

5. Fragmentation and Strife

Institutions of science and technology in the developing countries are more fragmented, and have more strife within and among them than is the case in the more advanced countries. Besides possibly traditional reasons, this is likely to be due to the law of scale: In a country where science and technology is small, personal enemies have no way to find a course other than the collision course, and differing opinions, aspirations, and directions cannot easily be given different but equally satisfactory outlets. Partly as a result, internal communication within the scientific and technological communities of a given developing country is astoundingly weak, thus enhancing the isolation of the individual researcher or developer.

6. The Few and Overextended Activists

As mentioned earlier, there are relatively few accomplishers

in any group of people. Where this number is especially low, the lone accomplisher or activist tends to work by himself, oblivious of the necessity of finding allies on an equal footing and of grooming successors for future times. Thus many great accomplishers, once their time is up, find their work aborted and disrupted. A national or institutional tradition in scientific research or technological development work is well known to play a crucial role in the excellence of such activity, and such a tradition is difficult to establish through the overextended lone wolves who struggle valiantly to build science and technology in developing countries.

7. Separation of the Scientific and Technological Community from the Institutional Management of Science and Technology

As mentioned earlier, the active members of the scientific and technological communities in developing countries are not well involved in the decision making over institutions of science and technology, whether these institutions are educational, research, or organizational. Conversely, those in charge of such institutions are often not part of the scientific and technological communities and sometimes are even antagonistic or at least incomprehending of the goals and needs of the latter.

8. Quantity versus Quality

Most institutions in developing countries stress quantity over quality. Educational institutions are geared toward maximizing the number of diplomas awarded, and the idea of small, quality institutions is often denounced as elitist. Research institutions

have funding and personnel policies which favor sheer size to the detriment of quality. This is again understandable in the light of the aspirational function of science and technology in developing countries, but it hinders the operational function. National development plans and other organizational bodies all stress numbers and are generally silent on quality.

9. Lack of Evaluation

To a casual observer of the science and technology scene in developing countries, perhaps the most startling feature of this scene is the almost complete absence of an evaluation procedure of research completed, or of development work performed. In fact, a similar absence is also noted in the assessment of research or development proposed, or in the granting of funds for such research or development. Correspondingly, national development plans are virtually always formulated in terms of input into science and technology (buildings, manpower, money, organizations) and practically never in terms of output. Similarly, no attempt is made to assess whether previous development plans have been met in terms of the achievements of science and technology. Not only is evaluation absent, there is no methodology for such an evaluation either. Again, from the point of view of the aspirational function of science and technology, this is not surprising, since from that standpoint the results of science and technology are unimportant compared to the process of being involved in science and technology. From an operational point of view, however, the lack of evaluation is quite disturbing and detrimental.

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IV. TECHNOLOGICAL CAPACITY AS AN ELEMENT OF DEVELOPMENT STRATEGY*

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A. Introduction

Twenty years of research on the choice of technology, the process of innovation and the development of technological capacity in developed and developing countries have clearly demonstrated the critical influence of a wide range of policies which are not explicitly oriented towards the development of technology and technological capacity.

For instance, although it might not always be apparent, economic policies have a decisive impact on the development of indigenous technological capacity and often have unintended mixed technological side-effects. Exaggerated tariff barriers and other protectionist measures make inefficiency profitable, and may reduce the pressures on local scientific and technological activities to meet international standards of quality. Overvalued exchange rates, plus tariff exemptions and other incentives to import machinery and equipment to produce import-substituting consumer goods, reduce effective demand for local technology. Combined

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with subsidized interest rates and social policies (e.g., minimum wages unrelated to worker productivity), the policies make investment in equipment more attractive than exploring measures to expand the labor force. Underutilized capacity eliminates the incentive for improved technology to increase output since production can easily be expanded.

Finally, gross inequalities in the distribution of income orients technological activities toward the needs of a small segment of the population with the bulk of the purchasing power. In turn, the type of products and services produced determines to a large extent the technology that will be used, which will further influence the level of productive employment and the distribution of income.

The direction and rate of technological change and development of local capacity is thus critically influenced by a number of policies that are at first sight unrelated to the university and laboratory. Although these are usually not considered technological policies, in reality they are critical influences on whether technology is determinant of the nature of technology and how it is brought to bear on a country's development problems.

B. The Technological System and the Productive System

Technology, broadly defined, is the technical means of reaching an objective. Thus virtually any activity requires technology of some kind -- even primitive agriculture with a "pointed stick," More formally, it is the organized set of all the empirical and scientific knowledge required for producing and distributing any goods or services. It includes equipment, installation, and materials (hardware), as well as production, organizational and managerial practices (software).

Technology is commonly said to be "embodied" in hardware, and to

be "transferred" through purchase of equipment, e.g. a turn-key installation of a factory. Strictly speaking, this is installation of hardware, not transfer of technology. The embodied technology remains in the firms that designed, manufactured and installed the equipment.

The acquisition of production technology begins when local capacity is developed to operate the machinery, to manage and maintain the plant, to make minor innovations and improvements, and to design comparable installations. As its technological mastery increases, a country reaches international standards of cost and quality. Even before this has been achieved, it may begin to re-export the technology in the form of products, capital goods, technical services and even turn-key plants, and to make significant improvements in the technology through its own research and development and its own knowledge of the local international market.

We may distinguish between the <u>productive</u> system of the country, and the <u>technological</u> system whose task is to assist in the specifically technological aspects of productive activities. These are: to identify and define technologically feasible development goals and strategies at the sector and project level; to shop for, select, negotiate for, and acquire technology and insure its adaptation to local conditions and resources; to implement, operate and improve that technology, and to solve practical problems as they arise; and to evaluate the effect of technology and assess its overall social impact; to generate new technology and scientific understanding; to train qualified scientists and technologists and insure their productive utilization; to keep up to date on global developments in science and technology and on the scientific and technological elements of problems (such as food and energy) requiring global management; to assess the impact of and opportunities

created by real or potential technological innovations; and to advise the government and the public at large on national and international policy issues requiring an understanding of technology and science.

The line between the productive and technological system is sometimes fuzzy, especially when, as in smaller enterprises, productive and technological activities are undertaken by the same small group of people. The engineer of a small medium-sized business in the modern sector may, for example, test a new prototype at the same time as he supervises the firm's regular production schedule. Even in the traditional sector, a small farmer or entrepreneur may be an inventor and hence part of the technological system of his country. For example, a small farmer in Upper Volta himself invented a system of low dikes and culverts to slow the flow of rainwater washing across his flat land and hence to increase percolation and make more water available to his crops.

The definition of technological capacity should include the vast pool of technological resources that can be found in the informal sector, such as village workshops, small industries, individual entrepreneurs, common service organizations and cooperatives, as well as the quasi-volunteer "appropriate technology" organizations that are springing up throughout the developing world.

This definition of technological capacity, we would suggest, is the proper starting point for the analysis of the effectiveness of institutions for science technology in devioping countries. It is also a useful starting point for economists who wish to assess the effects of policies which were adopted for reasons not directly connected with technology, or policies intended to provide general encouragement to the importation of production technology, the use of socially appropriate technology,

or the development of indigenous technological capacity. It differs from the definition of the technological system used by most researchers on technology policy,* in that technological activities within the productive sector are grouped with the technological system rather than the productive system. We suggest that this reformulation has the important advantage that it brings clearly into focus the fact that the major objective of technological policy is to create technological capacity -- which is best located in the productive sector -- not the creation of technological infrastructure per se.

C. Technology: Its Demand and Supply

It is usual and for many purposes useful to distinguish between the demand for technology and its supply. The locus of the demand for technology is the decision maker within an operating entity -- a farmer or entrepreneur (large, medium, small or tiny), the managing director of a government-owned plant, or the operating head of a public service such as an irrigation district, a water supply company, or a highway authority. The technological capacity of such an entity will vary widely -- from the three-man shop or small farm whose owner makes all decisions based on his wits and experience, to a medium-sized firm or farm with a full-time production manager who can squeeze out some time for planning and equipment selection, to a ministry, large public or private firm, or multinational corporation with a substantial planning and engineering staff. The willingness of the operating entity to retain technical staff on its payroll and to use it in the making of technologically based decisions

*As for example, in the recently concluded IDRC-financed Science and Technology Policy Instruments (STPI) Project, a 10-nation study on the process of technology policy implementation in developing countries.

is the first, and in many ways the most important, element of the demand for technology.

The technical capacity internal to the operating entity is the first, and for many purposes the most important, element of the supply of technology. A decision by an enterprise to undertake a new activity or to improve existing methods may translate directly into the purchase of equipment through ordinary commercial channels from dealers and salemen or from purveyors of turn-key plants; or of proprietary technology and know-how through licensing and technical assistance agreements with local or foreign suppliers of technology. These salesmen and suppliers are often backed by substantial engineering, design and research staffs, and their presentations to entrepreneurs may include extensive techno-economic feasibility analysis of technological alternatives. The supply of hardware and proprietary know-how is the part of technology supply most familiar to trade economists.

Depending on the complexity of the problem and the sophistication of the operating entity, the decision-maker may turn to external sources of technical service and advice to supplement those available internally. This results in demand for auxiliary technical services such as management consulting firms, trouble shooting, extension and technical information services, standards and quality control institutes, and the pre-investment, engineering, and project implementation and execution services of consulting firms.

Particularly difficult investment or planning decisions, or particularly thorny problems of product design or plant management, may result in the commissioning of discrete projects of research, development or engineering, either in the entity's own staff or in an external laboratory,

domestic or foreign. From this point of view, research and development serves as a back-up to such advisory functions as pre-investment, trouble-shooting, and product planning and design.

Research laboratories (especially when publicly supported), should serve many purposes in addition to this role of direct support to operational entities. Their job is to scan the horizon for problems or opportunities that others in the country have not recognized, to apply science and technology to local problems, and to keep abreast of progress outside the country in science and technology and its possible domestic implications. Research associated with universities is a critical adjunct to the training of students, is essential to the retention and professional awareness of faculty, and is often the only opportunity for the study of scientific and technological problems specific to the country.

These, then, are the elements of technology supply -- hardware and know-how suppliers and their technical staffs, technological staffs internal to operating entities, auxiliary technical services, research laboratories, and universities. Added to these are the technical departments of financial and policy institutions, insofar as they are concerned with specifically technological matters.

In the fifties and sixties, developing countries, often with the assistance of bilateral and multilateral technical assistance agencies were concerned primarily with the "supply" of technology. To this end, they invested heavily in establishing a broad base of scientific and technological research. While this has perhaps helped in serving as a window to the outside world of science and technology, laboratories and institutes have, for the most part, not provided an adequate link between the innovators and the needs of the market.

The reinforcement of the capability of the decision makers in the government and the (publicly or privately owned) productive sector, including the small-scale and informal sector, the orientation of the demand toward the use of appropriate technologies and the strengthening of the capacity that will support this orientation in the design of investment projects, are at least as important as the building or reinforcing of formal research institutions. Especially in the least developed countries, it is crucial to link internal technical capability, at whatever level it exists, to the process of decision-making for investments. In all developing countries, a primary task in developing technological capacity is to build up the capacity to plan for and carry out investment projects, to consider alternative technological approaches, to manage foreign expertise and to train human resources. Technological capacity is needed at all scales of activity and all levels of sophistication.

There will inevitably be a gap between officials struggling with massive day-to-day problems and those managing laboratories and universities. This gap exists even in the most sophisticated countries -- indeed, even in the most sophisticated, technologically-oriented industries in developed countries.

For this reason, there is a need to defend technological institutions concerned with long-term problems from undue political pressures and fluctuations, to allocate resources, to and among them, to bring their needs and their special perceptions of the needs of the country to the attention of political decision makers, and to serve as the country's window on the outside world of science and technology. These efforts are critical to the long-run technological development of the

country and tend to be overlooked by officials with short-term horizons and large sums of money to administer.

A healthy climate for the development of laboratories and other infrastructure concerned with long run development begins with the perception of political decision makers that indigenous technological capacity can help solve their pressing problems -- which are, after all, the major immediate problems of the country. For this reason, thinkers concerned with the scientific and technological capacity of developing countries might well explore the technological roles of a variety of institutions hitherto considered to be non-technological.

D. The Technological Influence of Non-Technological Institutions

For technological capacity to be fully integrated into economic development, there must be vigorous interplay between entities seeking to "push" technology into the market and entities whose "demand" exercises a "pull" on the technology capacity and stimulates the creation of new supply. The interplay depends on the broad framework of national economic policy and on the attitudes, policies and practices of financial and other institutions which are not usually included in the study of scientific institutions and which do not have indigenous technological development as an explicit -- let alone a high-priority -- objective. We would suggest that these institutions should become aware of their critical influence on the evolution of technology and technological capacity and should develop their own capacity to deal with the technological implications of their activities and to interact with the technological system of the country.

The policies of financial institutions and government departments also influence the formation of technological linkages and the development of local technological capacity. It therefore behooves the policy maker

to examine the implications of: (1) the project appraisal criteria used by financial institutions, which influence the extent to which local factor endowments and natural resources will be utilized in projects; (2) the availability of risk and venture capital for the development and commercialization of innovative technologies; (3) the availability of technical and technological assistance in project identification and formulation, as well as during project operation; (4) the availability of domestic and foreign market intelligence and information on technological alternatives to enterprises; (5) the existence of policies and programs aimed at strengthening local consultancy services and encouraging their participation in project identification and formulation; (6) the use of government procurement practices to upgrade the technology used by local suppliers; (7) use of tax credits, subsidized loans, and direct grants for promoting innovations, technological improvements and commercialization of research and development; and (8) the technological impact of tariff schedules and of legislation to regulate foreign investments to increase local value added; (9) the level of internal technical skill within financial organizations in analyzing the projects with little bureaucracy and within fixed time limits; (10) speed with which the resources are made available to the taker; (11) the level of internal skill in project follow-up and evaluation and feedback of relevant information into operations; and (12) the availability of tax exemption for the import of all instruments and consumer materials needed to perform research activities.

E. Technology as a Part of Overall Development Policy

Just as analysis of technological institutions and policies must consider elements apparently far removed from technology, broad analyses

of a country's overall development strategy and economic situation should take explicit account of technological issues. Economists have always considered the possibility of policy measures designed to affect capital and labor in order to accommodate their costs to their relative availability. They should also begin to consider technology as a factor of production which policy makers can manipulate in order to accommodate to the availability in each particular situation of technological skills, capital, labor and natural resources.

For example, the analysis of a country's overall economic situation has traditionally focused on issues relating to the creditworthiness of member countries, e.g., output growth, investment requirements, resource mobilization, balance of payments, pricing, and fiscal and monetary management. The scope of such work is becoming increasingly broadened to include such topics as rural and urban development, employment and income distribution, and population and human resource development. This shift of focus from a short-term analysis of economic and financial policies toward more in-depth exploration of long-term structural problems makes it important to include explicitly the important scientific and technological dimension, in order to: (1) improve the understanding of how science and technology can be mobilized in the context of specific development projects and how it can be related to the overall socio-economic development strategy of the country; (2) bring about a better fit between investment projects and the country's scientific and technological needs and resources; (3) improve the design and implementation of the country's technology policies. Experts in each developing country should have the capacity to carry out such analyses.

As we have seen, such broad economic studies provide essential

background on strategic policies and issues that exercise a critical influence on the nature, suitability and impact of technology, and the possibility of adaptation of a given technology. For instance, a recommended shift from an import substitution to an export promotion policy implies the need for strengthened local capacity for overseas market intelligence, export standards, quality control and testing, preinvestment work and research development. Without such local capacity and in the absence of explicit governmental policies to stimulate its utilization by entrepreneurs, the consequences of such a shift in strategy could lead to a growing dependence on foreign technological sources. Both public officials and private entrepreneurs tend to favor the importation of the required technological inputs for investment projects in order to save money, reduce risks, avoid responsibility for failure, and shorten lead times and because of the greater political weight attached to short-term development targets compared to the longer-term goal of fostering an indigenous technological capacity.

When developing countries either have no, or at best a weak, local technical capability and do not take measures to counteract this tendency, their growing technological demand is met by foreign sources, a fact that in turn reinforces the weaknesses of the local technological infrastructure. The lack of shortage of domestic skills and capabilities has important implications for a country's foreign exchange position. A number of UNCTAD studies have focused attention on the direct foreign exchange costs of transfer of technology through such channels as feasibility studies, turn-key contracts, licensing agreements, and technical assistance. These costs may be disguised as higher prices for intermediate materials or equipment. Technology transfers may also

influence capital movements (for example, if the transfer agreement requires equity participation).

But at least as important as these direct costs are the indirect costs of having critical investment decisions made by foreign technologists who may not be closely familiar with local suppliers, raw materials, or cultural or ecological conditions, or who may be biased towards unnecessarily sophisticated technology or insufficiently diligent in seeking the lowest price or the best terms for the technology to be utilized.

