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SCIENTIFIC AND TECHNOLOGICAL CONSTRAINTS

TO ECONOMIC DEVELOPMENT:

An Analytic Cross-Country Framework

Volume 3: PILOT COUNTRY STUDIES

#1: SRI LANKA (Annex B)

#2: THAILAND (Annex C)

#3: TUNISIA (Annex D)

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Prepared for the Office of Technical Resources,
Asia and Near East Bureau of AID by

International Technology Management and Finance, Inc.,
1200 18th St., N.W.
Washington, D.C. 20036

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The views expressed in this report are those of its author
and are not to be attributed to AID.

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APPENDIX B

SCIENTIFIC AND TECHNOLOGICAL CONSTRAINTS TO ECONOMIC DEVELOPMENT:

An Analytic Cross-Country Framework

PILOT COUNTRY STUDY #1: SRI LANKA

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Summary

This appendix provides a brief assessment of the scientific and technological development of Sri Lanka, and its contribution to the country's economic development. It is primarily intended as a test case for the cross-country analytic framework set forth in the main body of the paper.

According to this analytical framework, Sri Lanka is at stage 1c in its overall scientific and technological development, i.e., it is at the stage of "islands of modernization," as evidenced by the following profile:

General State of the Economy	1c
Technological Capacity in the Productive Sector	1c
Science and Technology Policy	1c
Financing of Science and Technology	1c
Human Resources	1c
Scientific and Technological Institutions, Services and Research	1c

The scientific and technological development of Sri Lanka has been inhibited by a combination of economic and security factors. The country is emerging only slowly from the legacy of heavy protection and state direction of the economy: inefficient state-owned industry and plantation agriculture, private industry habituated to look to the government for direction, and a government bureaucracy which is still oriented to government control of the economy. Long-term investment of the kind needed for scientific and technological development is also severely inhibited by the security situation in the country.

Except for the level of effective protection (about 80%), the economy is (at least compared to its South Asian neighbors) relatively free of gross price or other policy distortions. Wage rates compare favorably to those of other South Asian countries, making Sri Lanka an attractive place for footloose investments, such as garment manufacture, which vis expanding rapidly.

Unemployment (officially at 20%) is a pressing problem, and greatly complicates the security situation. New investment has not taken the place of low-technology industries displaced by

freeing of imports, while job creation is constrained by overly complicated and generous labor legislation, as well as by fiscal incentives that favor large scale capital-intensive investments.

The universities have only recently reopened after being closed for three years because of the security situation. This closure deprived Sri Lanka of trained manpower, and created a large number of idle and frustrated students inside the country, who are ripe for recruitment into one or another radical force.

As regards the general state of the economy as it affects scientific and technological development, Sri Lanka is clearly past substage 1b, "First Emergence", and is well established in substage 1c, "Islands of Modernization." Sri Lanka has completed the construction of its basic road network and other physical infrastructure, has well-established commercial agriculture, and has an extensive network of parastatal organizations for public utilities, raw materials extraction, etc. Sri Lanka's exports are expanding rapidly from a small base, but are still concentrated in low-technology fields, especially garments.

As regards technological capacity in the productive sector, Sri Lanka is clearly past substage 1b, "First Emergence," and is well established in substage 1c, "Islands of Modernization." There are many enclaves of capacity for choice, operation, and in larger production units in agriculture, in industries connected with natural resources, and in parastatal authorities concerned with infrastructure (telecommunications, highways, power). Likewise, there are many small and tiny enterprises ingeniously managed in the face of difficult external conditions.

Numerous non-governmental organizations are active in applying conventional low-cost technology to the needs of poor and disadvantaged people in Sri Lanka. Some of these non-governmental organizations, most notably the Sarvodaya, have their own engineering staffs capable of backstopping village development work and also of developing new simple machinery to address village problems, such as improved handpumps.

On the other hand, Sri Lanka does not satisfy the requirements for substage 2a, although there are signs of progress in this direction. Quality and quality control is a serious problem throughout the industrial sector. So is the inefficiency of the larger industry in operating conventional technology, and there is little diffusion of technology by subcontracting or by the movement of technical personnel. There is little capacity to adapt technology and product design, and to innovate to meet local needs or maintain competitiveness in changing circumstances.

In its formulation of a technology policy, Sri Lanka is at substage 1c and may be about to take steps to bring it into stage

2a. Sri Lanka's prolonged isolation from world markets removed the incentive for improvements in technology throughout the economy. There was little explicit attention to scientific and technological development, and the few scientific and technological activities in the country were allowed to languish.

Sri Lanka still lacks any formal cross-sectoral science and technology policy, a major exercise to that end in 1985 having ended inconclusively. Government officials (at least in the previous government) now recognize the importance of science and technology, and the need for policies to encourage that aspect of the country's economic development. But there is no locus in the government of expertise or responsibility for such policies (other than operational responsibility for the publicly owned research and technological institutes). The recently adopted Industrial Policy Statement includes a chapter on industrial technology. A proposed action plan and policy for industrial technology were prepared by consultants just before the recent elections, but have not yet been formally considered.

As regards the financing of technology, Sri Lanka fits perfectly the criteria for stage 1c. The staffs of Sri Lankan development banks are reasonably competent in reviewing business plans and in the economic and financial aspects of project analysis. The Sri Lankan stock exchange is in its earliest stages of operation, and trading is thin in a few listings of large companies. There is little private risk-oriented capital available, and few well-formulated ventures seeking financing.

As regards human resources, Sri Lanka meets the requirements of stage 1c in the framework. Basic industrial discipline is well established, and the vast majority of the population is literate. Universities are well established, but their rigid structure hampers efforts to create links with the business community and to adjust their programs and curricula so as to meet the country's changing manpower requirements. The government's requirements for technical manpower are largely satisfied, so that technical graduates are forced to consider employment opportunities in the private sector.

The output of technical graduates from secondary schools and universities suffices to meet present demand, but would be insufficient to meet the needs of a rapidly expanding economy. There are, however, serious shortages of personnel in fields where global demand is high, such as computers and electronics. There are serious shortages of experienced technical personnel at all levels, from skilled machinist to engineering professor, due to the brain drain.

On the other hand, Sri Lanka does not meet the requirements for substage 2a, despite the excellent quality of its graduates and its role as a supplier of technical professionals to other

countries. The demand for scientists and engineering personnel in Sri Lanka itself is low and stagnant.

As regards scientific and technological infrastructure, Sri Lanka fits the description of substage 1c. Its few basic scientific and technological institutions are well established but of very variable quality and rather far removed from their clientele. There are many non-governmental organizations diffusing low-cost technology, with little relation to formal scientific and technological infrastructure. University-based "small science" is of long standing but is starved for funds. A single institution, the Institute for Fundamental Studies, maintains international standards of excellence in research.

A summary of the operational recommendations to AID is found at the end of this country study.

PILOT COUNTRY STUDY #1: SRI LANKA

General State of the Economy

Economic Geography. Sri Lanka is a small island, area 66,000 km^2 and population 16 million, off the coast of India. It is a low-income country with a per capita income of $400. PQLI indicators are those of a much more advanced country: life expectancy of 70 years, literacy rate of 87%, and infant mortality of 23.5 per thousand.

Sri Lanka's agricultural regions are well suited to growing a wide array of tropical crops. Tea is still Sri Lanka' leading export in terms of value-added, and rubber and coconut are other traditional agricultural exports. Temperate fruits and vegetables can also be grown at higher elevations in the center of the country.

Sri Lanka is a major exporter of gemstones, its major mineral resource. It has no known reserves of oil or natural gas.

Sri Lanka's excellent climate, outstanding beaches, and rich history and cultural tradition were the basis for a thriving tourist trade before the onset of the political troubles of the 1980s. The drop in tourism has led to a corresponding drop in airline callage, which has hampered foreign investment (much of which is a byproduct of tourism) and isolated the country from a flow of technology and market information.

