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DEVELOPING A METHODOLOGY FOR ASSESSING THE CONTRIBUTIONS TO IND--ETC(U)  
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Developing a Methodology for Assessing the Contributions to Industrial Development of Science and Technology Institutions in Developing Countries

G. E. Schweitzer and F. A. Long

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DEVELOPING A METHODOLOGY FOR ASSESSING  
THE CONTRIBUTIONS TO INDUSTRIAL DEVELOPMENT OF  
SCIENCE AND TECHNOLOGY INSTITUTIONS IN DEVELOPING COUNTRIES

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PREFACE

This report describes a methodology which evolved during investigations of the contributions to industrial development of science and technology institutions in Malaysia, Nigeria, and Colombia. Three companion reports set forth the substantive findings in each country. A fifth report, a cross-country comparative analysis of the country studies, highlights common problems and innovative approaches in the three countries.

Assessments of technical capabilities, of potential impact of science and education, and of appropriateness of technological approaches must be highly subjective. While some information may be available concerning program budgets, orientation, effectiveness, and impact, reliable data for quantifying such indicators of science and technology activities are frequently unavailable in developing countries. When such data are available, they can be helpful, but the important qualitative aspects of science and technology remain in the realm of subjective judgements.

The investigations in the three countries were limited in depth and duration. Less than three weeks was spent by a team of specialists in each country, and for each country the preparatory work, data analysis, and report preparation involved only several additional months of effort. Nevertheless, the investigations led to a number of firmly based conclusions concerning the science and technology capabilities of the countries.

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## INTERDEPENDENCE, INSTITUTIONAL DEVELOPMENT, AND ASSESSMENTS

### Increasing Role of Science and Technology Institutions

Science and technology, when employed within an appropriate policy framework and used in conjunction with financial and other necessary resources, can be critical determinants of the rate and direction of industrial growth. Thus, the development of the science and technology infrastructures within developing countries has 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 are affected by technological development paths. In the longer term, modernization within the developing countries will result in increased economic interdependence, and technology choices will shape the character of this interdependence. Meanwhile, as the science and technology infrastructures develop, the opportunities for international scientific cooperation increase, with attendant contributions to improved bilateral and multilateral relations.

Most developing countries now rely heavily on imported technologies to achieve near-term industrial goals. Licensing agreements, joint ventures, foreign subsidiaries, international engineering and service contracts, and technical cooperation arrangements are a way of life in the developing countries. At the same time, however, almost every developing country is attempting to strengthen indigenous science and technology capabilities which can help improve the selection, adaptation, and operation of imported technologies and also reduce reliance on external sources of technology.

The development of an indigenous science and technology capability which effectively contributes to industrial development is a slow process, with progress in developing skilled manpower and establishing institutional capabilities usually measured in terms of decades. Also, unlike the industrialized countries where industrial technology was the natural outgrowth of a well-established scientific and technical base, the science and technology institutions in the developing countries are continually "catching up" with sophisticated imported technologies and trying to keep abreast of the new technologies being developed in the modern laboratories of the industrialized world.

In addition to contributing directly to industrial processes and products, science and technology are expected to play an important role in reducing the costs and time involved in establishing the extensive physical infrastructure needed to support industrialization -- transportation, communication, power, construction, water, and other services which are taken for granted in the United States. Indeed, limitations in these areas are often a major handicap for industrialization programs in developing countries.

In most developing countries there are a variety of science and technology institutions, in both the private and public sectors, which have been established to support the industrialization drive. They vary widely in activities, capabilities, and effectiveness.

The need for strengthened institutions of higher education is generally accepted. The issues relate primarily to the most cost effective strategies

for upgrading educational opportunities in the short run, and include consideration of approaches such as centers of excellence, regional institutions, selected types of graduate education offered locally, reliance on expatriate faculty, the need for exposure to practical problems during university training, the appropriate role for basic science, and the orientation of university curricula toward local needs.

In the areas of research and development (R & D) the appropriate role for developing country Governments is not clear. Whether Governments should support public research institutions, support R & D efforts of private entrepreneurs, provide financial incentives for R & D, or simply let the private sector and the multinational corporations choose their own courses are questions that are being addressed in almost every developing country.

There are many other types of science and technology activities that relate directly to industrial activities. These include research and quality control laboratories associated with many locally and foreign-owned industrial complexes; training centers for technicians and operators in both the public and private sectors; standards institutes; information centers; and maintenance and service organizations. Earlier evaluations of the performance of these institutions vary widely within and among countries, but in general, these types of institutions are considered to be weak.

Meanwhile, the importance of economic policies in affecting the choices of technology and the frequent mismatch of these choices with factor endowments -- particularly availability of capital and labor -- are gradually being recognized. Indeed, appropriate technology has become a popular theme within the international development community.

For several decades, assistance agencies have been providing support to local science and technology institutions oriented toward industrial development. Unfortunately, some of these institutions have become so accustomed to such external support that a type of welfare mentality has developed, reducing the likelihood of improved budgetary discipline and more cost effective performance. Nevertheless, these institutions are in place, they usually have significant political support and a Governmental mandate, and they will inevitably play a role in future efforts to strengthen indigenous science and technology capabilities.

#### Need for an Assessment Methodology

Given the increased importance of effective science and technology institutions, a more systematic approach to assessing their capabilities has been of concern to several international organizations for more than a decade. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) and the Organization of American States (OAS), in particular, have undertaken numerous studies of science and technology infrastructures in developing countries. The National Academy of Sciences has similarly conducted workshops and studies of science and technology institutions in many countries and of Government policies that affect their activities. Recently, the International Development Research Center (IDRC) has supported ten country studies of science and technology policies that influence industrial development. Finally, in connection with the 1979 United Nations Conference on Science and Technology

for Development (UNCSTD), almost every country has reviewed its science and technology capabilities and the application of these capabilities to national development.