Another example of an economic issue, which has traditionally not been conceived as an important concern for technology policy, is that of poverty. One of the factors that has contributed to an exacerbation of poverty in many developing countries, is that rapid growth has occurred in a small "modern" sector of the economy using up-to-date advanced technologies, without much positive impact on the traditional areas of economic activity. The number of jobs that can be created in these modern sectors, which primarily involves urban manufacturing, is inadequate to keep pace with the growth in labor force. A policy aimed at alleviating poverty, through expansion of productive employment opportunities, also demands a strong and efficient indigenous technological capacity, geared to the requirements of the small farms, small scale rural industries and the urban informal sector, and capable of mobilizing technology from whatever source and installing it to meet their needs.

F. Summary

Analysis of the technological capacity of a developing country must begin with the capacity of operating entities in all sectors and of all sizes to make and implement technological decisions. Analysis of the technological elements of development policy and strategy must concern

itself not only with the growth and development of indigenous technology, but also with the appropriateness and the impact of the technologies actually in use in the various sectors of the productive system. Such analysis must include not only the health of the formal technological infrastructure, but the impact of a broad range of the policies and activities of a broad range of institutions which are not primarily or even explicitly concerned with the nature of technology or with the development of indigenous technological capacity.

V. INSTITUTIONAL INFRASTRUCTURE FOR TRAINING AND EDUCATION IN DEVELOPING COUNTRIES

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A. Introduction

Almost without exception, national papers and discussions and conclusions of specially convened expert conferences feeding ideas and specific strategies to the forthcoming U.N. Conference agree on one point:

> In order for the developing countries to fully exploit the benefits of science and technology for development, rapid and innovative approaches are urgently needed to enhance their technological capacity to assimilate both imported and self-generated technology.

Institutional infrastructure has unfortunately a physical connotation. In fact, until very recently, many development activities have emphasized the physical to the neglect of the human aspects of institutional development. Human vision and commitment, technical ability to plan and implement, and skills to transmute ideas to specific products and processes for beneficial use by society, are the stuff of which technological capacity is made. If human resources are both the ends and means of national development, institutions provide the organizational framework for purposeful conduct and direction of human effort toward agreed goals. It is difficult to conceive of institutions without

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people. The maximization of human welfare is the collective responsibility of institutions of a nation. Thus stated, the apparent dichotomy between institutional infrastructure and human resources development disappears. The education, training and motivation of manpower, and policies for their effective utilization thus become a central concern of development policy and practice. Mobilizing technology for development is just another way of saying mobilizing human and institutional resources of a nation in pursuit of national development goals. Technology transfer is essentially a transfer of skills and knowledge by people to people for people.

B. Institutional Development - An Indigenous Effort

The consideration of "human resources" or "human capital" or manpower as a "production input" is admittedly too narrow a view of education in the context of national development. How educational systems in developing countries are all too often ill-conceived and not adapted to their development goals, that they are copies of metropolitan models, and that they do not meet the needs of the disadvantaged sectors of societies is too elaborately described to need repetition. Also well known is the difficulty of implementing institutional change in developed and developing countries alike. While the history of development efforts (in education as in other sectors of development) suggests caution and humility, progress is not achieved by inaction. Energizing existing institutions (or promoting their demise) and creating entirely new structures require bold political initiatives which only domestic governments can take. Institutional development is truly an indigenous phenomenon. In the span of this paper, devoted to institutional infrastructure for training and education in science and technology, such broad questions that relate to national

educational planning or labor and employment policy can only be given limited attention, except to note that to enhance policy effectiveness conscious attention must be given to the inter-relationships between manpower, economic and educational policies by both national and international policy-makers.

C. Need For Demand-Oriented Strategies

Other speakers at this conference have described the nature, significance, roles and functions and inter-relationships among various institutions in the developing country context to generate and use technology to achieve development goals. This paper will focus on the supply and demand, and the policies needed for effective utilization of professional and technical manpower. In most developing countries, educational systems have "grown by popular demand," and supplies tend to far exceed demand. Spill-over of the excess supply across national boundaries through "brain drain" is a much discussed phenomenon. An assumption in this paper is that while there may be qualitative deficits in a variety of occupational categories (and of policies needed to close the deficits), the concern of manpower planners and development policy makers must now shift to a consideration of demand-oriented strategies for manpower development and utilization. In what follows, suggestions will be made on policies and programs to interconnect institutions that produce manpower and those that use them.

D. Some Major Issues In Manpower Policy and Practice

1. Specific Nature of Manpower Development

In most recent analyses, the importance of trained manpower is emphasized in every domain of development, be it industrialization, health, nutrition and population, food and agriculture,

resources and the environment, transportation and communication, and the education sector itself. Strengthening the infrastructure and consideration of new intiatives in each of these domains requires explicit consideration of manpower development and utilization policies and programs, since they are inextricably woven into the whole range of development issues. Clearly requirements, policies, programs for manpower development and utilization differ from domain to domain and from country to country.

2. Selected General Issues

On a more general level, there are several pressing issues of manpower policy and practice that have surfaced that need further analysis and discussion. These include such subjects as: developing cadres of specialists proficient in science and technology policy-making, improvement of LDC capacity in manpower forecasting and monitoring changes in supply and demand, including policies to cope with migration of qualified manpower, overseas education and training for LDC nationals, planning and management of graduate education in science and engineering, sub-professional technician training, regional disparities in educational services, training and education of women, management training in general and management of the educational interprise itself, and the relations between the non-formal and formal sectors of training and education in meeting manpower needs.

3. Influence of Decisions of Developed Countries

The decisions of developed country governments and voluntary

agencies providing development assistance, private corporations operating within the LDC's industrial, agricultural and national resource sectors exert a powerful influence on both the supply and demand for manpower. Similarly, investments by international development agencies and banks in industrial or agricultural development, and in international research centers, and in staffing international bureaucracies also exert a strong demand on LDC manpower resources. How these external forces can be modulated to assist countries at different stages of development to more rapidly achieve their economic and social objectives is an issue of concern in this paper.

E. Categories of Developing Countries

In recognition of the fact that manpower requirements and potentials differ from country to country and that different manpower development policies are needed, there have been several classifications of developing countries based on GNP and other indices of educational development. The fact that even in several poor and middle-income countries, a whole panoply of institutions devoted to science and technology exist, make generalizations across countries frequently untenable. For analytical purposes, however, the following typology of countries and their science and technology manpower potential might be useful:

Category I: Countries in which the infrastructure of science and technology is reasonably well developed; and the educational system, including the universities with graduate programs, research institutions, secondary level educational institutions are also well developed. Large

cadres of scientists and engineers have been formed. (Selected examples: India, Korea, Pakistan, Philippines, Brazil, Argentina and Singapore.)

Category II: Countries in which the infrastructure for science and technology is partly in place and university development has not passed beyond the stage of undergraduate education; only a few research institutions exist; and secondary level institutions especially those in industrial and agricultural specialties need to be upgraded; only small groups of scientists and engineers are available. (A partial list of such countries: Nigeria, Indonesia, Thailand, Egypt, Kenya, Colombia, Iran and Turkey.)

Category III: Countries in which both the science and technology infrastructure and the system of education are in rudimentary stages of development; very few scientists and engineers. (For example: Bolivia, Ecuador, Vietnam, Kampuchea, countries of Central American and several countries in Africa.)

Category IV: The OPEC countries, which are capital-rich and manpower-poor, but are rapidly building their economies and institutions can be described as developing manpower through import-substitution by relying on expatriates for management and training.

Judgments will naturally vary on which country belongs to a specific category. This categorization is necessarily subjective. It is intended as an aid to thinking about problems and opportunities, and that within the narrower focus of their scientific and technological development.

for example, several countries in Category I are exporters of specialized manpower, most recently to countries in Category III and IV. High level manpower deficits in these countries are only of a qualitative nature and demand oriented strategies for manpower development and utilization are obviously needed in these countries. On the other hand, in countries which belong to Category II and III, much greater attention will need to be devoted to institutional development and the related manpower issues, both from the supply and demand perspectives. Countries in these categories could learn from the experience of those relatively advanced countries in Category I on approaches to university modernization, non-formal approaches in education and training, and allocation of resources to middle level education and policis to promote research development and training activities in universities and industry.

The OPEC countries in Category IV have benefited from human resources developed elsewhere and have just begin through their aid programs to promote educational development in other countries of the region. Collective international action by OPEC and developed countries on educational development in the poorer countries on a much larger scale than has been attempted so far is urgently needed. As far as the developing countries themselves are concerned, while collaboration in trade and transfer of technology among them is being encouraged, promotion of similar interests in collaboration in education, research and manpower development deserves high priority attention.

F. Development Levels and Institutional Structures

Against the preceding categorization of countries and their development levels from a manpower standpoint, if one overlays the set of institutions that comprise a nation's scientific and technological

infrastructure, an analytical basis for assessing their needs and effectiveness would become available. In common with developed countries, a few developing nations boast of the following types of institutions devoted to science and technology. Some of these institutions are directly concerned with training and employment of specialized manpower.

1. National planning and policy-making institutions in science, technology and education (e.g., national research councils in science and technology: university grants commissions, councils of rectors, and manpower commissions).
2. National research and development institutions (e.g., state owned industrial and agricultural research institutions: institutes of health research and vaccine production, educational research centers).
3. Universities in science and technology.
4. National information and documentation centers.
5. Institutes devoted to standardization.
6. Special national research centers in housing, roads, irrigation and hydraulics.
7. Sub-professional technician training institutions in industrial, agricultural and health technologies.
8. Professional and scientific societies, some which act as certifying bodies.
9. Industrial and agricultural development banks.
10. Productivity centers and similar technical assistance agencies.
11. Research associations.
12. Research centers or departments in government ministries, public sector undertakings and in private industry.

13. Engineering and other technical consulting companies.

14. Management consulting companies.

The above list is not exhaustive, however. Many institutions in the non-formal sector, including those run by religious groups and voluntary agencies are directly concerned with manpower training and employment.

Several generalizations on the role and effectiveness of the institutional system as a whole and the component institutions can be made:

1. In most developing countries, these institutions are concentrated in the public sector, and are governed by civil service regulations. From a manpower development standpoint, they restrict mobility, tend to attract people with poor qualifications and motivation, and put credentials above competence.
2. Interaction among institutions, even among those in the public sector, is hampered by bureaucratic inertia and narrow institutional goals. This again reduces mobility of personnel and cooperation among institutions, when action by several government agencies on a common project or program area is called for.
3. Adversary relationships between public agencies and private industry result in regulations that tend to inhibit the autonomy of private enterprises in hiring and firing policies.
4. Professional and technical societies are in their early formative stages and cannot exert much influence on behalf of their members with regard to compensation and benefits. In the relatively advanced developing countries, however, (Category I), a few scientific societies conduct their affairs along internationally accepted standards. Few societies or

associations concerned with subprofessional technical manpower exist in the developing countries. An exception is a regional organization in Latin America called CINTERFOR concerned with skilled worker and industrial technician training.

5. Engineering and management consultancy companies are a recent development even in the countries belonging to Category I. Only in Brazil, Argentina, India, Mexico, and Korea and a few other countries are local companies beginning to function. They appear to hold much potential as sources of employment for engineering and management graduates.
6. While some governments run employment agencies or job centers for skilled and semi-skilled workers and official gazettes advertise government openings, information on employment opportunities for college graduates is difficult to come by in most developing countries. Very few private placement service companies exist in these countries.
7. Colleges and universities do not operate occupational guidance and placement services for their students. Guidance programs at the secondary level are virtually absent. Lacking dependable information, students flock to the universities and the traditional disciplines they offer.

The list of the imperfections in the manpower market could as easily be applied to several developed countries. The extreme severity of these conditions that characterize the developing country institutional structures is in stark contrast to those that obtain in the developed countries. What then are some of the remedies to correct these conditions? What new roles can these institutions play in manpower development and utilization?

G. Roles of National Planning and Policy-Making Institutions

A large number of developing countries have already established or are in the process of establishing national bodies concerned with science and technology matters. These research councils advise governments on science and technology policy, distribute funds for research and development in the universities and are concerned with scientific and engineering manpower. The concern with manpower tends to be on highly specialized aspects of scientific manpower. In many countries the data collected on scientific and engineering manpower in industry, universities and government is incomplete, intermittent and inconsistent wtih international standards anu definitions. In other countries, the capacity to collect such data does not yet exist. In yet others (Category III and IV) such instrumentalities as national research councils would need to be established for the first time.

An important role that national research councils play is through their fellowship programs for graduate training in science and engineering. These are the programs that nurture the future supply of scientific and engineering talent, especially the future specialist teachers and researchers. Although fellowship programs are the stock-in-trade of research councils and international agencies alike, quite frequently domestic resources devoted to such fellowships fall far short of the need. While a few fellowships for study abroad are generally available, fellowships for graduate study at local or regional universities are not available. Governments are averse to borrowing from international development banks for training, although in recent years project-related short-term training abroad, and some graduate degree level programs have been included in loans to developing countries. Since local fellowships

are one of the best methods of encouraging national graduate programs struggling for viability, it would seem that national governments and international agencies would invest larger sums in this activity. Such fellowships could also be earmarked for candidates from non-metropolitan universities, for women, or based on other criteria of disadvantage.

National research councils or similar bodies such as university grants commissions, or councils of rectors, would also provide a desirable locus for incubating a "manpower planning cell" (a la CSIRO in India) within which to train and maintain a nucleus of specialists in the newer methodologies of manpower forecasting in science and technology, with linkages to national economic planning offices, and to labor departments, which are generally concerned with the larger questions of employment and unemployment. With the availability of the computer, continuous updating of data and analysis is more feasible. Even specifying a few more questions on scientific and technical manpower for the national census would be a small but important contribution of such groups.

Publication of an annual "Manpower Report" (similar to the U.S. Manpower Report to the President) highlighting the supply and demand for critical occupations in science and technology could focus the efforts of manpower forecasting groups in each country.

Since national research councils are closely allied with university planning in each country, manpower forecasts could be used to advantage in planning the size, location, and specializations to be offered by new universities. They could through such interaction establish initial conditions for maintenance of quality in educational programs offered.

Most national research councils tend to concentrate their efforts

on manpower supplies. There are several roles they can play on the demand side of high level manpower. Maintaining rosters of scientists in training abroad and keeping them posted on developments at home or facilitating their repatriation from overseas training is one possibility. Providing small research grants to young promising scientists on time (championed for some time by Moravscik and others) would be one method of mooring them to the local environment. In spite of recommendations of many international conferences, facilitating the duty-free rapid passage through customs of educational materials and research equipment continue to be a serious problem in many countries. International science foundations have been recommended for such activities, but it would appear to me that these are activities for LDC research councils or similar organizations, if they are truly committed to developing local technical capacity.

H. Roles of National Industrial and Agricultural Research Institutes

Government industrial and agricultural research institutes or centers have been in existence for several decades in many developing institutions. Studies have shown that such government-sponsored institutions have failed to meet their objectives and remain outside the main stream of industrial development in their countries. Agricultural institutes have a slightly better record. In the health field they have performed well defined missions, but have not provided the leadership in national health matters. As stated earlier, the activities of such institutions have been hamstrung by bureaucratic regulations and lack of budget support. Many have retreated into basic scientific research activities, much against their mandated missions.

Renewed interest in the rejuvenation of research institutes has led some countries (in Category I) to gradually wean them away from full

government support and encourage them to rely on contract research activities with their constituents. Industrial research institutes are being pressured to seek contracts with domestic firms, multinational firms and government departments. Agricultural research institutions serving the poor farmers must obviously depend on government support and some governments do levy taxes on agricultural exports to finance such institutions. Some multi-purpose research institutes are being permitted to atrophy to a point of extinction and are being replaced by strongly mission-oriented, industry supported and managed single-purpose institutions in specific areas of technology.

While such modernization of the research enterprise is taking place in Category I and some Category II countries, and when new research institutions are being created in countries in Categories III and IV, several manpower considerations are important. An opportunity exists under these circumstances to convert such manpower hoarding institutions to those that have a dynamic relationship with their clients, provide training and retraining services to them and serve as windows to the world of international technology in their fields. For example, such institutions could:

1. Provide short-term technical training to scientists, engineers, and technicians in newer technologies.
2. Offer short courses to managers of small and medium enterprises on R and D management.
3. Prepare state-of-the-art reviews of certain areas of technology and project manpower needs for them.
4. Provide opportunities for university professors and students to use equipment for thesis research.

5. Offer regular courses in such areas of common interest to industry and government as instrument repair and calibration, glass blowing, corrosion prevention, energy conservation, noise abatement, pollution monitoring.
6. Undertake joint research, development and engineering activities with private firms to assist them in commercializing new technology, even to the point of undertaking certain production activities when firms cannot bear the cost of investment in such activities.
7. Provide in-plant training in work simplification, job re-design, quality control and similar functions.
8. Promote training, research and design services to multinational companies and international agencies.