Sri Lanka's outstanding harbor at Colombo has been a traditional stopping point for the trade between Asia and the Near East for centuries, and is now the major port in South Asia. There is also a second outstanding natural harbor at Tricomalee. These traditional links have facilitated a steady flow of Sri Lankan people to the Persian Gulf area in search of employment.

Sri Lankan development is hampered by an antiquated road network that makes the 150 miles between Colombo and Tricomalee into a five-hour drive. Telecommunications are adequate for most business purposes but not for data communications.

General Economic Environment. Sri Lanka is still working its way out of the aftermath of the strongly dirigist government that ruled the country for more than two decades prior to 1977.[1] During this period, private enterprise was suppressed, and the economy was insulated from world markets by high tariffs,

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[1]. Dirigism refers to the belief that the government should control and direct the economy.

quantitative import restrictions, and far-reaching price controls.

Since 1977, the government has espoused a liberal economic policy. Progress in implementation has been steady but slow. Top officials generally realize the need for structural adjustment, and an Industrial Policy Statement, drafted with the aid of the World Bank, has set as its goal to remove the country's narrow dependence on agricultural exports. Even so, much of the bureaucracy still retains the attitudes acquired during the years of dirigism.

The Sri Lankan economy has been growing at a rate exceeding 5% since the change in government in 1977. It is relatively free, at least by comparison to other countries in South Asia, of economic policies that grossly distort the course of technological development. Industrial and trade policies by and large encourage competition among domestic producers, and between them and imports from abroad.

Prevailing market prices provide reasonably accurate signals to guide the choice between imports and local production or between labor and capital, the choice of raw materials and products, the conservation of energy and raw materials, and the choice between export and domestic markets. From the point of view of a foreign investor or buyer, Sri Lankan wage rates compare favorably with those in other South Asian countries that are their main competitors.

Effective protection is still about 80%, although efforts are underway to reduce this to about 50%. Nominal tariffs are more liberal than that of other South Asian countries. The tariff structure does not contain a major bias among industrial subsectors, although exemption procedures do favor larger industries.

The Sri Lankan economy has not undergone much structural change since 1970. According to Central Bank statistics, agricultural production has fluctuated in the narrow range between 26.5-30.5% of GDP during this period, while manufacturing rose from 16.7% of GDP in 1970 to 23.1% in 1977 in response to the government's import substitution policies, only to drop back to 14-15% for 1982-85. Non-traditional exports have grown rapidly since the mid-1970s, especially garment exports, which rose from $3.5 million in 1975 to $340 million in 1986.

The private sector, although vigorous and thriving, is still cautious about long-term investment, partly because it is only just emerging from a trading mentality, but in large part because of the security situation. Private investment has declined from 12.6% of GDP in 1980 to 9.7% in 1986. Private businesses are also still somewhat wary of the possibility of government take-

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over (a law permitting this is still on the books), and still retain the habit of looking to the government for guidance and incentives.

Despite major efforts at privatization, public enterprises still are responsible for a major proportion of manufacturing and of agriculture. Their inefficiency relative to the private sector is illustrated by the fact that manufacturing output in the private sector contracted by 1% in 1987, despite the fact that it was allocated a disproportionate share of investment capital. By contrast, at the same time, private manufacturing output was growing by 15%.

Two free trade zones have been established to stimulate exports. Outside these zones, new investments not involving exports pass through approval procedures in line ministries, who often consider that their role is to protect domestic industry against the establishment of "excessive capacity." Technical assistance from foreign experts is discouraged by visa requirements that the applicant show that the relevant expertise is not found in Sri Lanka.

Unemployment is Sri Lanka's most pressing economic problem and is a major driving force contributing to the country's chronic political instability. Trade liberalization has exposed Sri Lanka's many low-technology, labor-intensive small industries, to unaccustomed competition which they have proved in many cases unable to meet. As a result, unemployment has returned to a level of about 20% according to official estimates. The structure of investment incentives and the business turnover tax favors large-scale, capital-intensive projects, and in this way may be unintentionally contributing to this problem.

Job creation in the private sector is further constrained by a complicated maze of overlapping labor legislation which mandate an excessive number of holidays a year, severe limits on the hours and working conditions of female employees, and strong safeguards against firing redundant or incompetent workers. What is more, in many cases newly hired workers must come from a politically approved list.

The field study was informed of other undesirable distortions imposed by economic policy. The business turnover tax was said to discriminate against local production vis-a-vis imports, while the structure of credit subsidies was reported to discriminate against the high value-added and long gestation periods typical of technology-oriented investments.

The most serious constraint on Sri Lanka's economic growth has been the security situation. This has preempted the attention of the government from economic matters, and has

discouraged medium- and long-run private investment of the sort that would be essential for scientific and technological development. Business is discouraged by the prospect of periodic closure of Sri Lanka's ports as a result of the security situation.

Projects using relatively advanced technology may also be vulnerable to security-related disruption. For example, a promising shrimp aquaculture project in northeastern Sri Lanka, using relatively advanced biotechnology of the sort that should play an important role in future high value-added fisheries, was destroyed as a result of a security-related incident.

The universities have only recently reopened after being closed for three years because of the security situation. This closure not only deprived Sri Lanka of trained manpower, but it also induced a substantial drain of foreign exchange due to the demand for overseas education, and created a large number of idle and frustrated students inside the country, who have qualified for entrance into the university and who are ripe for recruitment into one or another radical force.

In summary, Sri Lanka is clearly past substage 1b, "First Emergence," and is well established in substage 1c, "Islands of Modernization," in the general state of the economy as it affects scientific and technological development. The rationale for this assignment is as follows.

Sri Lanka has completed the construction of its basic road network and other physical infrastructure, has well-established commercial agriculture, especially in the tea sector but also in coconuts and rubber, and has an extensive network of parastatal organizations for public utilities, raw materials extraction, etc. (Indeed, the privatization of much of this network is now an urgent item of public policy.) Sri Lanka's exports are expanding rapidly from a small base, but are still concentrated in low-technology fields, especially garments.

Technological Capacity in the Productive Sector

After several decades of isolation from world economic and technological trends, Sri Lanka is climbing onto the lower rungs of the ladder of technological development that it hopes will lead it to eventual status as a newly industrializing country.

The current reluctance of businessmen to invest for the long term, however, is reflected in the fact that most of the growth in manufacturing has been in footloose industries like garments, in which initial investments are relatively small and can be recouped quickly, and whose product specifications and technology are controlled by the buyer.

The agricultural parastatals were once world leaders in technology. In colonial days, Ceylonese planting stock and processing equipment was the best in the world. However, the tea industry has neglected investments in production plant and allowed its research and development laboratories to decline. What is more, the failure of the agricultural parastatals to forecast changes in technology and markets has already cost them major markets for latex rubber and bagged tea.

The industrial parastatals have grown up under a protective regime and are generally unable to export. Those concerned with manufacturing are not competitive with imports except at the low quality end of the domestic market. They have the capacity to acquire and operate imported conventional technology, but little capacity to forecast changes in markets and technology, to choose technology, to adapt it to local conditions, or to innovate.

The management of these parastatals is severely constrained by rules designed to prevent irregularities, and has limited discretion for innovation. For example, they do not normally attempt to develop the technological capacity of local suppliers, but are required to deal only with the lowest bidder. A few parastatals are beginning to invest in technological effort: training of technical personnel, improvements in products and processes, and engineering, development and research.

Parastatals concerned with the production of raw materials for export are at a similar stage of technological development. For example, their long delay in developing a technology to convert geuda stones into star sapphires had the effect of ceding most of the value-added of these gemstones to the Thais.

Capacity to manage conventional technology is well established in parastatal authorities responsible for physical infrastructure: telephones, electric power, railways and highways.

The Sri Lankan private sector is not far from its origins as a trading community of family-owned firms, and is oriented more to marketing and finance than to technology. These firms are generally competent at operating conventional technology, normally acquired from abroad, often to produce products specified by overseas buyers. They are sometimes extremely ingenious in "low-technology" adaptation and innovation.