The Organization for Economic Cooperation and Development (OECD), OAS, UNESCO, and IDRC have convened many conferences and written many reports concerning methodologies and approaches for categorizing, measuring, and assessing science and technology activities in developing countries. In early 1979, the World Bank also initiated efforts in this area. Meanwhile, there has been some interest in the transferability of approaches used to judge science and technology activities in the United States to the developing country scene. For example, at the national level, the National Science Foundation (NSF) report, Science Indicators 1976, has received considerable attention. At the institutional level, university accreditation procedures are well developed throughout the United States.

Almost all assessments of science and technology capabilities reflect more art than science. They usually concentrate largely on organizational responsibilities and their interconnections; use of public funds for research, education, and related activities; and correlations between innovation and industrial productivity. Three factors which complicate assessments are (a) the pervasiveness of science and technology throughout development activities and difficulties in isolating science and technology aspects from related factors, (b) the long lead times for research and educational activities to have discernible impacts on a nation's development, and (c) inherent complexities in the innovation process.

As nations increase their expectations for science and technology, improved methods to identify strengths, weaknesses, and gaps in developing and applying technical capabilities become more important. Policy decisions at the national level and program decisions at the institutional level can benefit from an understanding of functional and organizational capabilities, interdependencies, and interactions. Also, external agencies which support science and technology projects of limited scope should appreciate how their activities articulate with the broader range of related interests within the country.

At the same time, as has been learned in the development of agriculture sector models during the past decade, overly sophisticated modelling of technical activities in developing countries can rapidly degenerate into an exercise of little utility. The methodology for science and technology sector assessment should recognize that uncertain assumptions as to likely political behavior defy quantification. Secondly, the methodology should be sufficiently simple to be understood and accepted by policy officials who have limited technical backgrounds and who are characterized by a mixture of admiration for and skepticism of the power of science and technology. Finally, the methodology should be implementable at a reasonable cost and within a short time frame. Otherwise, there is a likelihood that the insights gained from assessments will be out of date before they are reduced to a written report.

## APPROACH TO DEVELOPING A METHODOLOGY

### Purpose of the Project

This project was designed to help clarify current and potential contributions to industrial development of science and technology institutions in three developing countries. A comparative analysis of the three country studies then provided insights as to common problems encountered in the development of a science and technology base and identified innovations in one country that could have applicability in other countries.

Another objective was to identify opportunities for bilateral cooperation involving U.S. organizations which could strengthen institutional capabilities in each of the three countries. Cooperation, as contrasted to technical assistance, was emphasized. Thus, bilateral programs which offer the possibility of tangible benefits, at least in the long run, to both countries are of principal interest. However, in view of the underdeveloped state of many institutions in the developing countries, bilateral programs often must involve a mixture of cooperation and assistance.

Finally, recommendations were developed as to policies and programs that should be considered by the Department of State and other U.S. agencies concerned with science, technology, and development. Principal attention was directed to general approaches in U.S. relations with the advanced developing countries. Also, specific suggestions concerning each of the three countries were presented.

With regard to the scope of the project, the emphasis was on science and technology as they relate to manufacturing activities, the physical infrastructure needed to support economic growth, and the natural resource base of a nation.

Science and technology activities in the fields of medicine, nutrition, family planning, and public health were clearly excluded. In the agricultural area, activities directed to food crops were in general excluded while the development of non-food crops (e.g., timber, rubber, palm oil) was included. Obviously, this artificial delimitation of industrialization requires exceptions in relation to agricultural machinery, food processing, and perhaps other activities.

### Procedural Approach to Country Studies

In carrying out each country study, the following procedure was adopted:

- Collection and review of relevant documentation available in Ithaca and Washington, with particular emphasis on the country setting, economic and educational priorities, descriptions of science and technology institutions, U.S. commercial and scientific interests, and cooperative programs of U.S. and international agencies.
- Consultations with country specialists in Washington to supplement the

review of documentation.

- Three-week visit to the country to collect additional documentation, interview knowledgeable persons, and visit selected facilities.
- Review of conclusions with country experts and science and technology specialists in Washington and with foreign students from the country in Ithaca.
- Preparation of a preliminary report for review by host Government officials.
- Preparation of a final report.

This procedural approach worked reasonably well despite the inevitable holidays and travel difficulties encountered within the countries. Funds were not available for brief follow-up visits to obtain data that could fill in a few gaps and to review conclusions with selected persons. Such visits would have been useful.

Clearly, a more extended study effort in the United States and in the countries would have resulted in greater scope and depth of the analyses. However, by dividing the teams into smaller groups, a large number of institutional visits was possible within three weeks. Indeed, longer stays within the countries would have soon reached the point of diminishing returns.

Consideration was initially given to carrying out the project jointly with local institutions. In Nigeria and Malaysia, however, appropriate counterpart groups for this type of study do not exist. In Colombia, where several appropriate groups are in place, the short lead time for the study precluded arranging a joint effort. More local participation in reviewing conclusions would have been useful, but the logistical aspects of such participation are formidable.

#### Selection of Countries for Field Visits

The selection of the countries was influenced by several factors: a desire for a geographic spread by selecting countries from Asia, Africa, and Latin America; some similarities among the countries that would enable comparative analyses of the country studies; and political considerations by the U.S. Embassies and the host Governments as to the appropriateness of country visits. Also, the limited time for the studies ruled out several countries with a large base of science and technology activities such as India, Mexico, and Brazil.