Ideas have not been lacking on the remaking of these research institutions in which the developing countries have made large investments of money and high level manpower. Implementation of these ideas has been difficult even in the developed countries which are also not too happy with the productivity of free-standing government-sponsored research institutions. Only in those countries such as Germany, where a strong triangular connection among research institutions, government and universities exists and mobility of personnel among them is promoted as a matter of policy, have the research institutions been successful.

I. Multiple Roles of Universities

The university represents an important component of national capacity in science and technology. To characterize the LDC university as just a high level manpower supply institution is to detract from the many development roles it has been asked to assume. University science and engineering

departments for example, are expected, in addition to preparing technical manpower, to expand the frontiers of knowledge through basic research, adapt imported technology for local use and generate entirely new and appropriate technologies for development. University extension activities are expected to include, among others, curriculum improvement projects for elementary and secondary education, information and extension services to industry and agriculture, and a variety of other public education and policy analysis activities outside the central function of teaching and research. Quite frequently external development agencies entice universities to take on these additional functions since, frequently, no other institutions exist in the developing countries with the autonomy and intellectual competence of universities.

The influence of universities on the entire educational system is powerful and pervasive. Its credentialing power profoundly influences the character of demand for manpower. Social demands encourage its expansion, even while graduates swell the rolls of the unemployed. University systems in many countries defy control over their size and policies, and yet manage to attract sumptuous support from legislatures. Overgrown university systems increase supply of high level manpower faster than demand can be generated through economic growth. Disillusionment with the results of decades of development efforts have not left the universities untouched. Their detractors have charged that they are far too expensive, that their concentration in urban centers has increased regional disparities and inequities, that they perform imitative research under international pressures for conformity and that they are caught in an immobilizing conflict arising out of the simultaneous pursuit of excellence and national relevance of their work.

Amid the din of detraction some solid accomplishments of developing country universities must be recognized. They may have performed too well in high level manpower production, but it must be admitted that the rapid build-up of cadres of scientists and engineers in most of the relatively advanced countries (Category I) is impressive. Such expanded manpower pools have kept wages as a percentage of the total costs of production sufficiently low as to enable these countries to compete in international markets of manufactured goods. As stated earlier, some developing country professors and researchers are staffing universities in other poorer (Category III and IV) countries of Asia, Africa and the Middle East. Many universities in Asia and Latin America have undertaken structural modernization of their universities to adapt them to new needs of development. Several university centers in the developing world have become active agents of social change through a variety of non-formal training and extensive activities. They have frequently been caught in the crossfires of political activism, but remain centers of intellectual autonomy. They may be troublesome institutions to manage, but they are a free society's best hope for continuity and renewal.

Among the major issues that confront universities and external development agencies as a new era of institutional development unfolds, some are new and others have been with us for some time:

1. Planning of university systems and of individual institutions continues to be an extremely important issue, especially when in many countries per capita government expenditures on higher education is frequently several multiples higher than per capita GNP. Countries in Categories II, III and IV need assistance in undertaking such planning activities.

High level manpower projections and goals for scientific and technological development (for example, enunciated in national papers submitted to the UNCSTD Conference) would provide important inputs to such planning. Simulation and optimization techniques could be used in the determination of the best location and size of universities to fulfill these goals.

National research councils or other central bodies could be linked to university planning exercises. When such councils exist, they provide a useful vehicle for channeling external assistance to university planning and institutionalizing the planning functions.

2. Issues of internal efficiency of universities have led to a variety of suggestions for applying cost-effectiveness principles to university management. Faced with a deluge of applicants, and increasing costs under inflationary conditions, universities have been hard put to stay within their budgets. The wider use of educational technology to meet the surging demand for services will require even more incisive analysis of costs and benefits lest institutions be saddled with rapidly obsolescent hardware. Unfortunately many of the techniques of cost control have not been consistently applied, while political pressures for free access to higher education continue unabated. Expansion of student loans with deferred payment provisions and scholarship schemes hold much promise as devices for shifting the financial burden on students who ultimately benefit from university education. There is much relevant U.S. experience in this field that would be of value to developing country universities.

3. The issue of university curricular relevance for development has been with us for quite some time and opinions are strongly divided on this issue. Foreign universities in the West, which LDC nationals attend maintain that universities must uphold the best scientific traditions and cannot, for sound educational reasons change curricula to accomodate the needs of the developing countries. With good reason, they suggest that the functions of university education is to provide the student basic scientific approaches or models for thinking about problems, and these are then applied in the real world. Graduates gain practice in applying these principles to the problems they meet on the job in industry, agriculture or other problem areas. Science, it is argued, is truly universal, while relevance is a national issue. Educational systems in each country have a responsibility to address the problems of their societies. I tend to agree with this position and thus to assign responsibility for curricular innovation on the developing country university. Surely U.S. universities and those of other advanced countries can provide methodological assistance and share experiences in curriculum development, but the onus for relevance rests squarely on the domestic universities. This is not to say that the development of balanced curricula, integrating new scientific knowledge while providing "relevant" experience is easy to accomplish. Support for enlightened approaches by LDC educational leaders in this effort is an urgent need.

Closely related to curriculum development is the training of teachers and publishing of educational materials. Support to

developing countries in the technology of production of inexpensive textbooks in science and engineering written by local specialists and using local examples continues to be a pressing need. Previous attempts to provide international technical assistance in these matters have demonstrated the problems and potentials of such undertakings. Mobilization of the local educational community for a national curriculum and textbook development effort is a job for the national educational leadership. International and regional development banks have come to recognize that such approaches are indeed "bankable."

4. Another aspect of the relevance of university education to development is in the kinds of "out reach" activities that universities engage in. We should remember, however, that it is easy to subvert the central educational functions of universities by using them as stalking horses for social action projects for which other institutions already exist in most societies or new ones need to be created. The single most criterion for relevant out reach or extension activities is that they are educationally meaningful, and not just features added for short-term experimentation in social action or technical development.

To summarize, new initiatives are needed more to address the qualitative deficiencies of developing country universities than in encouraging their quantitative expansion. This implies less concern with physical facilities and greater concern with efficiency, relevant curricula and teacher preparation, and educationally meaningful demands for university services by local governments and international agencies.

On a regional level the further development of existing graduate

programs at the national level in science and engineering, and assistance to new starts, only when they are fully justified in terms of needs or costs seem worthy of consideration. Graduate education is by its nature an expensive low-yield process. This argues for mechanisms for linking national programs in a regional network through such devices as faculty and student exchange, collaboration in research, and joint curriculum development and teacher training efforts. Such collaboration has already started in the different regions, but supra-national efforts have difficulty in commanding commensurate resources. Here is an opportunity for external funds to play a contructive role.

The role of U.S. universities in university development abroad has become passive while educational aid policies have been directed to meeting the basic needs of the developing countries. However, U.S. universities continue to host more than 200,000 students from many developing countries. A majority of these students are enrolled in engineering and management programs. Foreign students now account for 12 to 20 percent of the student bodies in the major U.S. universities. An unheralded program of technology transfer of major proportions is taking place via their training. When universities are facing escalating costs and decreasing total enrollments, the training of foreign nationals puts a net financial burden on many institutions. More importantly, the interactions with foreign universities previously available through technical assistance contracts are no longer the accepted mode of international educational assistance; also, many nations which have developed their university structures no longer need or want this assistance. Funds for collaborative research are not available in sufficient amounts to establish long-range relationships with overseas institutions. While

U.S. universities are being urged to internationalize their programs, they find themselves isolated for want of resources with which to do so.

One method for U.S. institutions to provide relevant education is through increasing the number of faculty members who have first hand knowledge of the LDC development needs and potentials. The other would be through special programs mounted by large universities or several universities in a consortium arrangement on subjects of special interest to developing country students. Yet another but more difficult method would be through internship arrangements managed by universities in close cooperation with government, industry and voluntary organizations. Special incentives are also necessary to encourage U.S. professors to undertake teaching and research assignments overseas. An Educational Service Corps similar to the U.S. private program in industrial technology and management may be the model to follow.

The U.S. university system is one of the largest resource base available for development. While interest and competence are evidently available, new modalities for their mobilization for development must be fashioned. These must be matched by sufficient and dependable source of support, so that existing international programs of U.S. universities are revitalized and new initiatives developed <u>in close collaboration with the developing countries</u>.

J. <u>Sub-Professional Technician Training Institutions</u>

Manpower studies in the developing countries repeatedly point to the relative abundance and in some countries, oversupply of university graduates in science and engineering and to the shortage of middle-level engineering and industrial technicians. These "non-commissioned officers" of industry skilled in the implementation of new industrial technologies,

indigenously developed or imported, are badly needed in all developing societies. Educational programs for their training provide a method for diversifying secondary and post-secondary education and diverting numbers of young men and women to useful occupations, and away from universities which are not always euipped to provide such training.

During the past two decades, international banks, bilateral programs and foundations have provided assistance to vocational and technical education at the secondary level and countries in Categories I and II have reasonably well-developed programs for training skilled workers for industry, commerce and agriculture. Even at this level modernization of curricula, improvement of teacher training programs and relating them more closely to the sectors they are supposed to serve, are important needs.

At the post-secondary levels, training of industrial and engineering technicians in larger numbers and newer specialties is a pressing need, if developing countries are to ingest new technologies efficiently and if such critical manpower resources are to be become available in non-metropolitan centers. The same applies to agricultural, health and social service technicians, where new approaches to delivery of services require a level of skill and knowledge beyond those provided at the secondary level. Rapid changes in technology in several areas of electronics and communication, computers, mechanical and materials technology, conventional and non-conventional energy technology, marine resource recovery require that post-secondary technical training institutions must quickly introduce those technologies into their curricula. Concomitantly, they must train new or retrain their older teachers in these technologies.

During the past two or three decades, the U.S. has developed a vast array of institutions and programs in industrial and engineering, health

and business in junior and community colleges, and in technical institutes and colleges. These programs offer the most direct, hands-on relevant experience for foreign students with U.S. industrial technology. Assistance is, however, needed to enable U.S. institutions in focusing their efforts to engage in international activities and provide more closely supervised training to foreign students, and especially teachers of technology subjects.

In the developing countries, much greater effort is needed to establish vital connections between training institutions and their clients. Technicians are still considered second class citizens in the occupational hierarchies and are treated as such in terms of pay and recognition. Migration of technicians, which is not as closely monitored as university graduates, seems also to be increasing.

The possibility that technician training could lead to self-employment opportunities for qualified graduates remains to be explored. This would require imaginative use of government loans and grants for skilled technicians to start small and medium service and manufacturing opportunities. Government procurement programs could provide the initial markets for such enterprises.

Several efforts have been made to introduce production and service activities into vocational and technical schools, but only with modest success. Experiments in which small and medium productive enterprises run on strict commercial lines and physically located close to technical training institutions, with students and staff provided opportunities for part-time employment, would appear to be a more viable alternative. Such arrangements require good leadership and management, however.

These approaches are intended to illustrate the range of possibilities of demand-oriented training operations. Clearly new educational and

industrial development policies are the key to innovative development.

K. Small and Medium Scale Enterprises

Recent data on U.S. electronics companies, and studies in Israel, Australia and several other developed and developing economies have shown that small and medium enterprises in certain high-technology sectors have significantly increased employment relative to their size and have contributed to indigenous innovation and technology-intensive exports. Previous and continuing attempts in several developing countries have been directed mainly at small and medium scale industries in the traditional consumer goods sectors of the economy. With the increasing technological sophistication of several developing countries, there are new opportunities to bring the resources of industrial research institutions, productivity centers or similar technical assistance organizations and engineering consultancy companies to bear on the development of technology-intensive small and medium scale industries in the developing countries.

The World Bank has taken advantage of the policies of some rapidly developing countries in promoting research, development and engineering to enable them through its loans to expand their activities in industrial innovation.

From an education and training standpoint, the support for such initiatives must include the training of technical entrepreneurs in the art and science of managing technology-based enterprises, a field in which U.S. management schools could play an important role. The modernization of curricula of developing country management schools to include courses in R and D management, management of industrial innovation, risk analysis, technological forecasting, venture capital management is quite timely.

Several developed countries such as France and Belgium have introduced

laws and incentives to encourage new job creation in established industries. The applicability of such initiatives in the developing countries would need to be examined. The role of multinational companies in the expansion of job opportunities has been discussed in several fora but concrete initiatives depend not only on the incentives available and the nature of technology imported. Since developing countries are emphasizing the need for labor-intensive technologies, it would be necessary for multinational companies to examine much more intensively several mixes of labor and capital in the technologies introduced to LDC's and their costs and benefits. The capacity of developing countries to search and select technologies and to make decisions on the appropriate technology which would meet national development needs is basic to the development of national policies for technology transfer.

L. The Role of Professional and Technical Societies

The word "network" correctly describes the principal functions of professional and technical societies in the developed countries. They provide the informal channels of communication of technical ideas, while providing for professional and personal contact with their peers in the profession. Only in a few developing countries are such technical societies active at the present time. They are more developed in the areas of science than engineering, technical education or management. In the Latin American region, several countries have functioning "Colegios" in the professions, which play accrediting and certification roles. They also maintain rosters of practicing engineers and are a good source of data on the stock of specialized engineering manpower. The development of such professional societies and educational accrediting bodies would contribute much to the qualitative improvement of the professions in the developing countries. U.S. professional societies have much to gain and to contribute to develop similar

institutions in the developing countries. Such society-to-society programs would provide an international network for professional development.

Author's Note:

In drafting this paper I have benefited from a paper by Charles V. Kidd entitled, "Manpower Policies for the Use of Science and Technology for Development," Graduate Program in Science and Technology and Public Policy, George Washington University, October 1978.

I am also indebted for the opportunity to participate in a 1978 Seminar at Washington University, at which the draft of a paper entitled "The Role of U.S. Universities in Science and Technology for Development: Mechanisms and Policy Options," Robert P. Morgan et al., was discussed. Some issues presented in that paper are reflected here.

Several of the ideas presented in the paper have appeared in my article in Impact (May 1978) entitled University-Based Science and Technology for Development, and in an editorial by Lawrence Barrell and myself in Science (22 September 1978) entitled Engineering Technology: New International Role.

VI. TECHNOLOGY CHOICES IN DEVELOPING COUNTRIES - STRENGTHENING THE ROLE OF THE SCIENCE AND TECHNOLOGY INTRASTRUCTURE

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A. The Importance of Technology Choices

Science and technology offer many opportunities for meeting basic human needs and for shortening the road to modernization in developing countries. At the same time, mistakes in the choice of technology can be costly -- in terms of adverse economic, environmental, or social impact; and commitments to technological development paths are usually difficult to change.

Technology choices in developing countries are of far-reaching consequences not only for these countries but also for the United States and other industrialized countries. In the short run, trade and foreign investment opportunities and access to raw materials are affected by technology choices. In the longer term, modernization within the developing countries inevitably results in increased economic interdependence among nations, and technology choices will influence the character of this interdependence. Also, U.S. technical capabilities to support modernization are respected throughout the world. As the developing country technical base expands, the opportunities for international cooperation increase, and the contributions of scientific cooperation to improved bilateral and multilateral relations have been frequently demonstrated.