Even so, most Sri Lankan small and medium industry is isolated from information on alternative sources of technology, and <u>a fortiori</u> on the latest developments. They are beginning to realize the desirability of carrying out feasibility studies before undertaking investments, but are lacking in skills

relating to the choice of technology.[2] They are therefore often at the mercy of equipment salesmen, or (what is the same thing) feel they must grasp at any offer of a joint venture or of supplier financing. Independent testing, consulting and engineering services are available in fields related to construction and project management, but do not have much capability in fields relating to industrial technology.

Sri Lanka appears to have missed its main chance to participate in the rapid world-wide expansion of electronics manufacturing. On the other hand, Sri Lankan businesses are beginning to establish themselves in labor-intensive branches of "high-tech" industries, such as software, data entry, and value-added agriculture and aquaculture (tissue culture of ornamentals, strawberries, mushrooms, prawns, tropical fish), for which Thailand is a chief source of technology adapted to the conditions of tropical developing countries. These agricultural and service industries may be as important to Sri Lanka's future as manufacturing.

Numerous non-governmental organizations are active in applying conventional low-cost technology to the needs of poor and disadvantaged people in Sri Lanka. Many of these obtain financial and technical support from one or another bilateral development assistance organization. Some of these non-governmental organizations, most notably the Sarvodaya, have their own engineering staffs capable of backstopping village development work and also of developing new simple machinery to address village problems, such as improved handpumps or low-cost wheelchairs. On the other hand, these organizations do not make a major investment in the training of the staff in technical fields, such as road building and ground water hydrology, preferring to rely on the secondment of experts from technical ministries responsible for public health, road building, water supply, etc.

There is little communication between these village development organizations and the country's formal scientific and technological infrastructure. Several bilateral organizations, especially the Dutch, Germans and Japanese, have supported small projects for the development of specific technologies suited to the needs of poor and disadvantaged people, or addressed to problems of the environment or the exploitation of renewable sources of energy. Examples include efforts to develop and/or diffuse improved technologies for low-cost geotextiles for road-building in mountainous areas, fibercement roofing, small-scale coffee processing, and non-

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2. The promotion of feasibility studies is one of the functions of the AID-supported Sri Lanka Business Development Center.

polluting production of paper from rice straw. These projects have had mixed success. In general, there is a pressing need for increased resources and commitment to research, development, testing and commercialization of innovative technology suited to the problems of the poor.

Sri Lanka is clearly past substage 1b, "First Emergence," and is well established in substage 1c, "Islands of Modernization," as regards technological capacity in the productive sector. There are many enclaves of capacity for choice, operation, and in larger production units in agriculture, in industries connected with natural resources, and in parastatal authorities concerned with infrastructure (telecommunications, highways, power). Likewise, there are many small and tiny enterprises ingeniously managed in the face of difficult external conditions.

The modern technology for public sector and larger private sector plants in Sri Lanka is imported, mainly as equipment or turnkey plants, but is no longer usually operated by foreigners under management contract. Local civil works construction capability is well established in private sector consulting firms, and reasonable local operating and trouble-shooting skills are available. (The field study did not review the state of negotiating skills in larger enterprises for extracting concessions from multinational corporations.)

On the other hand, Sri Lanka does not satisfy the requirements for substage 2a, although there are signs of progress in this direction. Quality and quality control is a serious problem throughout the industrial sector. So is the inefficiency of the larger industry in operating conventional technology, and there is little diffusion of technology by subcontracting or by the movement of technical personnel. There is little capacity to adapt technology and product design, and to innovate to meet local needs or maintain competitiveness in changing circumstances. On the other hand, there is limited investment in developing firm-level technological capacity in some of the larger firms, and applications of biotechnology to agriculture are beginning.

For example, Sri Lanka is dependent on imports of technology-intensive industrial products, whereas Thailand is developing some export capacity, as is shown in the following table:

Exports of Selected Technology-Intensive Industries
(nearest $million, 1985)

	Sri Lanka		Thailand	
	Imports	Exports	Imports	Exports
Electrical Equipment (ISIC:3831-3839)	84	1	418	351
Fabricated Metal Products (ISIC 381)	16		987	128
Primary Metals (ISIC 37)	16		987	128

AID should sponsor studies of the likely future evolution of markets and technologies in "high-tech" fields offering labor-intensive entry points to Sri Lankan industries, analogous to those offered by the electronics industry a decade ago. These studies should identify programmatic and policy interventions needed to facilitate building capacity in these areas or to overcome unnecessary bottlenecks. Such fields may include software, biotechnology and data entry.

AID should also explore the feasibility of a catalytic service, perhaps associated with the Sri Lanka Business Development Center (SLBDC) and the Industrial Development Board (IDB), to identify new markets for the products of very small Sri Lankan industry, and to develop and diffuse new products or technology as needed.

Science and Technology Policy

The de facto policy of Sri Lanka as regards the contribution of science and technology to economic growth lies in the gradual liberalization of its economy and the gradual privatization of its parastatal sector. The Industrial Policy Statement includes a chapter on industrial technology, which calls for increasing the demand for technology by creating a more competitive environment, by removing the constraints on the importation of foreign technology, and by stimulating domestic technological capacity.[3]

The Statement envisages steps to improve the quality of imported technology, and to improve the capability of domestic

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[3]. Ministry of Finance and Planning, Industrial Policy Statement, 1987.

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research and development institutions to help local enterprises to master imported technology and to improve their technical and managerial skills.

It also states its intention to institute comprehensive measures to improve quality and quality control, to subsidize domestic research and development, and to contribute to the costs of investments in improved productivity, in new or improved products, and in the introduction of new technology.

Present regulations for importation of technology, while not onerous by comparison to those of india or other countries in South Asia, do impose important bureaucratic preferences on commercial transactions involving technology. There is a bureaucratic preference in favor of joint ventures and against licensing arrangements, a strong prejudice against second-hand machinery, and an unwillingness to allow marketing skills, which are badly lacking in the Sri Lankan private sector, to be the basis for equity in a joint venture. Some of these strictures are designed to prevent technology transactions to be used as covers for currency smuggling, and will require careful review of the trade-offs between technological development and the prevention of fraud.

Sri Lanka has no explicit policy to deal with the many cross-sectoral aspects of science and technology. An ambitious effort to develop such a policy in the mid-1980s, chaired by the Scientific Adviser to the President, foundered on internal dissension within the scientific community. The proposed policy was the work of scientists and technologists based in universities and publicly funded institutes, and dealt largely with safeguarding and improving the effectiveness of these institutions. The business community was hardly consulted in its formulation.

There is at present no focal point in the government concerned with the impact of economic policies and other factors on the demand for improved technology. Few Sri Lankan government officials are familiar with the way in which science and technology can contribute to the country's economic growth and to the equitable distribution of the fruits of that growth. For this reason, there would be a shortage of competent staff for such a focal point, were it to be established.

Nor are there officials in the various line ministries who are competent to judge the value of proposed investments of public moneys, whose usefulness depends on their prospective contribution to Sri Lankan scientific and technological development. Thus means in turn that potentially valuable proposals, such as the Technology Center at the University of Moratua, may be evaluated by ministry officials who may not be in a good position to judge the advisability of financing them.

What is more, there is in Sri Lanka no research capability outside of the government (say, in a university or an independent research center) capable of carrying out independent research on science and technology policy. The Sri Lankan economics profession, depleted by the brain drain that affects all aspects of professional life, is especially weak in industrial economics, one of the key disciplinary elements of technology policy.

The absence of policies for scientific and technological development makes it difficult for the government to consider the impact of world-wide changes in technology on the competitiveness of the Sri Lankan economy, or to supplement the commercial transfer of technology with essential government actions: provision of technological services needed by industry; encouragement of technological effort by Sri Lankan industry; improved technology management by parastatals in industry, agriculture, and public services; and support to research of national importance.