While there are striking differences among Malaysia, Nigeria, and Colombia, they share some common characteristics, including:

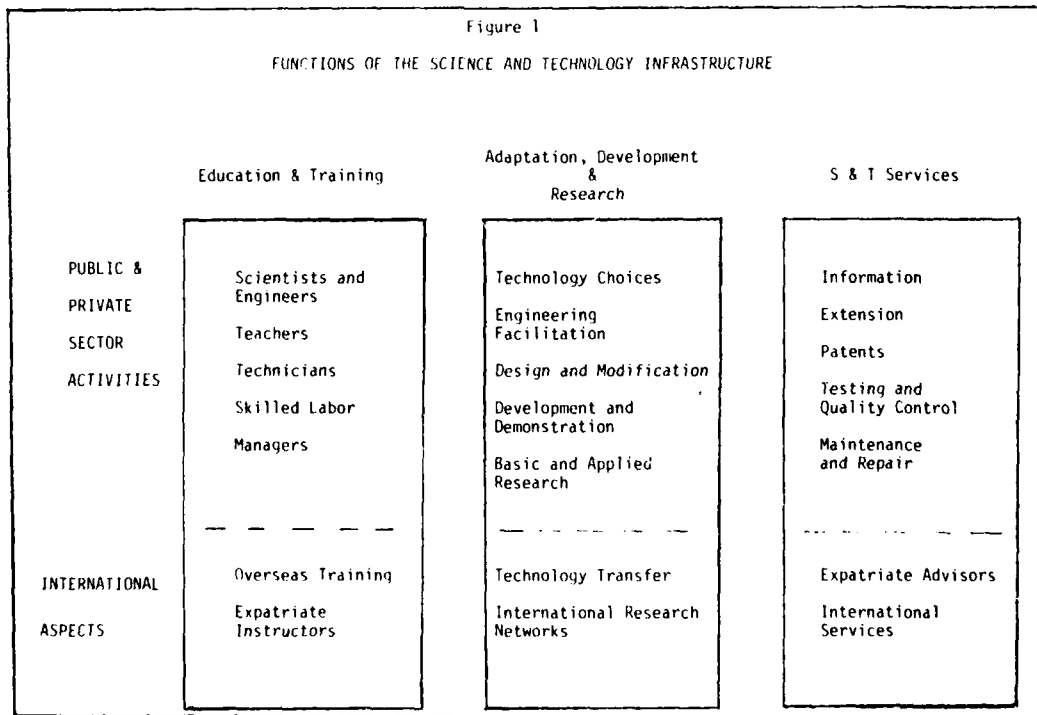
- Reasonably good prospects for industrial growth.
- Rapidly developing science and technology infrastructure.
- Good supply of energy resources.

- Very important role for private sector industry.
- Good foreign exchange position.
- Heavy reliance on one or several export products.
- Important U.S. trading partner.
- Strong interest in increasing bilateral cooperation with U.S. science and technology institutions.
- Many students in United States.
- Minimal program of the Agency for International Development (AID).

Malaysia and Colombia are clearly within the category of advanced developing countries. In the African context, Nigeria is approaching such a status even though the vast majority of the population lives well below the poverty line. Somewhat surprisingly, in all three countries, including Nigeria, the range of science and technology interests encompasses roughly the same activities even though the level of development of these activities varies widely.

What Is the Science and Technology Infrastructure?

Often, the science and technology infrastructure is considered to be a collection of institutions with responsibilities in the field, which are categorized as public, quasi-public, and private institutions. However, categorization of functions, rather than institutions, proved to be a more meaningful point of departure for assessing national capabilities and for understanding how individual programs fit into the overall picture.



As shown in Figure 1, 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.

Of considerable 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.