Finally, technology transfer is an important theme of the New

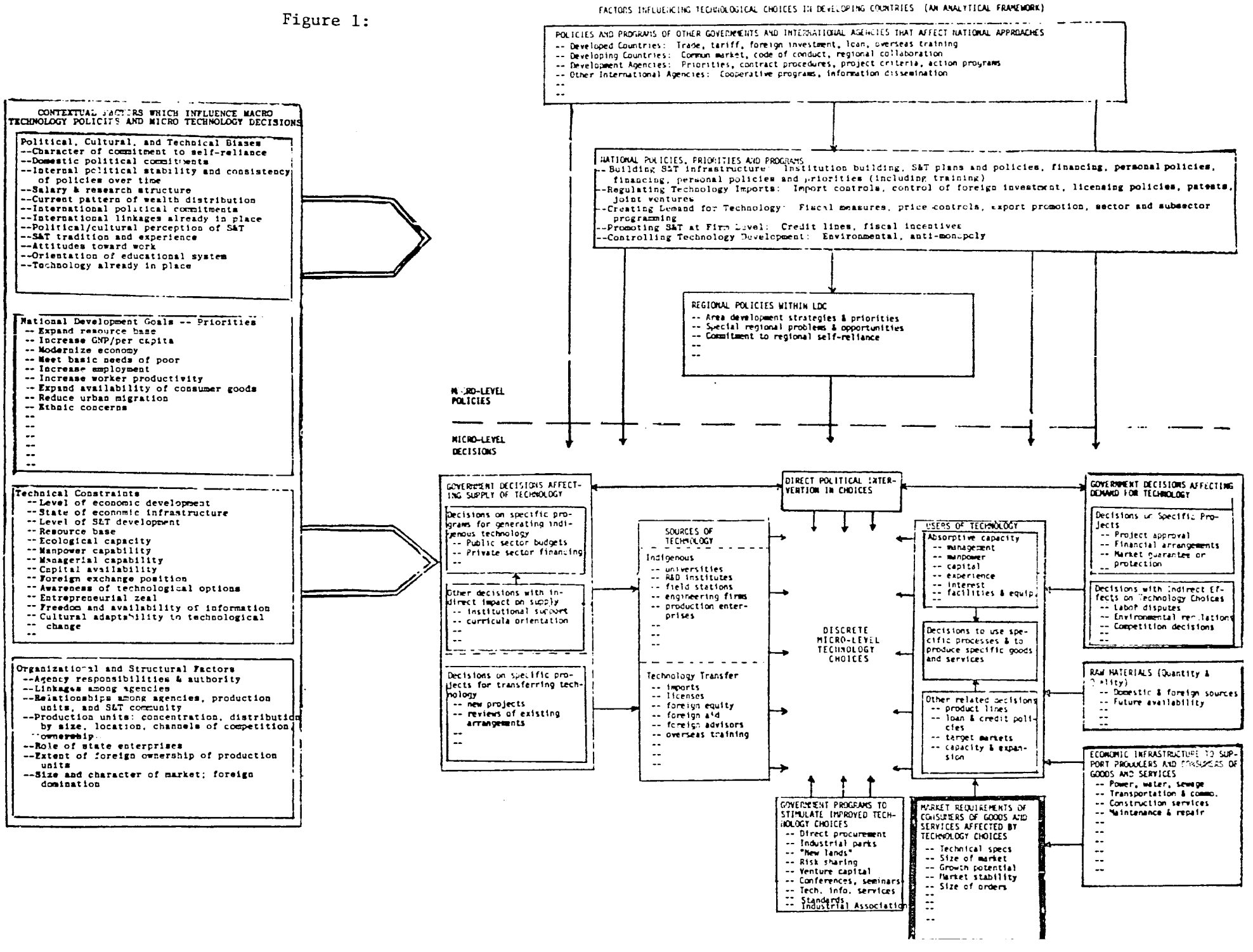
International Economic Order, and this topic has become a divisive issue in the North-South dialogue. A better common understanding of the processes of technology transfer from abroad and of technology development and adaptation within developing countries could help reduce these adversarial confrontations and lead to more productive discussions and relationships.

Technology choices permeate all aspects of the development process. Sometimes these choices are discrete decisions of Government organizations, private entrepreneurs, or consumers. They may be associated with explicit or implicit technology development or utilization strategies embodied in Government policies and programs or in private sector investment and business commitments. Technology decisions may be subsumed in broader political or economic choices. Also, they may be irreversibly biased by horizontal and vertical organizational linkages between the users of technology and other interested parties.

Technological innovation encompasses the entire process from the inception of a new idea through successful introduction of the idea into practice and use. Thus, assessments of technological change must consider a variety of intermediate steps, each involving one or more decisions, and must take into account the many marketing, financial, and resource issues surrounding the technical aspects of the research and development process. This process is not well understood in the developed countries and even less well understood in the developing countries where innovation is often based on imported ideas which are then adapted to meet local requirements.

Further complicating efforts to understand the factors influencing technology choices are the variations in the significant factors that affect different <u>types</u> of technology decisions at different <u>levels</u> of

Figure 1:


FACTORS INFLUENCING TECHNOLOGICAL CHOICES IN DEVELOPING COUNTRIES (AN ANALYTICAL FRAMEWORK)
POLICIES AND PROGRAMS OF OTHER GOVERNMENTS AND INTERNATIONAL AGENCIES THAT AFFECT NATIONAL APPROACHES
-- Developed Countries: Trade, tariff, foreign investment, loan, overseas training
-- Developing Countries: Common market, code of conduct, regional collaboration
-- Development Agencies: Priorities, contract procedures, project criteria, action programs
-- Other International Agencies: Cooperative programs, information dissemination
NATIONAL POLICIES, PRIORITIES AND PROGRAMS
--Building S&T infrastructure: Institution building, S&T plans and policies, financing, personal policies, financing, personal policies and priorities (including training)
--Regulating Technology Imports: Import controls, control of foreign investment, licensing policies, patents, joint ventures
--Creating Demand for Technology: Fiscal measures, price controls, export promotion, sector and subsector programming
--Promoting S&T at Firm Level: Credit lines, fiscal incentives
--Controlling Technology Development: Environmental, anti-monopoly
REGIONAL POLICIES WITHIN LDC
-- Area development strategies & priorities
-- Special regional problems & opportunities
-- Commitment to regional self-reliance
MACRO-LEVEL POLICIES
MICRO-LEVEL DECISIONS
CONTEXTUAL FACTORS WHICH INFLUENCE MACRO TECHNOLOGY POLICIES AND MICRO TECHNOLOGY DECISIONS
Political, Cultural, and Technical Biases
--Character of commitment to self-reliance
--Domestic political commitments
--Internal political stability and consistency of policies over time
--Salary & research structure
--Current pattern of wealth distribution
--International political commitments
--International linkages already in place
--Political/cultural perception of S&T
--S&T tradition and experience
--Attitudes toward work
--Orientation of educational system
--Technology already in place
National Development Goals -- Priorities
-- Expand resource base
-- Increase GNP/per capita
-- Modernize economy
-- Meet basic needs of poor
-- Increase employment
-- Increase worker productivity
-- Expand availability of consumer goods
-- Reduce urban migration
-- Ethnic concerns
Technical Constraints
-- Level of economic development
-- State of economic infrastructure
-- Level of S&T development
-- Resource base
-- Ecological capacity
-- Manpower capability
-- Managerial capability
-- Capital availability
-- Foreign exchange position
-- Awareness of technological options
-- Entrepreneurial zeal
-- Freedom and availability of information
-- Cultural adaptability to technological change
Organizational and Structural Factors
--Agency responsibilities & authority
--Linkages among agencies
--Relationships among agencies, production units, and S&T community
--Production units: concentration, distribution by size, location, channels of competition, ownership
--Role of state enterprises
--Extent of foreign ownership of production units
--Size and character of market; foreign domination
GOVERNMENT DECISIONS AFFECTING SUPPLY OF TECHNOLOGY
Decisions on specific programs for generating indigenous technology
-- Public sector budgets
-- Private sector financing
Other decisions with indirect impact on supply
-- Institutional support
-- Curricula orientation
Decisions on specific projects for transferring technology
-- new projects
-- reviews of existing arrangements
SOURCES OF TECHNOLOGY
Indigenous
-- universities
-- R&D institutes
-- field stations
-- engineering firms
-- production enterprises
Technology Transfer
-- imports
-- licenses
-- foreign equity
-- foreign aid
-- foreign advisors
-- overseas training
DIRECT POLITICAL INTERVENTION IN CHOICES
DISCRETE MICRO-LEVEL TECHNOLOGY CHOICES
USERS OF TECHNOLOGY
Absorptive capacity
-- management
-- manpower
-- capital
-- experience
-- interest
-- facilities & equip.
Decisions to use specific processes & to produce specific goods and services
Other related decisions
-- product lines
-- loan & credit policies
-- target markets
-- capacity & expansion
GOVERNMENT DECISIONS AFFECTING DEMAND FOR TECHNOLOGY
Decisions on Specific Projects
-- Project approval
-- Financial arrangements
-- Market guarantee or protection
Decisions with Indirect Effects on Technology Choices
-- Labor disputes
-- Environmental regulations
-- Competition decisions
RAW MATERIALS (Quantity & Quality)
-- Domestic & foreign sources
-- Future availability
ECONOMIC INFRASTRUCTURE TO SUPPORT PRODUCERS AND CONSUMERS OF GOODS AND SERVICES
-- Power, water, sewage
-- Transportation & comm.
-- Construction services
-- Maintenance & repair
GOVERNMENT PROGRAMS TO STIMULATE IMPROVED TECHNOLOGY CHOICES
-- Direct procurement
-- Industrial parks
-- "New lands"
-- Risk sharing
-- Venture capital
-- Conferences, seminars
-- Tech. info. services
-- Standards
-- Industrial Association
MARKET REQUIREMENTS OF CONSUMERS OF GOODS AND SERVICES AFFECTED BY TECHNOLOGY CHOICES
-- Technical specs
-- Size of market
-- Growth potential
-- Market stability
-- Size of orders

the economic and social structure and in different economic and social environments.

B. The Impact of the Science and Technology Infrastructure

Figure 1 is an attempt to lay out the range of factors and institutions which influence the choices of technology in developing countries. In some ways, the concept elaborates and refines the approach set forth by Sagasti and others. (See, for example, Sagasti, Francisco R., "Guidelines for Technology Policies," Science and Public Policy, February 1977.) As you will recall, the STPI report discussed at some length the five types of policy instruments that influence technological development identified in Figure 2.

Figure 2

TYPES OF S & T POLICY INSTRUMENTS

To build up S & T infrastructure

To regulate technology imports

To create demand for technology

To promote S & T in enterprises

To support S & T activities

Source: Main Comparative Report of the STPI Project, 1978

This paper emphasizes the role of the science and technology infrastructure in influencing technology choices, particularly in the industrial sector. This aspect was treated rather lightly in the STPI report.

As shown in Figure 3, the science and technology infrastructure in a developing country can be characterized as encompassing three sets of national and international functions: education, applied research, and technical services. Many public, private, and international institutions play active roles in carrying out each type of function. Some institutions

such as vocational schools and standards institutes usually concentrate their efforts in a single functional area. Other institutions, such as some universities and some multinational corporations, are active in all three areas.

Figure 3

FUNCTIONS OF SCIENCE AND TECHNOLOGY INFRASTRUCTURE

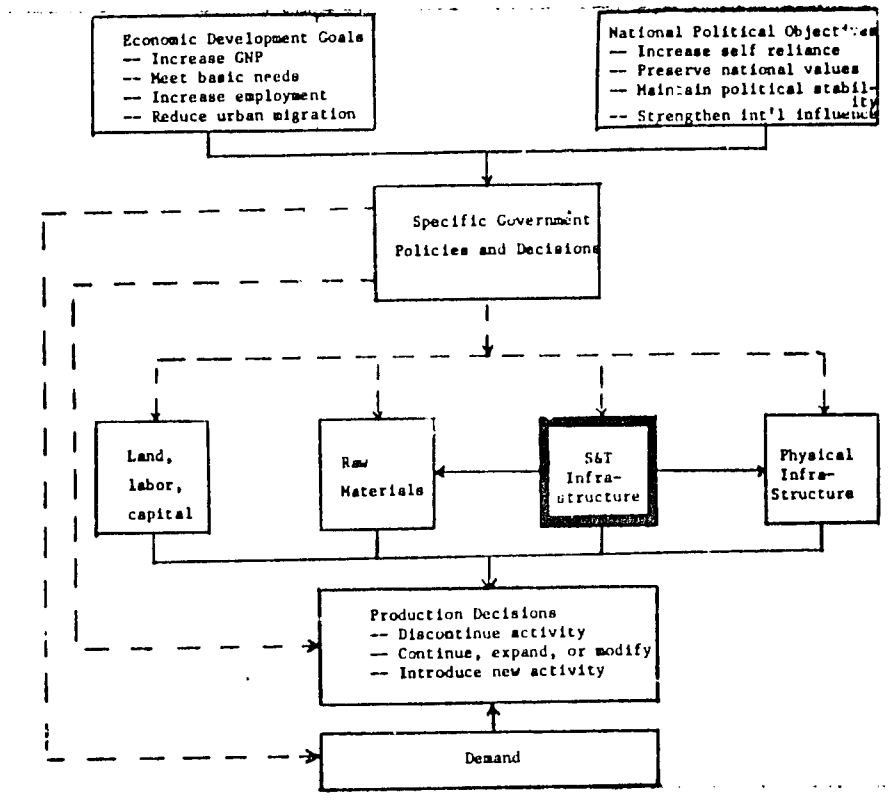
	Education and Training	Adaptation, Development and Research	S & T Services
Public and Private Sector Activities	Managers Scientists and engineers Teachers Skilled labor	Engineering facilitation Design and modification Development and demonstration Basic and applied research	Standards Patents Testing and quality control Information Extension Maintenance and repair
International Aspects	Overseas training Expatriate instructors	Technology transfer International research networks	Expatriate advisers International services

Of central importance are the interfaces between the domestic and international aspects of the science and technology infrastructure and between the activities of the public and private sector organizations. The Governments of both developed and developing countries have many mechanisms for influencing the division of labor among different types of institutions and the interactions among public, private, and international activities.

Abandoning the complexities of Figure 1 with a simplified approach, Figure 4 suggests that the science and technology infrastructure affects industrial development through at least three, and probably more, routes: direct interaction with manufacturing activities, impact on development of the physical infrastructure needed to support industrial activities,

and impact on the availability of raw materials used in manufacturing activities. Of course, many other factors bear on the direction of industrialization activities and the Governments of developing countries have many channels for influencing this direction.

Fig: 4 IMPACT OF S&T INFRASTRUCTURE ON PRODUCTION



Within this general framework, let us now turn to a few aspects of the science and technology infrastructure which have not received the attention they deserve. In each case, the relationship to technology choices, now and in the future, seems rather obvious.

C. <u>The Engineering Curriculum for Developing Country Students</u>

In recent years, there has been a general concern that Western-style engineering curricula do not provide adequate preparation for engineers who must often work without the benefit of strong technical staffs, modern supporting equipment such as the computer, and colleagues

who are equally well trained in related engineering disciplines. Further, in many cases engineers from developing countries are not exposed, prior to their schooling, to many technological developments reflected in everyday life in the West. Also, they are frequently elevated to senior management positions quite rapidly without the benefit of advanced on-the-job training.

The response to this need for better engineering preparation should not be to dilute the standard engineering curriculum by substituting more "relevant" topics, for there is no adequate substitute for a solid grounding in engineering principles. Rather, an enrichment of the engineering curriculum seems in order, recognizing that this process may extend the curriculum beyond the standard four academic years.

Ingredients of such an enrichment program might include broader exposure to engineering disciplines, in addition to the core discipline. For example, a chemical engineer operating in isolation could benefit from familiarity with problems encountered by mechanical, civil, and electrical engineers. Secondly, greater practice in identifying, characterizing, and solving specific problems which are often encountered in developing countries would be helpful when coping with the unexpected developments encountered on the job and the attendant need to innovate. Also, problem solving without the benefit of modern supporting equipment might be appropriate. More attention to design engineering would seem in order. Finally, internships in industry as an integral component of the academic program can often be helpful. However, lest such internships turn into paid vacations, the receiving firms must be committed to providing meaningful work assignments and the schools prepared to evaluate seriously the on-the-job work performance of their students.

D. The Need for Skilled Manpower

The inadequacy of the skilled labor force has been legendary for some time in most developing countries. The traditional response has been the establishment of a large array of trade schools, technical high schools, and other formal vocational training programs. The results have not been particularly encouraging, and the problem persists.

At the same time, there are a number of outstanding training programs directly coupled to industrialization which are turning out a limited number of trained technicians. Usually these programs are sponsored by private industry and do not involve Governments directly. Frequently the multinational companies are the prime movers. Often the companies award trade certifications that are more highly prized than certifications awarded by local educational institutions or by Governments.

There have been some attempts to capitalize on the training capabilities of the private sector through Government-sponsored programs. Usually, the Government develops the program and then tries to sell it to industry. Sometimes a tax is levied on industry to help subsidize the program.

A more serious effort to develop industry-based training programs -- including apprenticeship programs and structured on-the-job training activities -- would seem to offer a better likelihood of high payoff than the near total reliance on building more technical schools. The multinational firms have, in a number of instances, shown a willingness to train more personnel than they need themselves. Of special interest is the upgrading of the capabilities of suppliers through training of their personnel. However, both multinational and local firms have resisted participating in programs developed by Governments without their

involvement from the outset.

The training component of technology transfer arrangements is receiving increased attention by some of the developing countries which are interested not only in a capability to operate imported technologies but also in maintaining, upgrading, and eventually replicating the technology. Again, however, if such approaches are to be successful, the foreign firms should have an opportunity to participate in considering the specific requirements that are to be incorporated in regulations governing technology transfer.

E. Growing Importance of Civil Service Technical Schools

There is a rapid proliferation of specialized training institutes being set up by various Government operating agencies of developing countries to train their technicians (e.g., Public Works, Irrigation and Drainage, Power and Energy, Railways). Also, some public corporations are establishing their own technical training institutes as they assume greater operational responsibilities (e.g., utilities, petroleum companies).

These training institutes perform an important function. They offer courses ranging from two weeks to two years that have been developed to equip employees to perform very specific tasks. They usually have equipment that is identical or very similar to equipment in operation throughout the country. Also, they provide interesting points of contact for international collaborative programs designed to upgrade the appreciation of the developing countries of technological developments.