The establishment of a focal point for industrial technology policy in the Ministry of Finance and Planning, the training of specialist staff, and the familiarization of officials throughout the Sri Lankan government with the fundamentals of science and technology policy, are all key features of the proposed action plan for scientific and technological development drawn up under the auspices of the World Bank.[4]

Such formal attention to science and technology policy as exists within the Sri Lankan government is situated in the Ministry of Industry, and is concerned with the health of the four infrastructural organizations described in the final section of this country study. The Natural Resources, Energy and Science Authority (NARESA) looks after the meager support provided to basic scientific research in the universities.

The newly formed provincial governments being set up in response to the trend toward "devolution" (decentralization) of governmental authority offer a new opportunity to bring science and technology to bear on regional problems that might otherwise escape the attention of central authorities. Some of the provincial governments are in fact setting up institutional arrangements for science and technology, but it remains to be seen whether these will copy the rather ineffective pattern now in place in Colombo.

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4. "Building the Base: A Proposed Action Plan for Industrial Technology Development in Sri Lanka," prepared by International Technology Management and Finance, Inc., for the Ministry of Finance and Planning, Government of Sri Lanka, September, 1988.

In summary, Sri Lanka is at substage 1c in its formulation of a technology policy, and may be about to take steps to bring it into stage 2a. The rationale behind this assignment is as follows.

Sri Lanka's economic policies for many years held back its scientific and technological development, in the sense that its isolation from world markets removed the incentive for improvements in technology throughout the economy. Throughout this period, there was little explicit attention to scientific and technological development, and the few scientific and technological activities in the country were allowed to languish.

Sri Lanka still lacks any formal cross-sectoral science and technology policy, a major exercise to that end in 1985 having ended inconclusively. Government officials (at least in the previous government) now recognize the importance of science and technology, and the need for policies to encourage that aspect of the country's economic development. But there is no locus in the government of expertise or responsibility for such policies (other than operational responsibility for the publicly owned research and technological institutes).

The recently adopted Industrial Policy Statement includes a chapter on industrial technology. A proposed action plan and policy for industrial technology were prepared by consultants just before the recent elections, but have not yet been formally considered.

USAID should help the government of Sri Lanka to set up a focal point in the Ministry of Finance and Planning for technology policy, cooperating as appropriate with the World Bank and with other development assistance agencies. It might do so by providing funds for consultants and travel, and especially by providing funds for training seminars to promote a clearer understanding on the part of Sri Lankan officials, academics, bankers, and businessmen, of the relationship between Sri Lankan industrial policy, its scientific and technological development, its unemployment problem, and its future competitiveness, productivity and standard of living.

More generally, AID could assist in providing support to training and research in technology policy, both for specialists and for generalists who need a broad familiarity with the subject. It could also fund a USIA program to bring leading US academics for lecture programs on industrial economics and technology policy. Such a program would have the useful side effect of improving the dialog between US and Sri Lankan intellectuals.

Financing of Science and Technology

Sri Lanka has two development banks, the National Development Bank and the Development Finance Corporation of Ceylon (DFCC). These make both loans and equity investments. Their combined assets totaled $189 million dollars in 1987. They are reported to be short of fundable investment proposals.

The staffs of the development banks are generally competent in project analysis of projects involving conventional technology. The DFCC has a multi-disciplinary staff that is competent to review the choice of technology in industrial projects, and which claims the competence to assess proposals involving technological risk.

Sri Lanka also has two merchant banks, the Merchant Bank of Sri Lanka, with total assets of $5 million, and the People's Merchant Bank (no asset figure available). A holding company, Oasis, is designed to attract money from overseas Sri Lankans for technology-oriented investments.

Sri Lanka's market for shares and securities is small and undeveloped, and stocks and debentures are not a significant source of capital. This is due partly to the fact that debt financing is cheap and debt servicing risk is small, and partly to the fact that Sri Lankan companies are traditionally small and closely held, disclosure requirements are lax and protection for outside minority shareholders is slight.

Such risk capital as is now available for investments involving technological risk comes from "intrapreneuring" within one of the large, diversified private firms, such as Hayley's or Keels. Several "venture capital" funds are in various stages of organization, some with financing from AID, with the promotion of technologically oriented investments as one of their stated objectives.

Of these, the Employment Investment and Enterprise Development Division (EIED) of the Mahaweli Authority, is explicitly concerned with promoting small rural enterprises associated with the Mahaweli irrigation scheme. The EIED is experimenting with a system which trains would-be entrepreneurs to conceive a business and prepare a business plan, and provides a staff of "barefoot bankers" equipped with motorcycles and facsimile machines to facilitate the trainees' access to capital.

The entire banking system is hampered by extraordinarily slow procedures for foreclosure, which make bad debts virtually uncollectible. This harms not only the creditors of the deadbeat, but also his honest competitors who do pay their debts.

While the supply of technologically oriented long-term risk capital is thus meager, the same is true of the supply of fundable investment proposals based on adequate study of both technology and markets. The major bottleneck seems to lie at least as much in the capacity to put together such proposals as in any possible shortage of venture capital.

Further study will be needed to characterize the supply and demand in Sri Lankan capital markets for long-term or risky projects involving innovative technology: whether there is money going begging, whether there are good projects going unfunded, or whether, as we have suggested, there is simply a thin market with few projects and little money. It will then be possible to tell what kind of projects are needed, what it will take to launch them, and whether the country will benefit if they receive extra promotion, and to suggest ways in which the government and the private sector, working together, can provide a "venture catalyst" to encourage the formulation and financing of the needed investments.[5]

The imperfections described in the Sri Lankan capital markets will limit the possibility of launching entrepreneurial ventures based on innovative technology that will increase the value-added of Sri Lankan agriculture and industry and improve the country's overall competitive position.

In summary, Sri Lanka fits perfectly the criteria for stage 1c as regards the financing of technology. The rationale for this assignment is as follows. The staffs of Sri Lankan development banks are reasonably competent in reviewing business plans and in the economic and financial aspects of project analysis. Of the two development banks, one is said to be competent at assessing conventional technology.

The Sri Lankan stock exchange is in its earliest stages of operation, and trading is thin in a few listings of large companies. There is little private risk-oriented capital available, and few well-formulated ventures seeking financing.

AID should provide technical assistance to a feasibility study for the "venture catalyst" recommended by previous AID and World Bank consultants, and ensure that this study produce recommendations suited to Sri Lankan conditions. It should in due course consider funding the program it recommended by the study, as a supplement to existing AID support to venture capital in Sri Lanka.

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5. L.M. Miller, E.G. Evans, and S.B. Kay, "Sri Lanka: A Survey of Capital Markets," prepared for USAID/Sri Lanka by International Science and Technology Institute, July 1988.

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Human Resources

Sri Lanka's literacy rate (over 80%) and enrollment ratios (100% for primary schools, 63% for secondary schools) are unusually high for a poor country. Primary, secondary and most university education is carried out in Sinhala, a language spoken nowhere but in Sri Lanka. This decreases the fluency of Sri Lankan graduates in English, and contributes to their isolation from world developments in science and technology. Even so, a high proportion of the population is literate in English, a fact that is a substantial attraction to foreign investors.

Primary and secondary education in science and technology is reasonably good in urban areas, but laboratory equipment is lacking in disadvantaged rural areas affecting 20-30% of the population, giving school science there a decidedly theoretical cast. There is no national science museum and little use of the mass media to provide mass awareness of science and technology.

There is an adequate supply of freshly trained skilled workers, but the stock of experienced skilled workers and technicians is severely depleted by competition from the Middle East. The supply of technicians in such fields as electronics and computers is adequate for present needs but would quickly become limiting if the economy were to begin to expand rapidly.

The domestic stock of university-trained technical managers, engineers and scientists is adequate to supply existing demand but would quickly become a constraint should the economy begin to expand rapidly. Sri Lankan managers typically have adequate formal training and qualifications, but lack the entrepreneurial approach.

Sri Lankan universities are elite governmental institutions on the British model. They have room for only a tiny percentage of the secondary school graduates who would benefit from a higher education. These universities have a distinguished history but are at present severely strapped for money. Their output, though adequate for present needs, would be grossly inadequate if the economy were to begin to expand rapidly.