Figure 2  
GOVERNMENT POLICIES, S&T INFRASTRUCTURE, AND INDUSTRIAL PRODUCTION

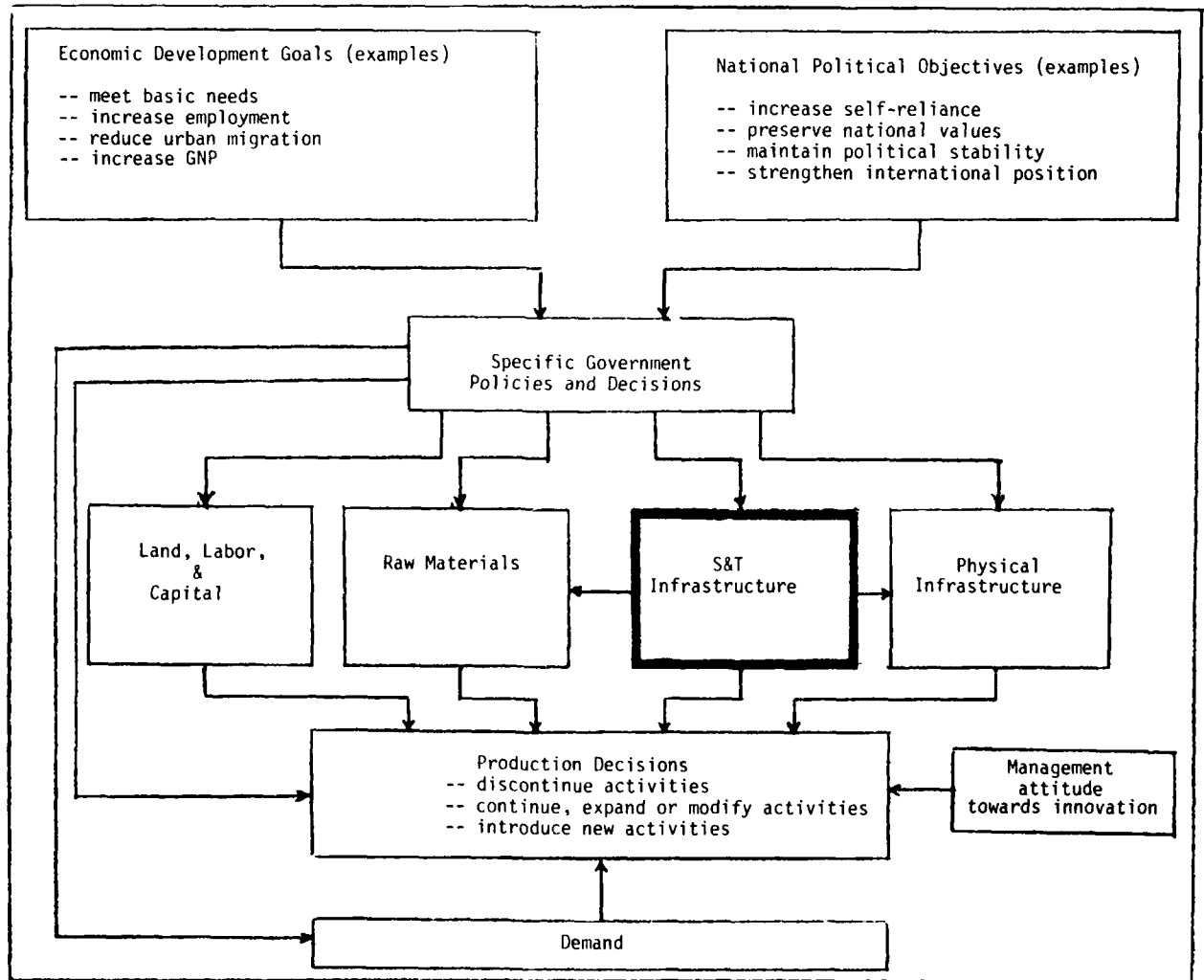


Figure 2 positions the science and technology infrastructure within the overall system of industrial production. As suggested, the infrastructure affects industrial development through at least three, and probably more, routes: direct interaction with manufacturing activities, impact on development of 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.

The foregoing emphasis on functional relationships does not mean that organizational groupings are not important. Indeed, the Government structure for science and technology is usually a central factor influencing scientific and technological activities throughout the country. Relevant organizational responsibilities within all Governments are diffused throughout many agencies and institutions and command considerable attention in any analysis of science and technology development.

#### Baseline for Judgement and the Country Setting

Judgements of the adequacy, effectiveness, and appropriateness of approaches to science and technology in developing countries are, of course, greatly influenced by the background and experience of the observer. Thus the "American experience" in developing its scientific, technical, and educational institutions and in linking their activities to the production and service activities of the economy provided an initial reference point for judgements. However, this orientation was significantly tempered by continuing sensitivity to

- The development goals and priorities set by the Government of the country.
- The program objectives established by individual institutions and the relationship of these objectives to national objectives.
- Experiences of other developing countries in approaching similar problems or opportunities.
- Opinions of informed observers of the local scene, including practitioners of science and technology and other parties, both domestic and foreign.

Clearly, many political, cultural, geographic, and economic factors influence the feasibility and desirability of alternative approaches to science and technology. Figure 3 illustrates some of the factors that were taken into account in reaching conclusions in each of the countries. In short, scientific and technological activities are in large measure an integral component of a nation's overall socio-economic structure.

#### Establishing a Data Base

Considerable information about the economic performance of individual developing countries is available in university libraries and within international development agencies in Washington. Some descriptive material of a general

FIGURE 3  
 SELECTED POLITICAL, ECONOMIC, AND CULTURAL FACTORS  
 INFLUENCING S & T ACTIVITIES

	MALAYSIA	NIGERIA	COLOMBIA
Domestic Political Commitments	Improve Malay participation in economy	Indigenize companies and institutions	Strengthen small entrepreneurs
Regional Political Commitments	Support ASEAN Regional S & T Institutions	West African Economic integration largely on paper	Andean Pact commitment on trade and technology transfer policies
Balance of Payments Situation	Excellent	Good	Very Good
Inflation	Not a major concern	Very serious	Serious
Reliance on External Aid	Several programs of World Bank, U.K., and Japan	Increasing programs of World Bank; traditional reliance on many agencies	Variety of World Bank and IADB loans
Energy Endowments	Promising oil and gas	Considerable oil	Good coal & hydro; some oil
Mineral Resources	Tin; maybe other ores	Not yet well developed	Good resources but often inaccessible
Road Transportation	Good roads connect major cities	Spotty road network	Difficult mountain roads
Communications	Generally good	Poor	Good
Brain Drain	Minor problem, but growing among Chinese population	Significant problem	Increasing emigration to Venezuela
Student Attitudes	No visible problems but Chinese increasingly discontent	Occasional demonstrations	Frequent demonstrations at public universities
Language	Substituting Malay for English at all levels	English emphasis	English emphasis declining
Attitude toward education	Highly cherished	Highly cherished	Highly cherished
Attitude toward manual skill	Historical dependence on Chinese	Associated with low status	Well accepted

nature about science and technology institutions in these countries has become available in connection with UNCSTD. OAS, UNESCO, UNIDO, and the World Bank also have a few reports on country-specific science and technology activities.

A few scattered evaluations of limited aspects of science and technology performance are buried in the archives of AID and NSF. However, caution should guide reviews of evaluations conducted by external agencies. For example, AID often employs an approach to evaluation that is far more appropriate for measuring near-term impacts of capital assistance activities than for assessing the effectiveness of scientific endeavors.

Relatively little data exists concerning the detailed aspects of science and technology activities. Most of this data is available only in the countries, and there the principal repositories are usually located within the science and technology agency, the Planning Office, the Central Bank, the Ministry of Finance, the Ministry of Education, the Ministry of Labor, and the Statistical Office. In countries which have active planning groups for science and technology, such as Colombia, some preliminary data collection will have been accomplished.