These institutes are bridging the gap between formal education and operations in public sector technologies. Consideration should be given to how some aspects of this seemingly successful approach can be diffused in helping to bridge the gap between formal education and and private

sector activities. For example, these operation-oriented institutes might offer special courses for selected students who are not employees of the Government agencies, or they might be co-located with general-purpose vocational schools with opportunities for sharing experiences.

F. Research Institutes as Educational Institutions

Directors of Government research institutes in developing countries continually complain that private industry lures away their best people to higher paying jobs. It is time to stop complaining and to recognize that these institutes serve an important educational function in preparing scientists and engineers to work in the private sector.

Two responses to the problem of turnover of technical staff seem in order. First, personnel recruitment policies of the institutes should take into account likely turnover rates, and over-hiring should become standard practice in an effort to reduce the problem of staff vacancies. Secondly, research programs should generally be of limited duration with many intermediate outputs required. Thus, the likelihood of reaping the benefits of the work of key researchers who are vulnerable to industrial recruiting would be enhanced.

Another aspect of the educational potential of Government research institutes is the unrealized opportunity in many cases for mutually beneficial interactions between these institutes and the universities. Often such interactions are thwarted by the distances between facilities and scientists working on related problems. Co-location can often be a key to effective collaborative endeavors within a country. It is usually unrealistic to relocate existing facilities to bring their activities closer together. However, in determining the location of future facilities, considerable importance should be given to the intangible benefits

of co-location of research and educational activities as well as the tangible savings resulting from the sharing of expensive equipment, libraries, and other resources.

G. Adaptive Research by Multinational Corporations

The extent to which multinational corporations conduct R&D in developing countries depends on the definition of R&D. In Malaysia, for example, a number of firms have active programs which would seem to fall within a reasonable definition of R&D, as shown in Figure 5. In Malaysia, and in other developing countries, three areas that are of interest to many firms are use of locally available natural resources, adaptation of products to the habits and tastes of the local consumer, and adaptation of products to the tropical environment. One interesting activity of another type is the Motorola program in Penang for design of specialized electronic circuitry. This program takes advantage of highly skilled Chinese manpower and is a technical counterpart of closely related activities conducted at the company's research laboratory in Ft. Lauderdale.

Figure 5

EXAMPLES OF MNC ADAPTIVE RESEARCH

Motorola - Design of special purpose circuitry

Dunlop - Blending natural and synthetic rubber for tires

Colgate - Use of natural products in cosmetics

Dow - Pesticide applications in the tropics

ICI - Paint applications in the tropics

Guthrie - Improving rubber tree production

Weyerhauser - Reforestation techniques

Source: Interviews in Malaysia 1/79

There has been a general assumption among development specialists that multinational R&D activities sited in developing countries benefit these countries, both in terms of transferring R&D skills to the local work force and, in the long run, developing opportunities for new industrial activities in the country. The developing countries have repeatedly called for an increase in such R&D by multinational companies. However, now that such R&D is on the increase, there undoubtedly will be political accusations that the multinational companies are exploiting the brains of developing country scientists.

In some developing countries there are tax and other types of financial incentives to encourage local R&D by both multinational and domestic firms. In general, such incentives have had only a marginal influence in decisions by multinational firms. They may tip the balance in a company's decision to locate regional adaptation activities in one country as opposed to another developing country or they might accelerate introduction of innovative activities. However, of much greater significance are other factors such as future market potential, internal political and economic stability, and availability of trained and trainable manpower.

H. Research and Development by Local Firms

Similarly, the extent of R&D conducted by local firms depends on the definition of R&D. Taking even the case of Nigeria which is in the earliest stages of industrialization, it is difficult to argue that some degree of innovation and adaptation does not characterize the activities of local industry as suggested in Figure 6.

Figure 6

ADAPTIVE ACTIVITIES OF LOCAL FIRMS

Insure quality of product

Adjust capital/labor mix

Adjust mix of local/imported raw materials

Upgrade quality in response to market pressures

Modify product line in response to market pressures

Source: Lagos Chamber of Commerce and Industry
3/79

Figure 7 present a specific example of how a local firm is moving toward an engineering design capability.

Figure 7

PRODUCTION OF REFRIGERATORS

Import refrigerators

Assemble refrigerators

Use local materials in assembly process

Manufacture selected components

Assemble/manufacture compressors and evaporators

Design refrigerator modifications

Source: Thermocool Engineering Ltd.
3/79

The STPI report discusses a variety of approaches to upgrade the technological capabilities of local industry. Again citing the Nigerian example as shown in Figure 8, such policy approaches are certainly not being ignored although the impact of these approaches is far from clear.

Figure 8

MECHANISMS TO STIMULATE INDIGENOUS TECHNOLOGICAL DEVELOPMENT
(illustrative)

Limitations on Technological Dependence
- restrictions on imports
- required use of local materials
- required use of locally made components
- requirements for standard product lines

Incentives for Indigenous Innovation
- tax holiday for pioneer industries
- tax deductions for R&D expenditures
- cash prizes for successful innovations

Government Services
- government certification of product quality
- R&D in government labs and universities
- extension services of government agencies and universities

Sources: Ministry of Industries, Ministry of Economic Development 3/79

I. Applied Research and Government Institutes

There have been unrealistic expectations in the past that Government research institutes, particularly in the industrial sector, could develop or even adapt processes or products for adoption by manufacturers in the private sector. While there are a few success stories, there are many more examples of unwanted research results. The multinational companies, in particular, have far greater technical resources available and have the advantage of being in a position to integrate their research efforts with long term financing and marketing strategies. The Government institutes may have opportunities to carry out programs of technological adaptation in response to requests from Government agencies which are in a position to utilize effectively the results of such adaptations -- for example, in public sector enterprises or through Government procurement (e.g., building materials). In any event, with a few exceptions, the most effective adaptation and innovation will be by technology groups which are directly linked to enterprises, public or private.

At the same time, Government research institutes have a broad potential for supporting industrialization in a number of other ways, particularly in the area of agro-business. They can provide the Government with an important capability to keep abreast on a world-wide basis of technical developments in specific product lines that could influence critical export opportunities. At the same time, this technical capability can provide important insights concerning the country's natural resources. Surveys and mapping of the nation's resources are particularly important in this respect. They can provide advice on applications for licensing agreements. They can promulgate standards of performance for certain products. Attainment of such standards has in the past provided reassurance for foreign importers as to quality of exports and has helped insure the quality of products on the domestic market. They can serve as centers of information networks -- acquiring and disseminating information on certain product lines throughout the country and internationally. They can provide low cost testing and analytical services. Finally, they can serve as repositories of information and material samples concerning resources in specific areas of the country.

Most Government research institutes have a special responsibility to provide technical assistance to small farmers or small entrepreneurs. Usually, to this end, they sponsor services, demonstrate available technologies, provide information on operational problems, and try to modify available technologies to the capabilities of the potential users.

J. The Rise of Technical Bureaucracies

The size of Governmental bureaucracies throughout the developing countries is growing rapidly. In particular, many agencies are expanding their technical departments with scientific and engineering talent. As

these agencies grow, they are assuming a greater responsibility for technological activities, activities that frequently by default had previously been left to the private sector. They have become particularly active in the development of specifications for Government procurements and in many cases in the detailed supervision of Government-financed projects.

Clearly, this technical capability has long been needed in most countries. However, now that it is beginning to materialize, several concerns are being raised. First, as the technical departments grow, there is a tendency for Government to begin to take over functions that could probably be more effectively performed by the private sector. For example, in the area of design engineering, in some countries the private sector has strong capabilities. Yet agencies are beginning to have their own design engineering staffs even though these same agencies are woefully shorthanded in monitoring the performance of major construction contracts.

A second concern relates to whether these technical staffs, often operating largely in Governmental enclaves, can stay abreast of technological developments. In several instances sabbatical programs abroad are being tried, but such an approach seems to be the exception rather than the rule.

Finally, the increasing opportunities for service on technical staffs are making ever less attractive employment of scientists and engineers in rural areas. This is particularly noticeable in the field of agriculture. Indeed, employment within the "Ministry" has become a very popular objective of many agriculturalists whose services may be critically needed on the farm. One approach to help minimize bloating the Ministries while serving the rural areas is a program of rotational assignments.

VII. RELATIONS AMONG NATIONAL INSTITUTIONS, INTERNATIONAL ORGANIZATIONS AND OTHER NATIONS

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A. Introduction

Many developing countries are embarking on a serious analysis of their national institutions for science and technology in the face of mounting problems in development. For some time to come there are bound to be wide differences of opinion regarding the structure and performances of these institutions. The dilemmas and choices are truly immense. There are not many tested models to be resorted to in resolving these dilemmas. However, there are widely accumulated experiences in building national institutions over the past three decades in developing countries. These experiences properly analyzed and objectively interpreted can be of considerable value in providing new directions.

Building national institutions involves great costs and raises fond hopes. Fortunately, the earlier assumptions that a large number of national institutions -- often randomly established -- would automatically solve the problems of development are being revised with more realistic perspectives. It is realized that the task of harnessing the potentials of science and technology to development extended far beyond the scientific and technological institutuions. There are many other elements -- such as political will, policy framework, administrative structure, financial resources, professional societies and academies, industrial base, media, historical and cultural traditions and international influences -- which

determine the effectiveness of this task. It will be unfair to attribute the blames for failure exclusively to one or the other of the elements without raising the conciousness of these elements to their relative functional roles.

B. Structure and Performance

Eminent scientists and technologists in lofty buildings with all the sophisticated equipments, by themselves, cannot adequately meet the challenges of the complex problems of development. Those National institutions, which interpret their roles within narrow spheres of activities, eventually get alienated and isolated from the mainstream of national concerns leading to low performance levels. Obstacles to their performance lie partly within the structure of the national institutions themselves and partly within the environment in which they function.

In analyzing these obstacles, the United Nations Advisory Committee on the Application of Science and Technology to Development (ACAST), identified the following major factors relating to performance of national institutions:[1]

First, absence of effective linkages between national institutions and the policy-making bodes on one hand and with the users on the other, contributes to depressed levels of productivity of scientists and technologists.

Second, shortages of middle-level technicians and management personnel to provide adequate support and maintenance services lead to deterioration in the quality of scientific output.

> "In the scientifically advanced countries, the ratio of scientists and engineers engaged in research and development to the number of available technicians can be as high

as 1 to 2.4; in the developing countries, the situation is often the reverse, with as many as six or seven scientists having to share one technician and this alone can present problems in designing and carrying out programmes of research."[2]

Third, a large proportion of expenditure in national institutions is devoted to salaries and wages thereby curtailing funds for hardware and software for serious research and development.

Fourth, the productive system shows clear preference to imported technologies thereby diminishing the motivation of national institutuions to perform at their best.

Fifth, the allocation of financial resources are inadequate and are not based on long-term development strategies.

Sixth, the proliferation of programs and institutions are uncoordinated and largely influenced by individual initiatives and preferences, not necessarily related to national priorities and socio-economic conditions.

More of such factors can be identified under these conditions. The challenges in building up national institutions are not so much in conceiving and establishing them as much as in insuring their longer term stability. Otherwise, they not only prove to be a permanent drain on scarce resources but also tend to be source of irritation and obstruction to change.

With very few exceptions, most national institutions in developing countries, after rapid rise to distinctions, either decline to mediocre levels or undergo oscillations and convulsions.

C. Sustainability

The ultimate test for the successful performance of national institutions

in developing countries will be their ability to sustain their growth in the face of the overwhelming odds of the environments. Except under extreme conditions of major political and economic turbulances, the national institutions in developing countries should exhibit the resilience and foresight in making the critical choices to demonstrate their effectiveness to the society. These choices are difficult to make and no single prescription will satisfy the varying situations among the developing countries with substantial differences in stages of development, resource endowment and cultural traditions. The characteristics of these choices are not as sharply defined as portrayed -- between science and technologies, between fundamental research and applied research, between industrial technology and appropriate technology, between indigenous and imported technologies, between centers of excellence and institutions of relevance, and so on.

The historical patterns of growth and stability (or instability) of national institutions in developed as well as developing countries provide many lessons on the relationship among science, technology and development.

Most developing countries in the wake of their political independence established institutions which were essentially science-oriented. The quality of their outputs were measured in terms of their prestige among their own peers. The common language of science cut across national boundaries establishing communities of international scholars. In spite of the distinctions earned by these achievements, these institutions acutely felt their inability to contribute significantly to the solution of immediate problems of the society. Consequently, the role of science as a whole and the peer relationships in particular came to be viewed as irrelevant and even with suspicions. Hastily many institutions attempted

to restructure their programs as "problem-oriented" activities in the direction of national "relevance." With some exceptions, these activities not only resulted in artificial exercises but also contributed to the decline of the positive environmental support which can be provided by a high-quality scientific acitivity to the development efforts.

Moravcsik[3] describes this phenomenon vividly in the following statement:

> "The attitude of politicians, economists, and even of many scientists towards the role of science in development is clouded by fundamental misconceptions. After an initial period of euphoria, in which it seemed that all the practical problems of poverty, hunger and economic backwardness would be solved at a stroke by the new understanding that would flow from the establishment of modern science in an old country, a reaction set in. The rhetoric was displaced by skepticism and cynicism: despite lip service to the contrary, there is now widespread disbelief that science can contribute significantly to development, except at the level of immediate practice.
>
> This skepticism is largely due to the extended time scale and subtlety of both the development process in general, and the contribution of science to it. In all walks of human life, short-term considerations tend to win out over potential long-term benefits. This tendency is epitomized in the use of the word 'relevance,' which has come to mean direct connection with an immediate material problem. In this sense, scientific research is often felt to be 'irrelevant' for the

less developed countries by comparison with problems like providing food for today and tomorrow."

Ranis,[4] while analyzing retrospectively the experiences of seven countries -- Great Britain, West Germany, United States, Hungary, Japan, Brazil and Ghana -- concludes as follows:

"It is, in summary, admittedly futile to attempt to manipulate basic science in any particular direction; the relationships and feed-backs are much too diffuse and complicated. But LDC's can, and we might add, must, exercise restraint as to the fields in which they decide to maintain a first-rate scientific establishment. What appears sensible in addition is a serious effort in re-orienting educational structures towards the very ability to make these selections i.e., via the achievement of a broadly based scientific literacy which not only conveys the capacity to perceive where indigenous frontier capacity should be installed but also guarantees the necessary access to the international networks.

With respect to technology, the task of public policy is perhaps easier, but by no means simple. Internationally, there exists a substantially larger number of borrowing options by country and by type than we used to believe, but many remain obscured by a lack of information and other institutional impediments; some related to the public and private capital transfer mechanisms. The options which exist, in nature, with respect to indigenous or adaptive technology change, new or derived, are much more numerous yet."

In considering resource allocations to institutional growth, conflicts arise between the goals of individual scientists and the institutions they belong to. As Kidd[5] points out:

> "In the use of science and technology in developing countries, a general problem for most countries has been to pass from the stage of heavy or total reliance on individuals to a stage characterized by productive institutions that endure while individuals come and go. Research is always the product of individual minds, and the growth of strong and stable institutions does not mean decreased reliance on the worth of individuals. Organization is worse than useless if if does not enhance the productivity, creativity and originality of the individual."

In the light of this experience, what are the viable policy objectives for national institutions that can sustain their healthy growth? Kidd[5] summarizes as follows:

> "1. Establishment of national priorities and of plans of science
>
> 2. Efforts to make science a more effective device for economic and social development
>
> 3. Coordination of the efforts and resources devoted to science in the country
>
> 4. Establishment of science as a component of national development plans."

There are genuine differences of opinion as to the manner of translating these policy objectives into practicable propositions. Should there be a monolithic and institutionalized science and technology plan for

development? Or should the science and technology activities be individually incorporated into each sector of national program?

The experiences of United States is recounted by Handler:[6]

> "A major strength of the American system turned out to be the very fact that it was not planned, that it was not centralized. The strength of the American arrangements for science was the strength of the society itself in that they were pluralistic; we did not have single policy; we did not have a single mechanism. Within the federal government we did not and I hope will not construct a science and technology budget and allocate within it some predetermined total. Rather, we ask how much we are willing to allocate to defense and within that allocation we ask how much should be spent on research and development."

No doubt, this approach to science and technology policy will be satisfactory where resource constraints are not severe and where the science and technology culture is all-pervasive. There will, however, be serious limiations to this approach in developing countries in the context of conflicting demands and limitations of resouces -- financial, human and institutional.

Specifically, how then, can the national institutions in developing countries interact with the national systems?

First, the national institutions evolve a deliberate -- even if unsolicited -- participatory role in the national policy-making process as an equivalent to the resources of a "think-tank." In most developing countries where the power to direct the development activities largely rests with the government, this role is not to be viewed as an interference

but shall lead to the recognition of mutual advantages to the national institutions in science and technology and the policy-making and administrative apparatus. These institutions, with the strength of scientific and technological competence, should demonstrate keen awareness, analyze, evaluate, forecast and suggest the options on socio-economic and national security issues in the areas of their professional interest. Such involvements will keep the institutions alert to the growing possibilities of their contribution to national dialogues besides providing meaningful directions to their programs of research and development. Devoid of a participatory attitude, the existence of national institutions will degenerate to a sum-total of individual projects conceived in darkness, with random impact on the society.