The brain drain draws off the cream of the country's experienced technical people in all disciplines. They leave because they see neither present opportunity nor any prospects for the future. The faculty of even the premier universities is demoralized and severely depleted by the brain drain: a leading engineering university reported vacancy rates of 75%! Any effort to expand the supply of trained people will be severely constrained by the fact that there are vacancies throughout the

engineering faculties of the universities, but especially in critical new fields such as electronics.

Private demand for higher education is such that there are substantial private resources potentially available to finance such an expansion, but in the absence of private universities or even private contributions to scholarship funds for public universities, there are at present no means to tap them.

Considerable ingenuity will be needed to mobilize private resources for higher education, in view of the likelihood of continued financial stringency. For example, business contributions could be solicited to support fellowships for undergraduate or graduate students, or to provide salaries for additional faculty or teaching assistantships.

Alternatively, ways should be found to overcome the various political difficulties involved in increasing the role of private universities. The one private university in Sri Lanka, the Institute of Technological Studies, offers good quality courses in electronics and business management, using primarily part-time faculty.

In any case, faculty would not be available to staff any such expansion, public or private, without a major recruiting campaign, which in turn would require raising faculty salaries to levels prevailing in Pacific Rim countries.

The engineering curricula of the public universities (there is only one small private university) are designed to train technicians for the government bureaucracy and the parastatals, with a few programs aimed at newer demands for engineers trained in fields like textiles and telecommunications. (The textile program at the University of Moratua is a model for how to train engineers suited to local requirements at minimum cost.)

The inflexible institutional and legal framework of the universities inhibits efforts to meet the needs of the newer industries. It is difficult, for example, to change the curriculum in response to changes in the market, or to provide paid services to paying clients. Even formal consultations with industry -- a prerequisite to obtaining employers' views on manpower needs or soliciting financial contributions to the university -- are difficult or impossible.

A large number of institutions in the public and private sectors offer in-service training in engineering and management, and a few of the larger companies run in-house training programs. Private companies do not reap any tax advantages for these training expenditures.

The shortage of trained managers limits possibilities of accelerated economic growth by inhibiting the establishment of new lines of private business based on technology -- just the kind of business on which future industrial and agricultural expansion depends. As things now stand, efforts to expand this supply are likely to founder on the extreme financial stringency facing the universities, their reluctance to expand at possible cost to the quality of instruction, and the inflexible laws governing the framework of the universities. Even if the universities respond to this challenge, the inadequacies of teaching equipment in many rural primary and secondary schools will make it difficult for them to provide graduates who will take a practical approach to higher education in science, engineering and technical management.

The Department of Science and Industry and the Labor Department run sizable programs of vocational education intended for unemployed school leavers. The newer of these programs are useful and up-to-date, but a few of the older ones teach obsolete skills. The various subsectoral ministries offer in-service training to those presently employed. These subsectoral programs offer useful training. The National Apprenticeship Board also runs an extensive program of apprenticeship training.

A substantial proportion of Sri Lankans still have a non-scientific outlook stemming from the nation's past status as an agricultural society using mostly traditional, pre-scientific technology. A substantial effort is needed to increase the popular awareness of science and technology through the mass media and through museum exhibits. There are many useful models for such a program, including the Oregon Museum of Science and Industry in Portland and the Exploratorium in San Francisco, which show how ingenuity can substitute for money in presenting basic scientific concepts to children and to the general public.

Sri Lanka thus meets the requirements of stage 1c in the framework as regards human resources. Basic industrial discipline is well established, and the vast majority of the population is literate. Universities are well established, but their rigid structure hampers efforts to create links with the business community and to adjust their programs and curricula so as to meet the country's changing manpower requirements. The government's requirements for technical manpower are largely satisfied, so that technical graduates are forced to consider employment opportunities in the private sector.

The output of technical graduates from secondary schools and universities suffices to meet present demand, but would be

insufficient to meet the needs of a rapidly expanding economy. There are, however, serious shortages of personnel in fields where global demand is high, such as computers and electronics. There are serious shortages of experienced technical personnel at all levels, from skilled machinist to engineering professor, due to the brain drain to the Persian Gulf and also to the English-speaking countries of the Far East and the South Pacific.

On the other hand, Sri Lanka does not meet the requirements for substage 2a, despite the excellent quality of its graduates and its role as a supplier of technical professionals to other countries. The demand for scientific and engineering personnel in Sri Lanka itself is low and stagnant, and several major engineering disciplines, such as chemical engineering and food processing, lack university curricula and professional organizations.

Sri Lanka suffers by comparison to Thailand, for example, in almost every measurement of human resources related to science and technology, as shown by the following table.

Sri Lankan and Thai Human Resources
for Science and Technology[6]

	Sri Lanka	Thailand
Engineers per 1000 population	0.24	2.21
Scientists " " "	0.19	1.31
Technicians " " "	0.19	5.96
Research and development expenditure as % of GNP	0.18	0.29
Patents filed by nationals (1985)	21	151

AID should explore ways in which to help the Sri Lankan educational sector to expand and modernize to meet the new demands that are being placed upon it, and especially to improve its relations with the private sector. Some possible programmatic interventions are:

(1) Provision of fellowships for study in the US, especially for Sri Lankan university faculty.

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6. Asia and Pacific Center for Transfer of Technology, Technology Atlas: an Interim Report, Economic and Social Commission for Asia and the Pacific, 1987. The statistics have not been verified.

(2) Provision of technical assistance to an engineering faculty to establish new programs in food processing, agricultural engineering, or chemical engineering, or to improve their programs in industrial economics. One way to do this would be by finding Sri Lankans resident in the US who would like to go home for a year to teach.

(3) Provision of scholarships to private universities in Sri Lanka; or more broadly, to establish scholarship funds to which Sri Lankan businesses might contribute as a way to support student fellowships and faculty salaries.

(4) Provision of technical assistance to Sri Lankan universities (perhaps in the form of sister relationships with US universities) in setting up business advisory groups and university-based consulting firms and science parks.

(5) Provision of science equipment for "underprivileged" high schools with science equipment, and assisting the Sri Lankan private sector in the design and manufacture of school science kits.

(6) Promoting bilateral relations with US science museums.

Scientific and Technological Institutions, Services and Research

Sri Lanka's formal scientific and technological infrastructure may be divided into three groups:

1. Two elite institutions attached to the Office of the President (the Institute for Fundamental Studies in Kandy and the Arthur Clarke Center for Advanced Technology on the campus of the University of Moratua)

2. Four applied science and technology institutions attached to the Ministry of Industry: the Sri Lanka Standards Institute, the National Engineering Research Development Center, The Ceylon Institute of Scientific and Industrial Research, and the Geological Survey.

3. Extension and technical service institutes for specific industrial subsectors: either for small industry as a whole (the Industrial Development Board (IDB)), or for specific subsectors, such as textiles and clothing.

Most of these institutions are severely hampered by their status as government departments and by the civil service status (and consequent limits on the salaries) of their staff. With the exception of the Arthur Clarke Center, none stresses close links with its constituency in the productive sector. As we have already pointed out (page B-7), much of the work of applying

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science and technology to the problems of the poor and disadvantaged lies in the hands of nongovernmental organizations.

Several interesting proposals for new institutions are in various stages of preparation, including proposals for product service development centers for food processing and metalworking (World Bank), and for a software park to provide start-up software firms with adequate power, telecommunications and other facilities (University of Colombo).

The overall expenditure for research and development in Sri Lanka amounts to 0.2% of GNP, a small figure typical of countries at its level of economic and scientific and technological development. The major cross-ministerial coordination of this budget takes place in the Natural Resources, Energy, and Science Authority (NARESA), which is widely regarded as having negligible influence over anything but its own meager budget. A proposal for a more powerful coordinating agency died with the national science and technology policy exercise discussed earlier.

AID has sponsored an apparently effective effort by the International Executive Service Corps (IESC) to provide hands-on management and technical assistance to a wide range of Sri Lankan small industry. This program has achieved a good understanding of the problems of Sri Lankan industry, and is limited only by the fact that IESC does not have access to all the expertise that may be needed by Sri Lankan firms.