Among the data that are very useful and are available in varying degrees in some countries are:

- Detailed organization charts of Government organizations concerned with S & T.
- Profiles of manufacturing enterprises, public works projects, and resource development activities.
- Public expenditures for R & D and for S & T broken down by discipline and by organization.
- Private sector expenditures for R & D and S & T.
- Inventory of R & D and S & T facilities with descriptions of objectives, programs, and staffing.
- Current and projected supply of and demand for scientists and engineers by discipline.
- Enrollments, graduates, staffing patterns, and trends at educational institutions.
- Students studying abroad by discipline and return rate.
- Emigration of scientists, engineers, and skilled workers.
- Compilation of laws explicitly adopted to influence educational and technological development, including regulation of technology transfer and industrial investment.
- Foreign direct investment trends by sector and by country of investor.

- Categorization of licensing agreements by sector, country, time duration, and conditions.
- Descriptions of local technological adaptations, their costs, and their impacts.
- Patents issued by field and by nationality.
- Inventory of S & T journals and related publications and description of publication capabilities.

It is difficult to predict the type of data that will be uncovered in canvassing organizations in different countries. For example, in Colombia, a recent survey of 100 manufacturing firms indicates that they spend an average of 0.5 percent of sales on development and modification of processes and products. A Nigerian survey reports that more than 50 percent of the teaching posts in science and engineering at Polytechnical Institutes are either vacant or staffed by expatriates. In Malaysia, data have been compiled which show the low productivity of public sector enterprises. At the same time, there are many deficiencies in data needed for planning and assessments in each of the countries.

The purpose of compiling data is to provide a broad perspective of the country's science and technology effort within the context of economic development trends. Within this perspective, judgements can be made as to the strengths, weaknesses, and gaps within the science and technology infrastructure.

#### Indicators and Related Concerns

Indicators of macro-economic performance are generally available, and social indicators are also becoming more prevalent. The relationships between science and technology performance and such indicators are not clear, although some very general observations may be possible in this regard.

The long-term impact of a nation's science and technology infrastructure on industrial development is not easy to isolate from the many other factors influencing industrial performance. In the developing countries this impact can probably best be measured in terms of quality, efficiency, and productivity. Are the power and water systems reliable? Are machines operative? What is the international competitiveness of locally manufactured products? Since data to answer such questions may be sparse, impressions often must form some of the basis for judgements.

Some of the indicators used in the industrialized countries for assessing the health of the science and technology base may not be as important in the developing countries: e.g., number of patents; number of publications; R & D as a percentage of GNP or of industrial sales. Indeed, other indicators may be far more relevant, such as salary levels for scientists and engineers, job turnover rates, migration from technical to administrative jobs, percentage of components manufactured locally. In short, the recommended approach is to keep all of these concerns in mind, but weight them on a case-by-case basis.

Indicators of the performance of individual institutions have received limited attention. UNIDO has a manual for assessing the activities of industrial research institutes. OAS and IDRC have checklists of questions that should be asked at the institutional level.

In Colombia, a limited attempt has been made to identify key aspects of the growth of universities. They include

- Student/instructor ratio.
- Professor/researcher ratio.
- Number of research projects per research unit.
- Number of researchers per project.
- Student applicant/admission ratio.
- Percentage of educational programs certified by Government.
- Percentage of new educational programs certified by Government.

There are no optimal norms or ranges for these indicators. Also, many important factors, such as average course load per instructor, are not addressed.

In assessing individual institutions, a central concern must be whether they are carrying out the tasks which they have been assigned. If they are performing their assigned tasks well, but the assignment is not quite right, arguments can be mustered to adjust the assignment. If they are not performing well within the assigned task, arguments for changes in assignment may primarily be an excuse for poor performance.

#### Country Visits

The principal objectives of each field trip were to visit representative samples of the nation's science and technology institutions and to discuss with knowledgeable observers national and international developments in the country. As indicated in Figure 4, a significant number of institutions were visited in each country. These visits were supplemented by discussions with Government officials whose responsibilities impinged on science and technology activities. Also, discussions with industrialists and visits to manufacturing plants provided an important perspective of the "users" of trained manpower and technology and insights as to their interests and capabilities in research and development.

Two checklists were prepared to provide a general framework for analyzing the overall effectiveness of the science and technology infrastructure (Fig. 5) and the capabilities of individual institutions (Fig. 6). Within this framework, individual interviews were usually structured along several of the following themes:

- The adequacy and appropriateness of manpower training programs.
- Problems and opportunities for selecting, adapting, and developing technologies.