Second, national institutions, and units within them, should establish national coalitions -- interdisciplinary and multidisciplinary -- to foster unity of purpose within diversity of approaches. It will help to generate mutual respect between the "islands of excellence" to more modest institutions, and reduce the negative aspects of interpersonal and inter-institutional interactions.

Such coalitions will also help to arrest the degeneration of academies and professional societies.

Third, the focus of the activities of national institutions should be centered around the surrounding environments. The power of trained minds and modern facilities will be assets in constructing solutions to the problems of the immediate neighborhood. It will naturally be highly cost-effective. Innovations and adaptations will be more organic than artificially contrived. The resulting improvements and substitutions in techniques will enhance the credibility of these institutions in the

minds of the people, be they farmers, industrialists, administrators or politicians.

Fourth, instead of aiming towards spectacular visibility, national institutions should direct their efforts towards continuous and incremental goals with multiplication potentials.

Fifth, the policy-making apparatus should respond positively to the developments of these frameworks through formulation of explicit and implicit policies.

D. Scope of International Efforts

National self-reliance within the framework of international interdependence is now universally accepted as a desired goal for the International Order. Building up the indigenous capacities of developing countries is recognized as an essential prerequisite to attaining this goal.

The U.S. national paper to the United Nations Conference on Science and Technology for Development[7] states:

> "Indigenous capacity Building: It is necessary to improve the technologies and mechanisms of industrialized countries for assisting developing countries in upgrading their scientific and technological skills and resources. This would enable the developing countries better to generate; select, adapt and apply science and technology in pursuit of their own economic and social goals."

This position is further stressed by Vance[8] as follows:

> "...despite severe economic pressures, the United States remained committed to making international trade fairer for developing countries and to encouraging the transfers

of resources and technology to these countries. These topics have dominated North-South dialogues for years.

"We cannot spend so much time and energy on our international discussions of the road map that we lose sight of our destination. The destination -- the goal we share -- is to find practical ways to have an appreciable impact on the lives of people around the world, and especially on the lives of those for whom daily survival is an unanswered question.

"Our progress in North-South negotiations, our progress toward a more equitable and healthy international economic order will turn on our common ability to avoid endless debates on sterile texts and to focus instead on concrete development problems which we can tackle together and which directly affect people's lives.

"Industrial nations must maintain their commitment to the well-being of the developing nations. The developing nations must recognize that making demands which the industrial nations cannot meet will only produce international acrimony, not progress. And the oil producing nations, must recognize their social responsibilities for the health of the global economy and their fundamental stake in its continued vitality.

"The United States intended to concentrate on four specific goals involving energy, food, health and increasing the capacity of the developing countries to obtain and apply the knowledge and technology they need."

Frank Press[9] provides further rationale to these sentiments:

"The future of these countries is of major importance today -- socially, politically and economically. While most of them have been born politically only within the past 30 years, within the next 30 they will contain more the 80% of the world's population. Therefore, the way we go about assisting them could well determine the future of all humanity. International technology transfer already has its impact on every major issue today -- world peace, global resources -- and environment, hunger, health and economic development.

"When it comes to the economic issue, we must recognize that there is a 'new economic order' evolving today. It is not just a product of developing-nation rhetoric. There is a growing interdependence: and mutuality of interests between the advanced and developing nations. Not only are many of the developing countries current and potential sources of natural resources, essential to the continuous growth of the industrialized world, they are the future markets of that world. They are also future producers of many of the world's manufactured products. A preview of all this can already be seen in today's trade between the United States and the developing world. As a recent State Department paper has pointed out, that trade is far more important than most Americans realize. Of the $120.2 billion of goods the U.S. exported in 1977, more the $40 billion -- about 35% -- went to developing countries. That was more

than our sale to Western Europe and Japan combined. At the same time, we imported $67 billion from developing countries, about 46% of our total purchases. Approximately 1,200,000 American jobs are directly dependent on such exports; with many more indirectly involved. It is facts like these that are making economists begin to view the Third World on the future engine of economic growth."

Practically every other nation subscribes to the need for building indigenous capacities. Zevin[10] states the Soviet approach as follows:

"Cooperation between developed and developing countries must thus clearly by based on such a blending of foreign technology and know-how with national efforts as will, in the long run, open the way to the independent growth of the productive, scientific and technological potential of the Third World based on greater international division of labour in production and in scientific and technological research."

These expressions are definite improvements to the situtaion foreseen earlier by Moravcsik and Ziman:[3]

"Yet there are still those who seem too unconvinced of the urgency of the need for an indigenous scientific community in a country such as Paradisia.* With scientific knowledge and technological know-how available for all on the world market, would it not be easier to import and use whatever is needed, without building 'local production facilities'

*Pseudonym for developing countries.

in these commodities? This commercial metaphor is appropriate, since the essence of this arrangement is an appeal to the principles of classical liberal economics -- the open market, free trade, economies of scale, and the division of labour. Let the great knowledge factories of the advanced countries export their great surplusses of information, fact and theory, in exchange for cocoa, bananas, oil and copper and eventually in exchange for industrial products manufactured in the newly developed countries.

At the most elementary level, this analogy is entirely fallacious. Scientific knowledge lacks many of the necessary attributes of a commercial commodity and cannot be fairly bartered for material goods and services. It is not possible to 'import' science and technology in the absence of an indigenous scientific and technical community. And even if this were possible, it would be insatisfactory and undesirable for economic, political and psychological reasons."

In spite of these universal agreements on the need to build indigenous capacities of developing countries, differences are bound to persist. The questions of "the capacities for what? for whom? and how?"

There is an influential body of opinion which advocates that the indigenous capacities of developing countries should be primarily (if not exclusively) towards solving problems of basic human needs. There is an equally vehement argument that the access to all sciences and technologies should become unrestricted, the choice being left to the developing country alone. There are demands for free and open access to the markets of developing world and at the same time advocacy of

"selective" delinking of developing countries from the world technological system. These debates will continue into the foreseeable future till developing and developed countries agree in their own self-interest and survival to find workable solutions. That day is likely to come sooner than some would hope for.

In the meantime, the developing countries have an urgent need to evaluate the directions of their national institutions to adequately assimilate these rapid changes in the international economic order.

E. International Mechanisms

The international channels to assist in this endeavor are (1) intergovernmental mechanisms -- binational, multinational and United Nations systems, (2) private commercial corporations and (3) non-governmental mechanisms -- foundations, universities, professional societies, academies, consortia and voluntary groups.

1. Intergovernmental Mechanisms

Science and technology will be increasingly used as instruments of diplomacy in intergovernmental relations. Huddle[1] states that:

> "Technology is perhaps the most powerful of all forces for change in the modern world. It measures the qualification of nations for the leadership in the community of nations. It affords a means for the achievement of a nation's domestic and foreign goals. It is a principle substance of modern diplomacy. A nation's diplomatic voice is often heard in proportion to the nation's excellence in science and technology, and in its competence to use these for national and international purposes."

At the same time, developed countries are agreeing to subscribe towards building national capabilities of developing countries. These two somewhat different purposes will call for a mature strategy of reconciliation and compromises on the part of the developed world.

The possible trend in U.S. strategy is summarized (but not subscribed to) by Cowhey[12] based on as a synthesis of papers by NYE,[13] NAS,[14] and Department of State:[15]

> "As America's economic hegemony and self-sufficiency declines, it gains a corresponding dependence on the opening up of Third World markets and raw materials for American industry...
>
> "What should the U.S. strategy be, according to the conventional wisdom? It has four parts. Where there is a Very Large Gap between American technological capabilities and those of the Third World, offer generous aid to help lessen the relative gaps and solve immediate specific problems of the less developed countries (LDCs) (e.g. research on new strains of seeds for agriculture or control of tropical diseases). Where there is a small gap between the U.S. and "77," withdraw most aid, rely on the mechanism of the market place to transfer or develop technology, and commit the U.S. not to withdraw from the principles of liberalism (e.g. no new trade quotas on Third World products). Where the issue is not one of a gap, but rather one of mutual need, as in exploring fundamental frontiers of science, encourage selective research and development cooperation

with appropriate costs and benefits assigned to each participating nation (e.g., in dealing with fishing problem). And, in all three cases, the American government must underscore its commitments to the roles of the market place and private enterprises as indispensable pivots for the creation and distribution of science and technology."

Thus it is reasonable to expect that the willingness of developed countries to assist in building national institutions in developing countries will be limited to (1) protection of global commons, (2) preservation of diplomatic and commercial advantages, and (3) reducing extreme symptoms of human suffering, i.e. "worst aspects of poverty."

It is also reasonable to expect the present "special" relationship in scientific and technological cooperation among developed countries will continue for some more time before such relationships can be fostered with developing countries.

In the meantime, the possible effect of these policies on building national institutions in developing countries will need careful assessment.

Most developing countries look upon industrialization and employment as an inseparable part of their basic human needs strategy. The possible position of the developed countries, as surmised earlier, will be incongruent to this expectation. Overemphasis on certain kinds of problems (e.g., basic needs, global commons) with the exclusion of other problems (e.g., lack of industrial base, processing of natural resources) will inevitably be viewed with suspicion, if not annoyance. These offers will be considered as distortions to their national planning efforts. At best, the national institution should be able to recognize the potential advantages

and distortions within the matrix of their national goals and should have the capability to accept or politely decline the international overtures.

Another cause for inadvertent distortions in the efforts of national institutions is the multiple operations, i.e. several developed countries simultaneously pursuing their own priority objectives or several agencies of a developed country operating on overlapping or contradictory missions. These will be relatively easy to solve, if the national institutions of developing countries have clearly defined objectives and can resist simple temptations.

Relative to these limitations of binational mechanisms, the United Nations system enjoy a higher degree of credence. In the words of Cleveland:[16]

> "They (U.N. Conferences) are best seen as problem-oriented sensitivity training on issues that have been neglected by national governments and international agencies precisely because they had to do with purposes of production, the quality of life and the values to be served by growth.
> "There is a certain irony in the fact that national criticism of the bureaucratic sins of United Nations agencies -- which are many, and fully exposed -- is at its height when the United Nations system is breaking this new ground and pushing national governments to break at the right subjects for the transition we are in."

2. Private Commercial Corporations

Private commercial corporations enjoy two advantages over developing countries: investment potentials and technologies. Some countries (e.g., in Latin America) encouraged liberal investments in order to attract

technologies. This did not materialize to the extent they expected.

Urquidi[17] summarized this situation as follows:

> "Nevertheless, in the absence of an adequate build-up of scientific and technological infrastructure, rapid industrialization meant a growing technological dependence, through licensing agreements, upon research and development carried out in the developed countries. In effect, it also meant a simultaneous penetration of transnational enterprises in the industrial structure of the Latin American countries, motivated by the need of the corporations to gain a foot hold in the protected markets, and the Latin American countries' need to create urban industrial employment and to modernize, in most cases, the capital-short Latin American countries welcomed the new foreign investments as a supplement to domestic savings. The net result, in the 1970's, is a considerable industrialization in the larger countries of the region, less so in the intermediate and smaller countries, and a large percentage of ownership of industrial assets by the transnational corporations, through their subsidiaries and affiliates, and of control of local industry through licensing agreements. Very little research and development is carried out by domestic industries directly, there is little farming out of research and development to local technological research institutes and relatively scarce innovation and adaptation of technology is performed by the subsidiaries or the licensees."

A different approach was adopted by some other developing countries (e.g., India), to control acquisition of technology through the control of investments.

> "The basis of this policy is that foreign equity is not regarded as making any sizeable impact on the country's requirements of capital and is therefore welcomed only if it brings technological know-how which cannot otherwise be bought and assimilated. This narrows the range of foreign investment, particularly foreign majority equity to a relatively small number of industries. Existing foreign companies, if they wish to retain foreign majority shareholding will be required to operate predominantly in technologically sophisticated areas or reduce their equity to levels below 40 percent."[18]

The comparative merits of these two approaches are obvious. Yet, both these approaches of developing countries seem to have failed to produce significant direct efforts on the part of transnational corporations in building national institutions.

The experience of Western developed countries seem not very different.

> "A survey of 100 United States firms carrying out research in Europe, made by the Stanford Research Institute, found that most of these companies spent less than 4 percent of their total research and development budget there. For many, the main purpose of this was to gain access to the European scientific community and to monitor other research and development being carried out in Europe."[2]

The exceptions are IBM, which has seven laboratories in Europe, each

specializing in a certain set of components; Dutch Philips has five research laboratories in other European countries; British ICI has research units in USA, Canada, Australia and India. Royal Dutch/Shell has research establishments in United Kingdom, Netherlands, France, F.R.G., Japan, Canada and United States.

The justification for the demand of the developing countries to the TNC's to foster local research arises from the fact that their own domestic research and development funds are smaller in comparison to their payment for patents and technical know-how. Sri Lanka, for example, paid 0.5% of its GNP for transfer of technology in 1970 compared to 0.2% on its own research and development. Nigeria spent 0.8% of its GNP for foreign know-how in 1965 compared to 0.5% on its domestic research and development.[2]

In Peru, for instance, the ratio of payments for imported technology to expenditure on local research and development was approximately 2 to 1, while in most Western European countries and Japan was between 1 to 10 and 1 to 20, and in the United States, 1 to 240.[19]

These complex issues are being discussed in various fora in order to arrive at mutually satisfactory solutions. In any case, one of the prime considerations for the national research and development institutions (particularly in private sector) is to establish compatible capabilities and obtain prior commitments in research and development collaborative arrangements.

3. International Non-Governmental Mechanisms

There are several examples of successful achievements of these mechanisms in solving many problems of development. Examples are: International Center for Maize and Wheat Improvement (Mexico); International

Rice Research Institute (Philippines); International Center for Insect Physiology and Ecology (Kenya); International Center for Theoretical Physics (Italy); Consultative Group on International Agricultural Research (USA); International Development Research Center (Canada); Ford and Rockefeller Foundations (USA); Humbolt Foundation (FRG); and the list can be extended.

The chief merit of these mechanisms has been to direct concentrated attention in particular sectors of concern through a high degree of coordination with national institutions, while remaining substantially free from politicalization of their efforts.

Additionally, they have served to accelerate the diffusion process of knowledge and its application around the world for concerted and effective action.

It is for serious consideration of world leaders whether such mechanisms can be extended several times to embrace other sectors of perceived concern to development (e.g., industrialization, energy, transport, and communication) where binational efforts suffer from limitations.

One aspect of concern about non-governmental mechanisms (especially in professional and scientific societies) is the predominant influence of members and resources from developed countries. Their interaction with developing countries and their problems naturally assume unequal relations, thereby creating credibility problems.

F. Summary

To sum up, national institutions need to become pervasive in developing societies to be able to sustain themselves; their policy-makers should utilize them more effectively; the internal structure is an important as external environment in their performance; and the

international efforts are assuming positive postures in building indigenous national capabilities, though the realities of the world will induce considerable variations in their effectiveness. To quote Brooks:[20]

> "In the view I have just outlined, the world is not a zero-sum game, in which one person's gain is another's loss. On the contrary, the mutual gain achievable through co-operative effort far outweighs the unilateral advantage that can be captured by any subgroup aching in its own particularistic interest. The more we avail ourselves of the potentials of science and technology, the more we find ourselves in a positive sum game, that is, a game in which all players gain by asking mutual concessions. The catch is that the gains from mutuality tend to be much longer-term than the gains possible through striving for immediate unilateral advantage."

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VIII. SIGNIFICANCE OF TRANSNATIONAL FIRMS FOR TRANSFER OF TECHNOLOGY

R.H. COTTON
ITT CORPORATION - NEW YORK

A. Examples of Technology Transfer by Transnational Firms

This paper focuses on just part of the problem of technology transfer - the creative role the transnational firm can play under the right circumstances. Transnational firms do have technology which developing nations need, and Transnational firms do transfer technology to developing countries (LDC's) as indicated by these examples:

1. Energy

Corporations from the developed world have helped LDC's explore for oil, find it, erect complex drilling rigs and pump the oil. This technology is crucial. Russians come to us for drilling technology and equipment; example drill bits. Once LDC's have the oil there are problems of storage, transport and marketing. Again TNC's provide both the technology and training needed. Over the years, this technology transfer has made positive contributions to LDC's.

2. Agriculture

TN firms developed tractors and have sent them around the world. They have helped LDC's produce their own. Russia has tractors and large scale farming but somehow does not have as productive an agriculture as Western visitors. The difference lies in management of resources and people and their motivations. TNC's not only export tractors but skills - how to train people to maintain equipment, how to use it to best advantage, how to manage repair facilities. In short, the TNC's often export the capacity for the teamwork aimed

at accomplishment of concrete goals, economically. The profit motive is obviously one of the big driving forces as well as a means of keeping score on progress. This involves large training programs overseas. Food companies are to a great extent the customer of agriculture. TNC's have gone to LDC's with a very small core of their own people, installed food production facilities which use and preserve local food; they have taught local people to run the complex machinery brought in, developed markets, provided employment and usually left the local organization to be run almost completely by natives of the LDC's. That is practical technology transfer.