The weaknesses in scientific and technological infrastructure limit the country's ability to provide essential services in such fields as geology, industrial standards, and applied research and development. The relative lack of interest on the part of these institutions in the problems of the poor and disadvantaged is a constraint on the country's ability to apply science and technology to more equitable distribution.

At the same time, however, it is important not to place too much stress on the role of these institutions. They could and should be made much more useful, but their weakness is not the decisive constraint on the contribution of science and technology to Sri Lanka's economic development.

In summary, Sri Lanka fits the description of substage 1c as regards scientific and technological infrastructure. Its few basic scientific and technological institutions -- agricultural research laboratories, a geological survey, a multi-disciplinary applied research institute, a standards institute, and an engineering research laboratory -- are well established but (except for the Standards Institute) of very variable quality and rather far removed from their clientele. There are many non-

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governmental organizations diffusing low-cost technology, with little relation to formal scientific and technological infrastructure. University-based "small science" is of long standing but is starved for funds. A single institution, the Institute for Fundamental Studies, maintains reasonable international standards of excellence in research.

AID should strengthen Sri Lankan scientific and technological institutions, for example by financing equipment and training for the Geological Survey and setting up a relationship with the US Geological Survey. It should assist the Sri Lanka Standards Institute to establish a similar relationship with the National Institute of Standards and Technology (formerly the Bureau of Standards). Such a relationship would also help US exporters, since standards can have the effect of a non-tariff barrier.

AID could also make a substantial contribution to Sri Lankan scientific institutions by providing a one-time redundancy allowance to the Ceylon Institute for Scientific and Industrial Research (CISIR), analogous to the redundancy allowances being provided to the public sector industrial enterprises, to enable it to recruit personnel in fields for which there is demand, such as pollution control, and to retrench in fields in which CISIR is unlikely to establish a viable presence. Any such allowance should be made contingent on CISIR being made an autonomous organization.

Recapitulation of Recommendations

This section of the appendix gathers together the various action recommendations made earlier, and classifies them according to whether they are designed to affect economic growth in the near or the long term.

Science and Technology investments with near-term payoff. The following investments in science and technology in Sri Lanka, taken from the text of this appendix, are recommended to AID for their near-term impact on economic growth:

(1) Technological capacity in the productive sector. AID should sponsor studies of the likely future evolution of markets and technologies in "high-tech" fields offering labor-intensive entry points to Sri Lankan industries, such as software, biotechnology and data entry, in order to identify programmatic and policy interventions needed. AID should also explore the feasibility of a catalytic service, preferably managed in the private sector, to identify new markets for the products of very small Sri Lankan industry, and to develop and diffuse new products or technology as needed.

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(2) Science and Technology Policy. USAID should sponsor training seminars in order to promote a clearer understanding on the part of Sri Lankan officials, academics, bankers, and businessmen, of the relationship between Sri Lankan industrial policy, its technological development, its unemployment problem, and its future competitiveness, productivity and standard of living.

(3) Financing of Science and Technology. AID should study the feasibility of a "venture catalyst" recommended by previous AID and World Bank consultants, and ensure that this study produce recommendations suited to Sri Lankan conditions.

Science and technology investments with long-term payoff. The following investments in science and technology in Sri Lanka, taken from the text of this appendix, are recommended to AID for their fundamental, long-term impact on economic growth:

(1) Science and Technology Policy. AID should provide support to training and research in technology policy, both for specialists and for generalists who need a broad familiarity with the subject. It could also fund a USIA program to bring leading US academics for lectures on industrial economics and technology policy.

(2) Human Resources. AID should consider explore ways in which to help the Sri Lankan educational sector to expand and modernize to meet the new demands that are being placed upon it, and especially to improve its relations with the private sector., through such interventions as:

(a) Provision of fellowships for study in the US, especially for Sri Lankan university faculty.

(b) Provision of technical assistance for the establishment of new engineering programs.

(c) Provision of scholarships to private universities in Sri Lanka; or more broadly, to establish scholarship funds to which Sri Lankan businesses might contribute, to support student fellowships and faculty salaries.

(d) Provision of technical assistance to Sri Lankan universities (perhaps in the form of sister relationships with US universities) in setting up business advisory groups and university-based consulting firms and science parks.

(e) Provision of science equipment for "underprivileged" high schools with science equipment,

and assisting the Sri Lankan private sector in the design and manufacture of school science kits.

(f) Promoting bilateral relations with US science museums.

(3) Scientific and Technological Institutions, Services and Research. AID should strengthen Sri Lankan scientific and technological institutions, for example by financing equipment and training for the Geological Survey and setting up a relationship with the US Geological Survey. It should assist the Sri Lanka Standards Institute to establish a similar relationship with the National Institute of Science and Technology (formerly the Bureau of Standards). AID should also provide a one-time redundancy allowance to the Ceylon Institute for Scientific and Industrial Research (CISIR).

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APPENDIX C

SCIENTIFIC AND TECHNOLOGICAL CONSTRAINTS TO ECONOMIC DEVELOPMENT

AN ANALYTIC CROSS-COUNTRY FRAMEWORK

PILOT COUNTRY STUDY #3: THAILAND

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I. SUMMARY

This appendix provides a brief assessment of the scientific and technological development of Thailand and its contribution to the country's economic development. It is primarily intended as a test case for the cross-country analytical framework set forth in the main body of the paper.

According to this analytical framework, Thailand is at a stage between 2A and 2B in its overall scientific and technological development, i.e., it is poised to enter into a transition stage of a newly industrializing country, as evidenced by the following profile:

General State of the Economy	2B
Human Resources	2B
Technological Capacity in the Productive Sector	2B
Scientific and Technological Institutions, Service & Research	2A - some in 2B
Science and Technology Policy	2A - some in 2B
Financing of Science & Technology	2A - some in 2B

Structural Comparison of Thailand
with Thailand, Turkey, Portugal, Greece & Three East Asian NICs

	Thailand	Turkey	Portugal	Greece	Korea	Hongkong	Singapore
Mid-86 Population	56.6	51.50	10.20	10.00	41.50	5.40	2.60
1986 GNP/Capita	810.00	1,100.00	2,250.00	3,680.00	2,370.00	6,910.00	7,410.00
Growth Rate GNP/Capital 65-86	4.00	2.70	3.20	3.30	6.70	6.20	7.60
Life Expect. at Birth (Yrs.) 86	64.00	65.00	73.00	76.00	69.00	76.00	73.00
Growth Rate GDP 65-80	7.40	6.30	5.50	5.60	9.50	8.30	10.40
Growth Rate GDP 80-86	4.80	4.50	1.40	1.50	8.20	6.00	5.30
Structure of Production - GDP '86							
% Agriculture	17.00	18.00	10.00	17.00	12.00	0.00	1.00
% Industry	30.00	35.00	40.00	29.00	42.00	29.00	38.00
% (Manufacturing)	21.00	25.00	-	18.00	30.00	21.00	27.00
% Services	53.00	46.00	51.00	54.00	45.00	71.00	62.00
Structure of Manuf — VA '85							
% Food & Agriculture	30.00	20.00	17.00	20.00	16.00	5.00	6.00
% Textiles & Clothing	17.00	14.00	22.00	22.00	17.00	39.00	4.00
% Mach. & Transport Equipment	13.00	15.00	16.00	14.00	23.00	21.00	49.00
% Chemicals	6.00	8.00	8.00	7.00	9.00	2.00	8.00
% Other	34.00	43.00	38.00	38.00	36.00	33.00	33.00
Exports 1986	8,794.00	7,985.00	7,242.00	5,648.00	34,715.00	35,440.00	22,495.00
Structure of Mftg. X % '86							
Fuels, Minerals & Metals	4.00	11.00	5.00	14.00	3.00	2.00	21.00
Other Primary Commodities	54.00	33.00	16.00	35.00	4.00	6.00	12.00
Mach. & Transport. Equip.	9.00	5.00	16.00	3.00	33.00	21.00	38.00
Other Manufacturing	33.00	51.00	64.00	48.00	58.00	71.00	30.00
(Textiles & Clothing)	15.00	29.00	31.00	29.00	25.00	35.00	5.00
Direction of Manufactured X '86							
Industrial Market Econ.	60.00	57.00	91.00	75.00	75.00	60.00	55.00
Non-reporting Non-members Econ	0.00	2.00	2.00	2.00	0.00	0.00	1.00
High Income Oil XS	8.00	5.00	0.00	5.00	5.00	2.00	4.00
Developing Economies	32.00	35.00	7.00	18.00	20.00	38.00	40.00
Education — Enrollment Ratio '85							
Total Primary %	97.00	116.00	112.00	106.00	96.00	105.00	115.00
Total Secondary %	30.00	42.00	47.00	86.00	95.00	69.00	71.00
Total Tertiary %	20.00	9.00	13.00	21.00	32.00	13.00	12.00