FIGURE 4

ORGANIZATIONS VISITED DURING FIELD TRIPS

	MALAYSIA		NIGERIA		COLOMBIA	
UNIVERSITIES	Malaya Science National	Technology Agriculture MARA Institute	Ibadan Lagos A.B.U.	Benin Ife Nigeria	Los Andes Nacional Valle Santander Medellin	Antioquia Cartagena Bolivariana Javeriana School of Engineering
TECHNICAL EDUCATION INSTITUTIONS	Ipoh Polytechnic Kuantan Polytechnic		Yaba College Institute of Technology & Management			
VOCATIONAL TRAINING	Ind. Training Inst. (K.L.) Telecom. Inst. (K.L.)		----		Sena School (Baranquilla)	
GOVERNMENT RESEARCH INSTITUTES	Rubber Forestry Mines	Geology Standards & Ind. Res.	Crops Ag Re-search Trypanosomiasis Leather	Projects Oil Palm Rubber Ind. Res. Bldg & Roads	Technology Research	
OTHER GOVERNMENT FACILITIES	Chemistry Department		Standards Lab. (Victoria Is.)		Min. of Works Lab. Standards (ICONTEC)	
GOVERNMENT AGENCIES	Prime Min. Of. Trade & Ind. --EPU Labor --MAMPU Primary Ind. --Pub. Ser. Min. of S&T --R&D Council Education Pub. Works	MARA Energy & Tel. MIDA Central Bank	NSTDA Education NUC Tech. Educ. Board Works Labor Finance	Agriculture Industry Mines & Power Econ. Dev. --Planning --Manpower --Hum. Res. --Agric.	Planning Office Pub. Works Mines & Energy Inst. for Ind. Dev. Pop. Fin. Corp. Planning (Call)	Education Colciencias ICFES ICETEX SENA Territorial Credit Inst.
PUBLIC SECTOR FIRMS	Pernas Charter Mgt. Modal Moulding Syarikat Jenka		National Petroleum Corp Electric Power Authority		Forjas National Corp. for Forestry Dev.	
DOMESTIC FIRMS	SSP Consultants		Thermocool Engr.		Carvajal TRANSEJES Trefilco Petroquimica Bavaria	Alimenticias Noel Inversiones Mundial Beetar Hermanes Hilanderia del Fonce INTEGRAL
MULTINATIONAL CORPORATIONS	Exxon Dow Colgate ICI Dunlop Goodyear	Motorola Guthrie Sime-Darby Malaysia Cement Nippon Steel	GTE 3M Mobil ITT VW	Pfizer Dunlop Singer Union Carbide	Dow Exxon GE Chrysler	
TRADE ASSOCIATIONS	Federation of Manufacturers Chinese Chamber of Commerce		Nig-Am Chamber of Commerce Lagos Chamber of Commerce Manufacturers Association Employers Consultative Association		ANDI Bogota Chamber of Commerce Cali Chamber of Commerce	
ANALYTICAL AND DEVELOPMENT GROUPS	Malaysian Center for Development Studies				FEDESARROLLO FICITEC FUNDAEC SER Inst.	Educ. Found (Call) Ind. Dev. Found. (Call) Reg. Dev. Res. Center
EXTERNAL ORGANIZATIONS	US Embassy ICA MACEE IESC	Peace Corps Asia Found. UNESCO	US Embassy US Consultates --Ibadan --Kaduna AID	ICA UNESCO IITA Ford Found.	U.S. Embassy U.S. Consulates --Cali --Medellin ICA AID	Col.-Am. Center Peace Corps UNESCO Fulbright IESC IDRC

Figure 5

IMPORTANT ASPECTS OF S&T INFRASTRUCTURE

National planning and decision making mechanisms  
Policy instruments to influence technology development  
Budgetary and manpower priorities  
Orientation and capabilities of educational institutions  
Capabilities of S&T institutions  
Coupling of S&T institutions with development activities  
Industrial capabilities to choose and absorb technology  
Mechanisms for horizontal technology diffusion  
General health of S&T community

Figure 6

MICRO ASSESSMENTS OF SELECTED S&T INSTITUTIONS

(Higher Education, R&D, Service)

Quality and productivity of activities  
Adequacy of staff, facilities, equipment  
Effectiveness of internal planning and management  
Acquisition and utilization of technical information  
Quality and distribution of reports/publications  
-----  
Linkages with Government and industry  
Linkages with other S&T institutions  
Extension and community services  
Consistency of programs with national priorities and needs  
Demand for and performance of products (or students)  
Actual/potential significance on national scene  
-----  
Impact of bilateral and multilateral programs

- Deficiencies in supporting services for technical institutions and for industrial activities.
- Linkages among technical institutions and the coupling of the institutions with Government and industry.
- Tradeoffs between greater self-reliance and international dependence for training and technology.
- Examples of particularly successful bilateral cooperative programs.

Visits to technical and educational facilities also involved detailed discussions of research interests, experimental activities, and educational curricula.

U. S. Embassy officials provided helpful advice throughout the visits, particularly as to knowledgeable persons in the science and technology area.

#### Analyzing Available Information

During the country visits, considerable documentation was obtained. Also, leads were uncovered as to previous studies and additional sources of information. Thus, upon return to the United States, a major analytical effort was undertaken to relate the on-site observations to the available written documentation.

For several months following a visit, relevant data were assembled and critiqued. The field observations were reviewed among the study team members and with other interested parties, including nationals of the country who were temporarily in the United States. These reviews were particularly helpful in tempering hastily developed conclusions based on very superficial impressions.

The effort culminated in a series of drafts of country reports, and then final reports for each country were prepared. In addition, a cross-country comparative analysis of the country reports was prepared. As a byproduct, it helped to clarify the strengths and weaknesses of the methodology. In particular, the importance of more systematic collection of quantifiable data became apparent.

#### Study Teams

Each study team included three or four senior investigators with strong technical backgrounds and a general awareness of the many non-technical factors influencing science and technology developments. In addition, a research assistant provided administrative and programming support for each country study. (See Figure 7.)

It is highly unlikely that less experienced investigators could have carried out the assessments in a credible fashion. The range of disciplines that were covered was simply too broad for more junior scientists and engineers. Initially an effort was made to emphasize educational institutions and technical institutions with some relevance to the chemical industry to provide greater depth in the investigations. While this focus proved useful, inevitably developments in other disciplines must also be considered to gain a perspective of technological progress and of opportunities for cooperation.