3. Telecommunications

No country can develop far without good communications. TNC's from developed nations invented and spread telephones worldwide. In the early days, ITT and others installed and ran LDC phone systems, trained local technicians to run them. Later, they brought in manufacturing plants; again, they trained local people to run them. Meanwhile, ITT, for example, provided South America with its first intercountry telephone system with the laying of the trans-Andean Cable and its first radiotelephone system to Europe. Today, of course, satellites can bring telecommunications to anywhere on earth with no need for long, local wires to sparsely settled areas such as the Sahara, for example.

4. Training

Training is one of the ways in which transnational firms contribute most effectively to transfer of technology. Again, because of familiarity, I will use ITT examples of training overseas even

though the same could be told of other TNC's.

It is ITT's philosophy to develop self-sufficiency through the provision of fully equipped training centers staffed by local instructors. Consequently, ITT operates telecommunications training centers in 16 countries and has built or is supplying training centers for its customers in another 12 nations.

Each year, the company provides formal training to an average of 200,000 individuals at 130 locations in 80 countries. This requires 3,000 training programs of varying diversity given by 1,700 qualified instructors.

In Algeria, two ITT Units are committed to training 3,000 engineers and assembly personnel in the manufacture, installation and maintenance of the Algerian PTT system.

In Nigeria, ITT teams are working in cooperation with the government's P&T in a program which will, at completion, result in the training of over 10,000 Nigerians, to service and maintain public and private switching systems, subsets and teleprinters.

In Indonesia, ITT is instructing over 20 engineers in the installation, maintenance and operation of a domestic satellite system, and of public and private switching, and also has established a technical assistance team to help in network planning and operation.

B. TNC Strengths and LDC Needs

For brevity we will list a few reasons why transnational firms are effective and then, looking to future expanded work overseas, ask the question - What is needed in the LDC's before successful technology transfer can take place? Surely, we all want it whether in private or public sectors.

One reason for the effectiveness of TNC's is very simply the profit motive. It promotes competition; it requires and gets teamwork; it discourages having two people where one will suffice; it finds and develops markets without which nothing can happen. Finally, it leads to training of people. Other factors in TNC capability are access to capital, access to markets (even if the market has to be created!), advanced technology, proven teamwork within and across company and national borders, management discipline which sharply defines goals, steps and plans to accomplish them, sets milestones and dates to achieve same and establishes methods for objective measurement of progress. Its employees have to be willing to make commitments to achieve these practical goals and be willing to be measured and rewarded against them. Result orientation prevails while the building of bureaucratic empires is constantly squelched.

Now looking to the future - what is needed in an LDC in order to have receptivity for technology transfer? Some key elements are:

1. LDC desire for close cooperative working relations with donor country and/or donor corporations .
2. An economic policy for development friendly to private or co-op entrepreneurial activity, including permission to repatriate profits for single or joint ventures.
   (a) In the case of creation of a local development institution such as Fundacion Chile, commitment of one or more major government, university and private LDC executives in terms of time and at least some money.
3. Inventory of local strenghts in raw materials, processing plants, technical institutions, if any, and especially leaders. Every country has brilliant doers who want to help their country grow.

4. An inventory of principal development needs with assigned priorities. These can be sharpened by joint LDC-DC working teams. Use of seminars on key areas is very helpful.
5. Allotment of scholarships at first primarily for practical training at home or abroad as compared to foreign PhD work which often leads to frustration at home after graduation due to inadequate facilities and funds for post doctoral research.
6. Realization that much of the technology needed, for example, to develop agriculture and agroindustry is relatively simple and often free. In fact, tremendous progress can be made with no payments for overseas technology. Obviously, this changes gradually as we move into more sophisticated industrial manufacture.
7. A policy to allow unfettered, quick imports of scientific instruments and reagents free or nearly free of tariff. Refer to excellent paper by Moravcsik given at this meeting.
8. A policy of free movement of scientists and technicians moving in and out of the country. Often, a foreign university professor or business consultant is only needed for a week or two and he has a tight schedule. This allows him to fit in the trip necessary to speed a program.

C. <u>How a TNC Can Operate in an LDC</u>

1. Provide turnkey projects for high technology industry. Problem of diffusion of skills technology and management - to enough LDC citizens. Can be done but difficult.
2. Wholly owned business. Can be beneficial. Can train many people. Not as desirable usually as (3) below.
3. Joint ventures. Generally quite desirable.

4. Sales of know-how. Good or bad depending on circumstances.
5. Technical service and training related to sale of capital goods. Again can be good or bad depending on way it operates.
6. Straight sale of technical items with no service or training. OK when infrastructure can use them.
7. Training programs for a fee.
8. Movement of locals to TNC laboratories or plants for practical shirt sleeve training. Can be for a fee or as part of joint or single ventures overseas.
9. Establishment of technical centers in LDC's in cooperation with local government. In rare instances this can be a gift. It need not be. It could be by contract with LDC government with possible DC aid grants from agencies such as the future Institute for Technological Cooperation. See appendix D.
10. Creative raw and/or finished material purchasing. Ideally joint ventures or long term contracts with well defined specifications and means for quality measurement by buyer and seller.

D. The Future

Most, if not all, nations have resources in material and people which can be unleashed to help LDC's grow and better feed their people. Much work is needed to prepare for reception of technology and to build an atmosphere which promotes wide cooperation in all key sectors - government, universities, cooperatives, and private industry. With clear goals and constant communication, TNC's can fit into LDC's in ways beneficial to both. Their technology can be used, and, of equal importance, their work ethnic and management skills can be transferred.

The Fund for Multinational Management Education has proposed a certain amount of volunteer work by employees of TNC's in the LDC's whereby they could be freed from work up to ten days a year to help non-competitive companies assess their needs for technology and prepare them to receive what they need. Their employees will usually be LDC natives who have been trained on the job. Many will welcome a chance to help their country grow. Such teamwork will be a new idea as indeed is teamwork between university and government laboratories in pursuit of projects for national growth.

As experiements such as Fundacion Chile and the excellent work of Canada's IDRC succeed, we visualize rapid growth of development projects around the world in which our government can and will encourage establishment of local technical - business oriented institutes where DC citizens will work right in the field with LDC partners for three to ten years. After that time, they will go home but perhaps others will follow in different areas of endeavor. We believe very high priority must be placed on work to develop agriculture and growth in industry to use the fruits of agriculture. This helps feed the LDC and provide jobs. Transnational companies overseas realize that their ultimate chances for profit increase if the LDC in which they work prospers. There are ways to foster the mutual effort to make this happen. One way is to use the proposed new U.S. Institute for Scientific and Technological Cooperation to foster creative and mutually satisfactory relationships between developing countries and transnational corporations. The potentialities for developing countries in expanding these relationships is so great that the United States should take all feasible steps to minimize the tension between some governments of developing countries and their image of transnational firms.[1]

[1] Some specific suggestions are presented in Appendix B.

IX. DISCUSSION

At the workshop ample time was allowed for discussion. The free exchange of views amplified and modified points made in the papers and generated some new ideas. There was general consensus that the major points made by the papers were valid. The discussion revealed disagreement with some details, but was for the most part an elaboration of the positions of the papers. Since much of the discussion related to matters touched upon in several papers, or to matters not mentioned, as well as on points made in the papers, the substance of the discussion is drawn together at a single point rather than attached to each paper.

In retrospect, those parts of the discussion which did not produce recommendations centered around three themes -- definitions, goals and means of attaining the goals. This section presents the ideas in that sequence.

A. Definitions

1. The needs and capabilities of developing countries vary widely, and the policies of developed countries must take this into acount -- a precept that is often violated in practice.
2. Science and technology should be considered separately in many respects. In many countries, institutions for the acquisition, modification, development and use of technology are less mature than those for science. Science has tended to be the actual focus of most national bodies that are called science and technology councils. Links of such bodies to universities have

been stronger than links with industry. University curriculum on development oriented areas such as management, financing of innovation and management of innovation have tended to be weak or absent. One of the most urgent needs of many developing countries is training of people -- managers, engineers, lawyers, economists -- with the diverse skills required to select, acquire, modify, produce and diffuse technology, and to provide the organizational structure within which they can work effectively.

3. Institutions relevant to the use of science and technology for development must, as stressed by Weiss, be broadly defined. Often institutions not directly concerned with science and technology make decisions that are more influential than those made by institutions directly concerned. Wage policy made by Ministries of Labor, interest rate decisions made by central banks, tariff quota and exchange restrictions inspired by Ministries of Finance are examples.

4. Many policy areas and types of institutions outside S&T narrowly defined affect S&T in important ways means that relationships among centers of power are critically important to the formation and execution of S&T policies. These links are often weak or missing, and not only in developing countries.

5. Technological capacity must also be broadly defined. Technological capacity does not involve only formally trained scientists but also the "practical" farmer who comes up with an innovation but does not know how to market it or disseminate his findings.

B. Goals

1. An overriding objective of development policy is generation of

indigenous capacity in developing nations. The workshop emphasized this not as a new thought but as a goal that is often neglected in operation.

2. Primary emphasis should be not on building institutions -- a means -- but on building institutional capacity -- the end. In fact, it is generally more important to attack the reasons for inadequacy of existing institutions that to establish new institutions because the underlying reasons for inadequacy will affect new as well as existing institutions.

3. The fact that institutions are imperfect, as pointed out by Moravcsik, should not obscure the fact that they are important and in general should be strengthened. One of the most significant examples of institutions with potentially important functions that are often poorly performed are central research policy bodies. They are often quite impotent, poorly funded, overly bureaucratic and not in the main stream of significant decisions. Making them more effective is one of the most difficult and important institutional requirements in developing countries. National industrial research institutes have generally remained outside the main stream of industrial development, primarily because their links to industry have been weak. Industrial research institutes supported by industry have a better record.

4. Initial attention must be paid in developing countries not only to technology but to what goods to produce -- now and in the future. For example, whether a country chooses an import

substitution policy or an export policy has important effects upon the mix of goods produced, as do decisions affecting the mix of consumer and capital goods. Premature emphasis on technology can result in poor decisions on the mix of products.

C. Means of Attaining Goals

1. The Imperative Organic Relation Between Institutions and Society

Anandakrishnan made the important observation that if institutions in developing countries are to have a sustained productive life they must be organically related to the society in which they exist. Their staffs must be local for the most part. They must understand and be sympathetic to the needs of society. They must be regarded by people generally and by politicians as being indigenous and not imported institutions. Isolation and alienation from society of which they are a part leads eventually to sterility and decay. The Indian Institute of Technology at Kanpur was cited as an institution formed on the U.S. model, staffed for years by excellent people, many of whom were from the U.S., and not linked to the local society and government. It is now declining. On the other hand the Institute of Science at Bangalore is an indigenous product which is growing slowly and productively.

The requirements for an organic relationship with society place some constraints on external assistance. First, long periods of time are required to build institutions, and external sources of aid are rarely prepared to persevere. Even if they were, the existence of large numbers of foreign people and large

amounts of foreign money in an institution tends to generate a rejection phenomenon. What foreigners can provide that is as useful as money is experience -- not necessarily applicable experience, but experience that can expose alternatives.

In building institutions with an organic relationship to their societies, the realities of society must be accepted, and worked with. It is not possible to wait for an ideal society, or for cultural changes that would make society more receptive to and supportive of the values of science and technology. For example, society in many developing countries is so stratified -- by class, by caste, by occupation -- that collaborative work is severely hampered. But this must be accepted and worked with.

2. Cooperation Among Disciplines

If progress exists in the realm of the theory and practice of economic and national development of poor countries, substantial credit must go to growing recognition on the part of wary groups of professionals that each has something to contribute. Most scientists and engineers now realize that resource allocation is important and that it is therefore worth listening to economists. Conversely there is growing recognition by economists that technology is a dynamic economic force in itself, and that communication with scientists and engineers is important. More than cooperation between scientists, engineers and economists is involved. The insights of sociologists, political scientists and psychologists are needed. The workshop benefited from the fact that eleven of the participants had scientific and engineering

training, four had background in economics, three were political scientists and one was a sociologist. All shared interests in the development process.

3. Multinational Firms

Robert Cotton's paper and a paper by Warren Keegan on multinational firms from developing countries (Harvard Business Review, January-February 1979) prompted a wide ranging discussion, led by Charles Dennison and summarized below, of multinational firms.

Multinational firms inevitably come under sharp rhetorical attack at international meetings. The charges are failures to conduct research and development in developing countries, perpetuation of technological dependence, overcharging local plants for centrally provided services and components, and refusal to "unbundle." Examples of such practices are not hard to find. Yet the multinationals have much to offer and examples of constructive action are not hard to find. For example, they are probably the most effective trainers in developing countries, and the source of most of the management expertise. The actual practice of many developing countries runs counter to their rhetoric. Those concerned with production in developing countries are often making deals with multinational firms while those in foreign ministries are excoriating them.

Warren Keegan noted the growth of multinationals in the more advanced developing countries -- Korea and Brazil, for example. He andothers saw a rapidly growing and productive role for

such concerns. They help to make developing countries full participants in the world economic system. They demonstrate the high technical and managerial capacity of staff from developing countries. They tend to have close rapport with other developing countries. They can demonstrate to skeptics in developing countries that multinational concerns can be powerful machines for the production and distribution of goods and services.

Dr. Cotton summarized the mode of operation of the Fundacion Chile, which is not a multinational firm, but which had its origins in the activities of ITT in Chile. The Fundacion was set up with funds derived in part from reparations paid by Chile for expropriation of ITT property. The principles underlying the work of the Fundacion could have wide applications:

(a) With little money a truly collaborative operation can be launched and run based on the study of national needs developed by a course of action within national policy and goals;

(b) Such an operation can do true development work and initiate team work with local industry, universities, and government laboratories, on clearly defined projects aimed at local needs;

(c) In the course of this work, local collaborators can be trained, in-plant production employees can be instructed, and graduate students can do thesis work;

(d) Such a foundation can organize seminars to explain to top industrial and governmental leaders needs for better quality control, management techniques, acquisition of techniques on favorable terms, etc. One seminar, for example, was expanded into a week-long meeting which resulted in several new export operations for the Chilean food business. The meeting involved top Chilean government officials and industrialists, plus representatives of fifty overseas companies.

However, others took a somewhat less expansive view of the potentialities of these concerns. The small number of developing countries with the capacity to organize and operate multinational concerns was mentioned. Brazil, Argentina, Mexico, Singapore, Hong Kong and South Korea -- and perhaps a few additional countries -- are the only ones with this capacity at the present time. It was also noted that multinational firms from developing countries are often exploitive -- particular family concerns. Finally, there is the question of the relationship of multinationals from developing countries to the goals of development. Multinational concerns operate in the modern sector. They tend to produce goods and services consumed by a small fraction of the population in developing countries.

4. <u>International Agricultural Research Institutes as a Model</u>

The international agricultural research institutes were mentioned in the papers by Moravscik and Anandakrishnan. These nine institutes include such organizations as the International Rice Research Institute (IRRI) in the Philippines and the International Wheat and Maize Improvement Center (CIMMYT) in Mexico. These large organizations have important common characteristics:

(a) They are focused on a defined problem related to agriculture;

(b) They are not creatures of national governments or of the U.N., but are private, autonomous organizations;

(c) They have a high degree of autonomy in personnel matters -- selecting staff, pay scales, promotion policy, etc.;

(d) They take a broad view of their mission but do not wander into peripheral areas;

(e) They have scientific leadership of high competence;

(f) They have a large degree of autonomy in deciding their work programs;

(g) They are adequately funded on a long term basis.

Any proposal to establish a large international research organization should be scrutinized carefully to ensure that prerequisites for success, such as those noted above, are met. The international agricultural institutes are linked together loosely by the Consultative Group for International Agricultural Research (CGIAR). The institutes obtain funds from members of CGIAR, and the pattern of their cooperative activities is influenced substantially by CGIAR discussions and reports. CGIAR, like the institutes themselves, is sometimes proposed as a model for other fields, such as population control, enviromental protection and small scale technology. While the idea is appealing, Joel Bernstein pointed out that CGIAR responds to a world situation in agricultural

research which has several unique characteristics and that this and the operating principles that it supports must be borne in mind when extension of the CGIAR model is considered.

The following set of characteristics of the CGIAR complex of arrangements are significant for the design of international R&D collaboration in general.

-- The CGIAR itself is essentially an interorganizational rather than an intergovernmental body (although the majority of its members represent their governments in the matters dealt with by the CGIAR). Thus its membership can and does encompass organizations that are national and international, and public and private.