Source: World Development Report 1988

III. A. General State of the Economy

The total area of Thailand is 513,000 kilometers. Bangkok is the principal city, with a population of 5.5 million or approximately 10% of Thailand's total population of 54 million. The per capita income of Thailand is about $900. Adult literacy is over 90%. Life expectancy in Thailand is lower than in Singapore, Korea, Hong Kong, Israel and Malaysia, but a higher percentage of Thailand's population in age group (18-22) is enrolled in tertiary education than is the case in Malaysia, Hong Kong and Singapore.

The agricultural sector was the major contributor to gross domestic product (GNP) until 1981. Thereafter, manufacturing exceeded agriculture's contribution to GDP; and manufacturing's share of GDP has continued to rise to 25%, agriculture's has declined to 16% (1987). Agriculture is still the country's major source of employment (about 60%).

As a percentage of merchandise exports, manufactures have increased from 4% in 1965 to over 50% in 1987, and as a percentage of GDP have increased from 6.3% in 1983 to 15.4% in 1987. The structure of exports has diversified, with more value added -- from rice and maize to frozen chicken and shrimp, and canned fish, vegetables and pineapples, and with more technological sophistication (product and process) -- rubber products, electrical machineries (including integrated circuits), and industrial chemicals. Thailand has moved from an import substitution strategy of the 1960s and 1970s. Thailand, unlike most industrializing countries, remains a net exporter of food.

Thailand's small and medium-sized firms (200 employees or less) are important contributors to this diversification strategy. In the late 1970s, small and medium-sized firms exported a greater percentage of their sales than did large firms (employing over 200 workers) and value added per unit of fixed assets per worker compared favorably to larger companies (IBRD, 12/85 report).

In November 1984, the Government of Thailand devalued the baht by 15%, delinked its value to that of the U.S. dollar and initiated a flexible exchange rate management process, and, in April 1985, rationalized some of its tariff structure by eliminating the general import surcharge and some price controls and quantitative restrictions. In early 1985, 75 products were subject to import licenses and 43 were banned; as of January 1988, the respective figures were 53 and 20. Thailand has benefitted from lower petroleum

prices since 1986, and from rising costs of Japanese goods due to appreciation of the yen.

With the exception of some distortions caused by tariffs on capital goods and raw materials and the absence of rebates of tariffs on imported goods used by intermediary suppliers to exporting firms, Thailand has created a relatively level and competitive environmment in support of manufacturing exports as an important part of its industrial strategy. For the period 1985-87, Thailand's manufactured export performance exceeded each of the other ASEAN countries, Taiwan and Korea.

Thailand's GDP in real terms increased 4.8% in 1986, 8.5% in 1987, and is estimated by the Royal Thai Government to have grown at 10.4% in 1988.

Thailand has put greater emphasis on foreign direct investment since 1984. By 1987, the Board of Investment was aggressively promoting manufacturing, export-oriented investments and small and medium-sized industries. Foreign direct investment has increased markedly, particularly in 1987 and 1988 to date. Applications approved for foreign investment increased from 15.2 billion baht in 1986 to 49.5 billion in 1987 and 105.2 billion baht, January - August 1988. (25 baht = 1 U.S. dollar.)

U.S. exports to Thailand have grown from $730 million in 1985 to $1.5 billion in 1987, to an estimated $2 billion in 1988. The largest U.S. export in 1987, $389 million, was electronic tubes (for other than TVs). Metals, machinery and transportation and equipment (commodity code B-6, which includes electronic tubes) is the largest U.S. export category, followed by chemical and related products. The fastest growing products are increasingly technology intensive: radiotelegraphic, $25 million; compressors, $21 million; machine (nspf), $17 million; digital cpu's, $11 million; instruments for measuring electrical and chemical mixtures, $15 million (all figures are for Jan.-Nov. 1988). U.S. imports from Thailand have increased from $970 million in 1983 to an estimated $3 billion in 1988, and show a similar pattern of greater diversity and more sophisticated embodied technology. Examples for the Jan.-Nov. 1988 period are: hard disc drives, parts for ADP machinery, $228 million (less than $1 million for the same period in 1987); floppy disc drives, parts for ADP machinery, $28 million ($.5 million for the same period in 1987); and watches. The overall trade balance is in Thailand's favor, increasing from $700 million in 1985 to $1.5 billion for the period Jan.-Nov. 1988. Two-way trade is about $5 billion. Thailand is becoming an increasingly large market for U.S. companies. U.S. investors have made substantial investments

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in Thailand, and this is reflected in U.S. imports from Thailand of technology-intensive products such as hard disc drives (Seagate) and integrated circuits (National Semiconductors).

B. Political Economy

Thailand is a constitutional monarchy. Executive power is vested in the Cabinet consisting of a Prime Minister and other Ministers appointed by the King. Legislative power rests with the National Assembly which consists of a Senate, appointed by the King, and House of Representatives, elected by the public.

There is a strong support throughout the Thai body politic for private sector led development and an increased emphasis on science and technology as an integral part of Thailand's industrial strategy. Debate will continue as will experimentation about the relevant roles of government, the universities and the private sector in formulating and implementing science and technology programs, but education is universally supported as an important private and public investment and such fields as agriculture, medical sciences and engineering are considered prestigious.

Science and technology was first incorporated in NESDB's Fifth (indicative) Five Year Plan (1982-1986); a separate chapter was devoted to Science and Technology in the Sixth Five Year Plan (1987-1991) including a recommendation to increase RD&E expenditures to 0.5% of GNP (presently 0.37%). Coordination is a major problem identified in the Plan which suggests the establishment of a Science and Technology Development Subcommittee under the Joint Public Private Sector Coordinating Committee and increased involvement of Thailand's many private professional societies in the formulation and implementation of Thailand's technology policies and programs.

Because professional societies are important, as are small and medium-sized industries, and because Thailand has a history of promoting and experimenting with vocational training, Thailand will likely follow a strategy of adapting existing technology rather than investing heavily to be in the frontier of developing new technologies specific to government priorities, as does the U.S. in defense. There are some spokespersons for following a frontier strategy for some aspects of industrial technology, e.g., biotechnology, but the limited availability of resources and the diffusion of responsibility for science and technology policy will mitigate against the mission-oriented science and technology strategy in the foreseeable future.

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Thailand falls well into the Stage 2B category, "Transition to Newly Industrializing Country," with growing manufacturing exports, many competitive on world markets, a transition from family-based to professionally-managed companies and locally-based multi-national corporations, such as The CP Group, Siam Cement, and Bangkok Bank, having extensive international operations.

IV. Human Resources

Thailand has a diversified higher educational system which has innovated and experimented in response to changing conditions, though some Thais argue not fast enough. There are 16 government universities offering degrees from diploma to Ph.D.s, 23 private universities which offer higher certificates of vocational education to bachelor degrees, The Institute of Technical and Vocational Education which has 28 campuses and offers certificate of vocational education, higher certificate of vocational education, advanced certificate of vocational education and bachelor degrees in technical-related subjects, 202 government vocational education and 363 private vocational colleges which also offer the same three levels of certificates. Post-graduate degrees in S&T increased from 618 in 1977-78 to 1,336 in 1985-86; bachelor degrees from 4,876 to 8,549 in the same period; and below bachelor degrees from 13,498 to 85,074.[1] Demand for higher education is great. Only 18% of the 90,404 applicants in 1987-88 were admitted to the government universities.