Figure 7

STUDY TEAMS

<u>Name</u>	<u>Specialties</u>	<u>Malaysia</u>	<u>Nigeria</u>	<u>Colombia</u>
G. Schweitzer	Mechanical Engineering S & T Policy	X	X	X
F. Long	Chemistry S & T Policy	X		
R. Hughes	Chemistry S & T Policy	X		X
R. Von Berg	Chemical Engineering Industrial Research	X		
J. Smith	Chemical Engineering Industrial Research		X	
P. Auer	Physics Energy Policy		X	
M. Drosdoff	Soil Science Agricultural Development		X	
R. Finn	Chemical Engineering Energy Technology			X
D. King	Research Assistant	X		
T. Bergh	Research Assistant		X	
P. Pinsky	Research Assistant			X

## IDENTIFYING OPPORTUNITIES FOR BILATERAL COOPERATION

This report is directed principally to development of a methodology for assessing the capabilities of science and technology institutions. In considering opportunities for cooperation, such capabilities are an important factor. Several Malaysian officials remarked, for example, that cooperative efforts should be undertaken only in those fields where a local technical capability already existed.

No attempt was made to develop a methodology for identifying opportunities for cooperation. The approach essentially was to uncover targets of opportunity. Interested U.S. organizations will undoubtedly apply their own criteria in determining the feasibility and priority of the suggested approaches.

In considering cooperation, the following aspects are important:

- The strengths, weaknesses, and gaps in the science and technology infrastructure identified in the overall assessment.
- Known capabilities and interests of U.S. institutions that seem to coincide with local needs.
- Likely benefits to the developing countries and to the U.S. institutions from cooperation.
- Interests and priorities of the local institutions for cooperative programs.
- Previous experiences in cooperative activities.
- Formal and informal linkages with U.S. and other institutions that are already in place.

Figure 8 lists some of the programs that are currently underway and also indicates the range of U.S. Government interests. While some programs might be funded by non-Governmental groups in the United States and by the developing country Governments, most programs of significance will require U.S. Government funding.

Discussions were held with field representatives of a few of the U.S. and international agencies which support or could support cooperative programs. Generally, these discussions were disappointing. While the local representatives were familiar with the projects of their organizations, they demonstrated little interest in the relationship of these activities with other science and technology activities in the country. The representatives of the International Communications Agency in Nigeria and Malaysia were exceptions, and they provided very useful insights concerning cooperation between universities.

FIGURE 8

SELECTED SCIENCE AND TECHNOLOGY ACTIVITIES OF U.S. AGENCIES

	MALAYSIA	NIGERIA	COLOMBIA
AID			
Bilateral	None	Revive agriculture in FY 1980	Small residual
Global/Regional	ASEAN projects	Occasional projects	Occasional projects (e.g., ATI)
Other	Minimal IESC program Asia Foundation	Reimbursable Services	Successful IESC Program
Peace Corps	Reducing S&T; now basic needs	None	Phasing out
ICA			
Fulbright	Little S&T	Some S&T	Strong S&T
Other	occasional S & T exchanges distribution of books and publications		
NSF	None	None	Not very active
NTIS	None	None	Active cooperation ended
NBS	None	Active cooperation ended	Active cooperation ended
NASA	L A N D S A T I m a g e r y a n d T r a i n i n g P r o g r a m s		
Geological Survey	Publications exchange	Publications exchange	Computer techniques for minerals inventory
COMSAT	C o o p e r a t i o n t h r o u g h I N T E L S A T		
OSTP	None	Discussion at political level	Under consideration