-- Members retain free choice regarding the CGIAR activities in which they participate, and regarding the amount and allocation of their financing among CGIAR supported budgets. The CGIAR operates largely by collective consensus-building regarding collaborative action, rather than formal decision making that binds its members or client research organizations. There is much consultation and discussion, illuminated by high quality staff analyses, but little voting.

-- These attributes permit relatively informal processes, and relatively fast movement to action decision and their implementation.

-- By pooling technical evaluative services, the CGIAR is able to improve the quality of this service to the assistance agencies and research organizations and to reduce the conflicts of opinion in this sphere.

The international research centers financed by the CGIAR members attempt to develop prototype technologies suited for local adaptation over wide areas of the world. (They also do much training and extension work and provide technical information services and research materials.) In doing this, they maintain extensive working linkages with national research organizations in all parts of the globe that are working on similar problems for their own farmers. They are also building slowly an array of working linkages to advanced technological and scientific research centers that can work in depth on problems impeding improvement in the prototype technologies. By fostering and servicing research networks, the CGIAR and the international research centers bring about a pooling of knowledge, products and processes emerging from R&D around the world. This greatly increases the access of the participating research organizations from developing countries to the world's stock of scientific and technological knowledge that is relevant to their concerns.

-- The international research centers are also addressing increasingly interactions of technology design and use with government policies and local socioeconomic as well as natural conditions.

-- The supported international research centers are focused on and gauged by production results and service to users of their products. Each R&D network is addressing strongly felt needs (by farmers, consumers, governments and development assistance agencies) for higher yields and larger output of the most important developing country crops, under both the favorable and unfavorable conditions under which these crops are actually grown.

Given this array of specific characteristics, the consensus of the workshop was that the United States should consider supporting large scale continuing international research institutes only after exploring carefully all pertinent experience, and that neither CGIAR or other modes of operation should be adopted uncritically.

5. Vitalizing the Extension Service

No discussion of development is ever complete without praise or condemnation of the agricultural and industrial extension services in the developing countries. The extension service is a favorite whipping boy in explaining the gap between the technology available in the laboratory and the primitive production methods of the smallholder and the small entrepreneur.

In many countries the extension services are a major responsibility of federal and state agencies. Usually, the universities and research institutes interested in extension rely on these services for disseminating their findings. Seldom does the system work very well, at least in terms of results.

In those instances where the universities and the research institutes have operated the extension services, the results have seemed a little more promising. In any event, more active involvement in the extension field by the universities and research institutes would seem appropriate in a number of countries. Hopefully, such involvement could strengthen and not compete with existing services. One area of particular importance is the improved packaging of technical information in an usable form, and technical institutions are almost always in a better position to handle this problem than are the Ministries. However, increased

involvement in field activities by the universities and research institutes might mean sacrificing some research activities in favor of such an increased effort in extension. It seems that, at least in some cases, such a tradeoff would be far preferable to continued generation of unused research results.

As it is well-known, extension needs almost always extend beyond the need for technical information and include credit and marketing concerns. Thus, an increased involvement of technical institutions in extension should include a range of capabilities of interest to the recipients of the services.

APPENDIX A

BUILDING NATIONAL INSTITUTIONS FOR SCIENCE AND TECHNOLOGY IN DEVELOPING COUNTRIES

A meeting convened by the American Association for the Advancement of Science at the request of and with financial support from the Department of State.

Joseph Henry Building, Room 500 A
National Academy of Sciences
2100 Pennsylvania Avenue, N.W.
Washington, D. C. 20052

WEDNESDAY, APRIL 18, 1979

9:30 - 9:45	OPENING REMARKS Charles V. Kidd, George Washington University
9:45 - 10:15	I. SIGNIFICANCE OF INSTITUTIONS FOR SCIENCE AND TECHNOLOGY POLICY Michael Moravcsik, University of Oregon Background considerations.
10:15 - 10:45	II. TECHNOLOGY POLICY AND INSTITUTIONS IN LESS DEVELOPED COUNTRIES -- AN ECONOMIC PERSPECTIVE Charles Weiss, Mario Kamenetzky, Jairam Ramesh, The World Bank Institutions influencing demand for and supply of technology; economic factors influencing choices.
10:45 - 11:00	COFFEE
11:00 - 12:30	DISCUSSION Comments on Weiss paper - Henry Nau Comments on Moravcsik paper - John Useem
1:00 - 2:30	LUNCH - NAS Dining-Room (2nd Floor)
2:30 - 3:15	III. STRUCTURES AND PROCESSES FOR IMPORTING, MODIFYING, DEVELOPING AND DIFFUSING TECHNOLOGY Glenn Schweitzer, Council on Science and Technology for Development Public and private institutions (national and international) identified; their roles and relationships outlined. Major unmet needs.
3:15 - 4:00	DISCUSSION Comments on Schweitzer paper - Franklin Long

6:00	COCKTAILS AND DINNER Adams Rib Restaurant

THURSDAY, APRIL 19, 1979

9:00 - 9:45	IV. A. SIGNIFICANCE OF TRANSNATIONAL FIRMS FOR TRANSFER OF TECHNOLOGY Robert H. Cotton, I.T.T. IV. B. DEVELOPING COUNTRY MULTINATIONAL FIRMS - GROWTH AND POTENTIALITIES. Warren Keegan, George Washington University The major assumptions of private firms relating to transfer of technology; patterns of relationships with developing countries; contributions of the private sector; major issues. The significance of multinational firms based in developing countries.
9:45 - 10:30	DISCUSSION Comments on Cotton & Keegan papers - Charles Dennison
10:30 - 10:45	COFFEE
10:45 - 11:30	V. SIGNIFICANCE OF TRAINED MANPOWER; INSTITUTIONS FOR TRAINING AND EDUCATION Nagaraja Rao, Massachusetts Institute of Technology Manpower requirements; roles of different institutions; capacity and limits of universities.
11:30 - 12:30	DISCUSSION Comments on Rao paper - John Thurston
1:00 - 2:00	LUNCH - NAS Dining Room (2nd Floor)
2:00 - 2:45	VI. RELATIONS AMONG NATIONAL INSTITUTIONS, INTERNATIONAL ORGANIZATIONS AND OTHER NATIONS M. Anandakrishnan, U.N. Office of Science and Technology Forces generating relationships; modes of interaction; trends.

2:45 - 3:30	DISCUSSION Comments on Anandakrishnan paper - William Wells
3:30 - 3:45	COFFEE
3:45 - 5:00	CLOSING SESSION - Charles V. Kidd Summary of presentation by commentators for each section; general discussion; recapitulation of points relevant to U.S. policy.

Appendix B

Workshop on "Building Institutions for Science and Technology in Developing Countries"
April 18-19, 1979

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APPENDIX C

DEPARTMENT OF STATE

Washington, D.C. 20520

OFFICE OF THE U.S. COORDINATOR FOR THE
UN CONFERENCE ON SCIENCE & TECHNOLOGY FOR DEVELOPMENT

March 13, 1979

Dr. Charles Kidd
Research Professor of Public Affairs
The Graduate Program in Science,
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Library, 714
George Washington University
Washington, D.C. 20052

Dear Charles:

Unfortunately I am unable to be with you for your workshop on "Building National Institutions for Science and Technology in Developing Countries" because of a previous engagement in New York for meetings at the United Nations.

Your workshop has exceptional potential for our preparations, as the building of national institutions for science and technology is close to the central objective of the UN Conference on Science and Technology for Development, which is to assist the developing countries in building an indigenous capability in generating, selecting, adapting, and applying science and technology. It cannot be done without infrastructure and the proper national institutions, which is the subject of your inquiry.

We look forward to receiving your report, which should greatly help us in preparation of the U.S. position in this area. I wish you and your colleagues well in your important undertaking.

Sincerely,

Jean Wilkowski
Ambassador
U.S. Coordinator

APPENDIX D

U.S. ASSISTANCE TO DEVELOPING NATIONS AND THE POTENTIAL ROLE OF THE INSTITUTE FOR SCIENTIFIC AND TECHNOLOGICAL COOPERATION

Robert H. Cotton
ITT
New York, New York

A great many U.S. corporations operating overseas realize that their host countries have serious technology and business problems. They recognize that a better business climate will exist if these problems can be solved. Thus, it is in the interest of U.S. companies to volunteer their services in helping to overcome development problems when it can be done without damage to their principal business. Not only do these companies recognize how important it is for the U.S. to have friends abroad, but many of their employees have a strong desire to help and be of service to developing nations. Major assistance efforts involving large amounts of time usually require remuneration. Short of this, however, there are many ways in which companies can and do help in improving the management and technological capabilities in host countries. The following discussion focuses on food production as a major component of the development process and gives examples of ways in which private industry and government can cooperate in this area.

Lack of sufficient, good food for a country's people is a major constraint to development. We believe that in many key developing nations a "rethink" is in order regarding self-sufficiency in food production. Too often national planners reason that a parcel of land should be used to produce an export crop to bring in money which will, but

usually does not, enable the local farm workers to buy more food. Sometimes a slight change in policy is all that is needed to ensure that there is enough food available locally, in addition to that produced for export. In some cases, a floor price on a crop vital for national nutrition is not available. Thus, to cite one example, land suitable for oilseed crop sits idle while Chile has to use critically short foreign cash to buy refined edible oils. Local technologists, with some help from U.S. industry experts, could correct this situation if government officials were to restudy their economic rationale. Even when raw food commodities are present, however, it is a huge job to process them properly and distribute them economically to those most in need.

The key to better food utilization and stimulation of agricultural production, to say nothing of increased food exports, is a country's agribusiness. Shortage of skilled management and financing hampers growth here. A creative and successful, though small, effort in this area is the Latin American Agribusiness Development Corporation (LAAD). It has studies new opportunities, worked at the local level with entrepreneurs, made loans to launch new ventures and has made a modest profit. U.S.-based multinationals provide the seed money for LAAD and U.S. AID funds (three dollars for each dollar raised by the founding firms) made possible many successful loans to new agribusinesses in Latin America.

LAAD is an example, not widely known, of U.S. government and private industry working together in a practical development program at the grass roots. We suggest that this program be extended to other continents and that in Latin America it be greatly expanded. Funds

should be provided to expand the technical services that LAAD will need, with emphasis on local, rather than overseas or U.S. sources.

There are now in some developing countries fairly competent development laboratories working in agriculture whose potential is not reached due to a lack of management and capital inputs. Just a few examples are IIT (Bogota, Colombia), ITAL and UNICAMP (Campinas, Brazil), and Fundacion Chile (Santiago). Fundacion Chile is unique in that it has a permanent staff of U.S. citizens working in and managing a local technology marketing and financial analysis team, successfully helping a country to develop its agribusiness. The foundation can go from concept to lab bench to pilot plant to industry.

In countries where there is no facility, such as Fundacion Chile, it should be created as an aid to organizations such as LAAD and to private local entrepreneurs in developing new or better agribusiness. It is important to note that Fundacion Chile employees are there for many years and are evaluated on the basis of concrete results, in contrast to many well-meaning consulting groups who are in and out of a country before they can achieve creation of essential "nuts and bolts" operations. Such a foundation can and does use overseas academic and business consultants, where needed, on well-defined, ongoing projects.

The idea suggested here is to forge close links between LAAD and other potential sources of capital to local technology centers. Fundacion Chile or a similar institution can provide new project proposals and do a great deal of training on the job and in seminars on the essential technology and management needed for successful enterprises.

U.S. overseas companies cannot do a great deal of "free" work

without damage to their business. How then did ITT become involved in the establishment of a $50,000,000 not for profit foundation aimed at improving the food and communications in Chile?* This was an outgrowth of the negotiations which led to Chile's payment to ITT for the Chilean Telephone Co. which the previous regime had confiscated. Private corporations ordinarily cannot, nor should they be expected to, make financial and personnel contributions of this size. Nevertheless, we believe that it is important to find ways of establishing and funding similar foundations in other developing countries. Once such an organization is established, it could be managed by a U.S. corporation under contract and could utilize the services of employees of U.S. firms overseas. We recognize that these employees could participate for only limited periods of time, but their contributions in this period could be substantial.

Illustrative Projects in Food and Agribusiness for Consideration by ISTC

How might the proposed new Institute for Science and Technology in Development take advantage of these developments in which the private sector gets involved? We believe that it can "accentuate the positive" by studying and expanding some of the efforts mentioned above. It could conceivably contract with Fundacion Chile for a development program in some narrowly defined area as a way of seeing how the foundation works. It also could expand the financial backing of LAAD. It could emphasize in its planning the need for close coupling of technology efforts with lending agency efforts in various countries. Finally, it might consider

*ITT will contribute $25,000,000 to this effort.

the establishment of similar foundations in other countries. Below are a few suggested topics for further development where U.S. leadership and concern can be expressed in concrete projects aimed at specific results.

1. Self-sufficiency and better efficiency in food supply and utilization. This is a very broad field. A few specific parts can be examined and constructive steps taken in many countries. We suggest that ISTC fund projects in several countries, with two key phases. The first phase would be economic -- a study to determine to what degree a given country is self-sufficient in its food requirements or to determine what can be done to encourage planting to achieve self-sufficiency. Expected results are more employments, better balance of trade, and better nutritional status for the local population.

   The second phase relates to better use and distribution of existing food resources. Here food science and technology can be productively applied.

We suggest that in the second phase ISTC look at a very simple application of food science in Chile. The Chilean government feeds many school and pre-school children throughout the country. The costs of the program are prohibitive because the central government ships food ingredients to schools for local preparation. Fundacion Chile, working with the government and local industry, has developed a biscuit, using

local ingredients, which is highly nutritious, hygienic, economical, and easy to ship and stable in storage. It is now in use in many schools. The results of this new product development are lower cost, less waste, better nutrition. Fundacion Chile will gladly share this development which can be highly useful in other countries.

2. Better utilization of marine resources and possible expansion of marine harvest. Seafood is a good source of high quality protein which is badly needed in developing countries. Many countries have off-shore marine resources that are not adequately utilized even though the need for these resources is crucial. There are opportunities to exploit species of so-called trash fish and to set up new gear to catch fish not now harvested but for which foreign markets exist. One example of this is found in Chile where saury is not now caught but for which there is an export market. Fundacion Chile is using foreign and local experts to push this project. Modest funding would accelerate the work and provide that last push needed for commercialization. Again, this type of project can and should be undertaken in a number of countries.

At present, Fundacion Chile has undertaken part of this program. Added funds are needed in Chile and other countries to speed this vital development. Although the concepts are simple, much down-to-earth work is needed to develop safe, inexpensive, novel forms of fish harvesting and processing techniques to avoid present waste

of fish and systems of gear to bring in fish not now harvested. Here again is a case where ISTC could "accentuate the positive" by further grants and by dissemination of this new information to other countries.

3. Upgrading local food processing. Even in hungry nations, food often goes to waste at harvest when the market for fresh produce can't absorb a sudden surge such as a big fruit harvest of just a few weeks. Canning, freezing, or dehydration are obvious solutions but experience teaches that it is not easy to use these techniques. Lack of understanding of industrial sanitation and quality assurance methods leads to waste and to quality so variable as to inhibit broad scales. Numerous other problems abound. There has to be found a way to use the science and technology and management techniques of the U.S. to help developing countries preserve their scarce food. Further, if such help is given, the quality level can reach international standards and export dollars can be obtained. Once a cannery has achieved this quality level, its capacity to sell at home as well as abroad is vastly increased.

   Fundacion Chile is now engaged in cooperative work with local food processors, university, private and government groups to upgrade fruit processing in Chile. This in a sense is an experiment: to achieve better teamwork among local industry, university, and government. We believe such efforts should be studied by ISTC. They represent an opportunity to show U.S. concern by harnessing U.S. technology to developing country

needs. It will be seen that to do so is far from simple. National and personal pride, lack of capital for simple improvements, lack of understanding of proper marketing backed by quality assurance -- all of these factors hinder progress. Nevertheless, we believe that we are seeing progress in this area. We are glad to see U.S. corporations and even the U.S. Food and Drug Administration giving help when needed. The foundation's approach appears to be unique in that it combines marketing, business venture analysis, economics, food science and technology in an integrated local teamwork approach to food problems.

4. Development of desert or semi-desert lands as sources of food. Where the desert is close to the sea (as it is in Chile, Mexico, and other countries), one can visualize creation of ponds for aquaculture of marine animals and plants. Furthermore, salt resistant wheat, barley, and other crops could be grown with only a minimum of added fresh water. Thus a whole new acreage of food production can be made available. This project could be a truly cooperative international scientific and technical effort. Chile, and probably other nations with desert areas, has good scientists who could make real strides in this area if given support. Technical foundations or institutes can contribute practical engineering and business skills to help the science to become a practical reality. Fundacion Chile is now studying the possibility of just such a project in the arid north of Chile. This is a long-range project, which illustrates

a key point: too often projects are funded for too short a period to produce practical results, and thus waste money. Most often it is the longer range projects that have the greatest potential benefit.