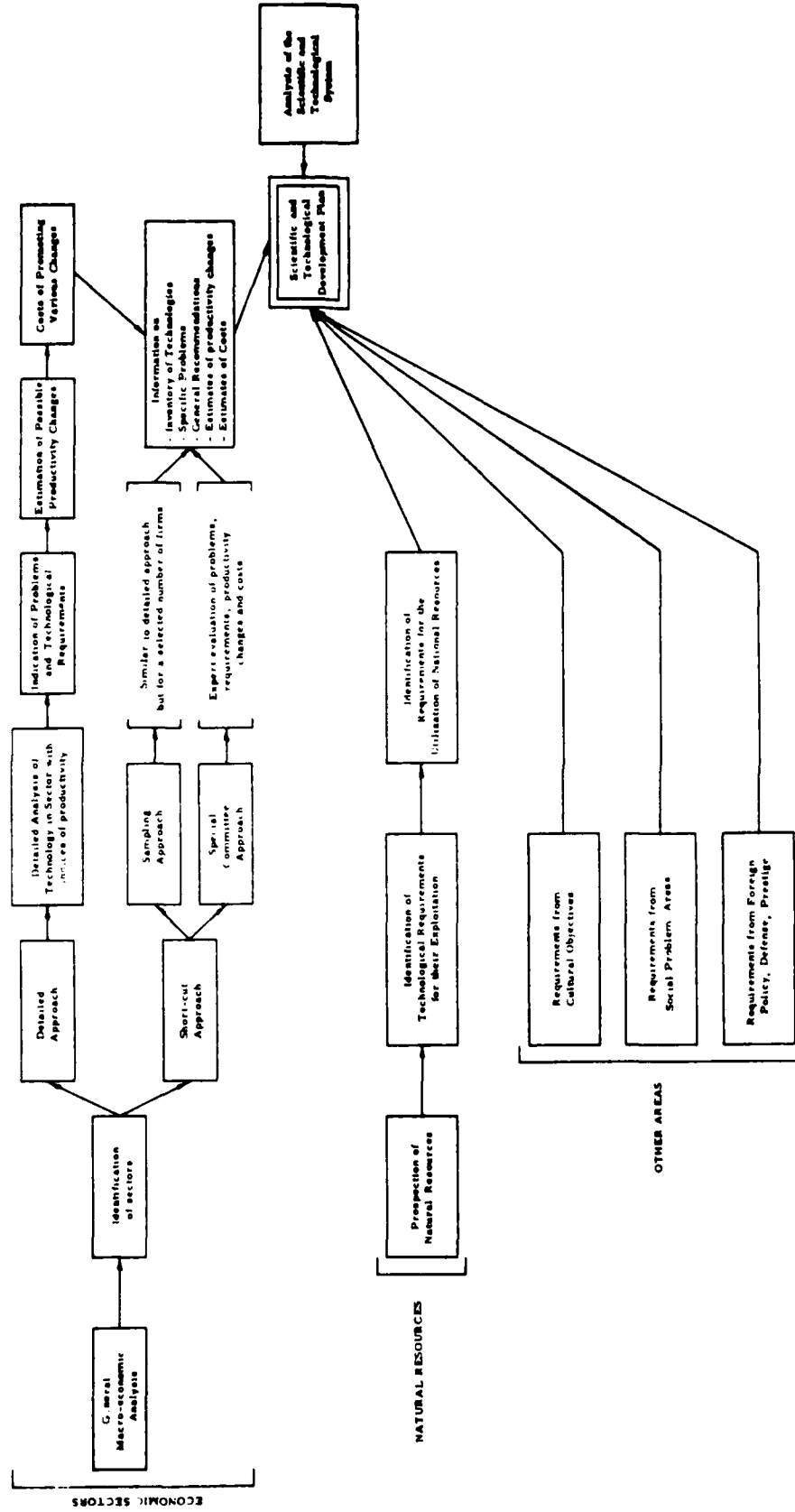


DIAGRAM OF THE OAS METHODOLOGY FOR DETERMINING REQUIREMENTS

APPENDIX B

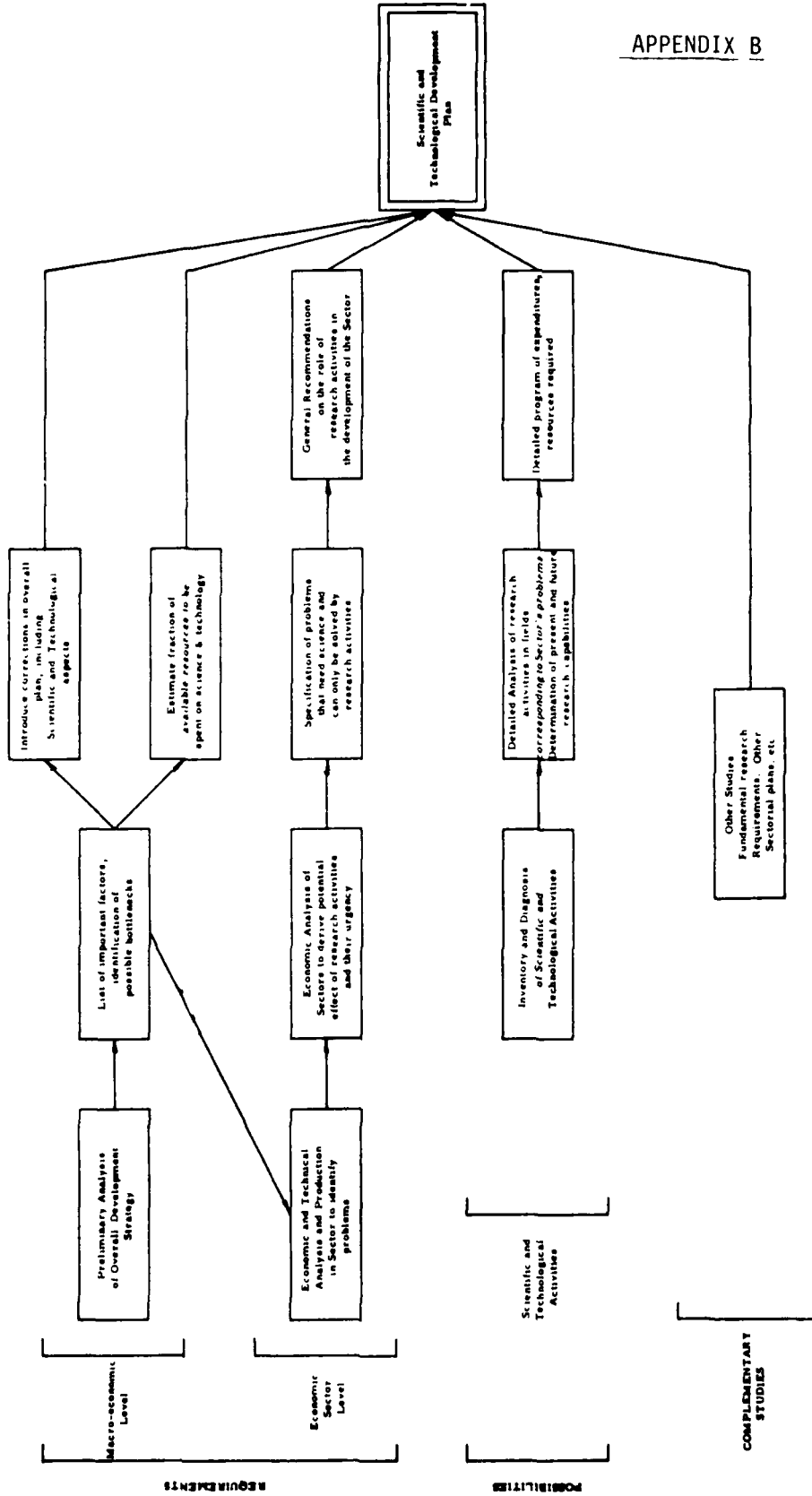


DIAGRAM OF THE OECD METHODOLOGY FOR SCIENTIFIC AND TECHNOLOGICAL PLANNING

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