Thailand has a reasonable supply of scientific and technological manpower, though low compared to most other Asian industrializing countries and low relative to projected demand. Thailand's S&T manpower per 10,000 in the labor force compares well with Korea in agriculture, fisheries and forestry -- Thailand 5.4 (1984) versus Korea 6.7 (1981), and in electricity, gas and water -- 844 versus 563, but is low compared to Korea in manufacturing -- 242 versus 377, and mining -- 251 versus 427. Scientists and engineers per 10,000 in the labor force and scientists and engineers engaged in R&D per 10,000 in the labor force were considerably less in Thailand than Korea in the mid-1970s, 9.1 versus 40.5 and 2.7 versus 7.1 respectively (ESCAP 1986 data).

Most science and engineering disciplines are established at the bachelor degree level in Thailand, some at the post-graduate level. Manpower projections point to a widening gap between supply and demand for scientists and engineers in specialty fields and for qualified production-oriented technicians. A TDRI survey of 68 firms employing 27,232 persons (total manufacturing employment in Thailand in 1987 was estimated at 2.1 million) in 1987 showed a relatively

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[1]"The S&T Manpower Situation in Thailand, An Analysis of Supply and Demand," The Thailand Development Research Institute Foundation, April 1988.

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low scientists' and engineers' ratio to skilled technicians and technicians (average 1:3).

In response to these problems, innovations are taking place. King Mongkut's Institute of Technology North Bangkok is initiating a program of practical training to include a genuine program for machinists -- an apprentice program which will include three years of skilled training producing machine tools -- and technicians are increasingly being hired to work as engineers and additional technicians will be admitted to the universities to pursue engineering degrees. The Department of Vocational Education has initiated many retraining programs of technicians from areas of declining demand to areas of increasing demand. These have generally been initiated with various professional and industrial societies. The government (MOSTE) is also establishing a fund, 2.4 billion baht, for the education of 700 scientists and engineers abroad (if they work for the government when they return). A major innovation is the establishment of The Petroleum Institute of Thailand in 1985, an autonomous not-for-profit foundation, established by contributions from private companies. Its first priorities are in training of the human resources for the oil and gas industry and educating teachers and students in science related to the oil and gas industry.

Some expatriate engineers and scientists are returning to Thailand but not in large numbers, though more are going abroad to be trained in the factories of joint venture partners established in the manufacturing sector in Thailand. An increasing number of Thai scientists and engineers are going into business for themselves or are rising to managerial positions within firms. Both groups tend to be more cognizant of the need for R&D and investment in upgrading the technical competence of their employees. However, there are no special government incentives for companies to invest in upgrading the technological capabilities of their employees. Labor mobility is relatively high among engineers and among highly trained people in expanding industrial fields, such as electronic and information services.

There is an increased awareness on the part of the government to educate the public on science and technology. A separate chapter in the current Five Year Plan on Science and Technology is one example. The National Research Council presents five annual awards for outstanding research contribution in the fields of medicine, chemistry, pharmacology, agriculture, biological sciences and engineering. Thailand holds science exhibitions annually,

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and Thailand has a science museum and a planetarium. The teaching of science and mathematics in the primary and secondary schools is considered reasonably good.

Thailand falls in the 2B category of countries in human resources. To move to 2C, Thailand must expand its science and engineering disciplines in specialty areas, increase exchanges between the universities and private firms, and expand its output of scientists and engineers in response to a rapidly changing industrial structure.

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V. Technological Capacity in the Productive Sector

Thai private firms receive uniformly high marks for operation of conventional technology, but lack the ability to make major modifications of either process or product technology.

Thai companies' abilities to acquire and adapt technology vary among industries and among firms within an industry according to size, ownership and whether promoted or not by the Board of Investment. Thai firms' innovative capabilities are superior in upstream technologies, e.g., in the biotechnology field (contrasting flower industry with alcohol) and in the electronics and information industry (application software versus design of new components). Companies with technically trained managers, good technical staffs and a R&D department rank higher in all technology capability attributes than firms without these characteristics.

There is some movement of engineers and highly trained technical people between firms, e.g., in the electronics and information systems industry, and from the universities to the private sector. Large Thai firms tend to integrate vertically rather than subcontract to smaller firms, because of a separate turnover tax on intercompany business transactions. They are more inclined to invest in internal human resources development than smaller companies. The technological capacity of Thailand's private sector is well documented in the three-volume study by the Thailand Development Research Institute, "The Development of Thailand's Technological Capacity in Industry," October 1988.

Thai firms large and small have the capacity to adapt technology and product designs for local needs if these do not require major innovations, but cooperative R&D among firms and between firms and government laboratories and universities is very limited. In the metals and materials industry, some firms indicate they are quite capable of greater innovations but are deterred because of the absence of sufficiently strong protection of intellectual property.

Quality control consciousness is increasing but cannot be termed widespread. Testing services are available but most testing laboratories are not certified by international organizations, a deficiency that impinges primarily on small and medium-sized companies. As exports of manufactures to industrial countries continue to expand, calibration (which is available from both private and government laboratories) and testing will become increasingly important to firms. While larger firms are investing in upgrading firm specific

technological capabilities, smaller firms rely on training on the job. Associations representing specific industries are becoming active in organizing training programs with universities to upgrade and reorient the technological capabilities of their workers.

Increasingly, Thai firms are negotiating with multinational corporations with a focus on better absorbing technology. Unbundling of technology is more common. This trend is somewhat negated in the electronics and information systems industry where foreign firms have been allowed 100% ownership for 100% export of products by the Board of Investment. To date, these are mostly assembly operations based on imported components. Both the BOI and the IFC/T are beginning to focus more on reviewing the technology of proposals, in addition to the foreign exchange and employment characteristics, before granting promotional privileges or making investment respectively. The BOI has indicated that it will promote technology development companies.

There is some research and development in Thai firms, more than is reported, because there is no special incentive to distinguish R&D from other business expenses. Siam Cement Group has a large R&D department with a budget of $5 million. Small companies lack the depth of technical personnel and the financing to undertake R&D and few rely on cooperative research with government laboratories and universities. R&D expenditures, mostly from public enterprises and agencies, are estimated at 0.37% of GNP.

Advanced technology has been applied to industry and agriculture in Thailand in a few cases. Although there is innovation taking place in Thai firms, it is not, as yet, what one could classify as "world class".

For purposes of placing Thailand in comparison with other countries in terms of technological capability, she has clearly mastered conventional technology and displays some, but not all, the attributes of a country entering the beginining stages of transition to a newly industrialized country, or from 2A to 2B. To move from 2A to 2B, according to the framework, Thailand must further develop the capital goods industries, technical services and consulting and engineering services, improve the ability to upgrade foreign technology, strengthen backward linkages between assembled exports and local production of components and subcontracting between large and small companies.

VI. Scientific and Technological Institutional Services and Research

Technical services to firms, on the whole, are underdeveloped in Thailand. Government groups established to assess and access technologies or to provide services to small and medium-sized companies are generally understaffed and lack experience in private firms. Most universities and institutes of technology have established offices to promote their consultancy and research services to industry on a fee basis. These efforts are modest to date but are meeting with some success. The government is encouraging a greater effort through limiting budget allocations to the universities.

Specific professional and industrial associations and clubs are quite active and important in Thailand. They interact with the government on various policies affecting technology development, such as tariffs and fiscal policy, and they cooperate with the government and universities in organizing seminars for exchange of information and training courses to upgrade or retrain technical people.

There are three research centers: The National Center for Genetic Engineering and Biotechnology, the National Electronic and Computer Technology Center, and the National Center for Metal and Material Technology. These organizations are under the Ministry of Science and Technology and Energy (MOSTE), and their principal role is to obtain funding to support research at universities, research institutes and government agencies. The oldest is the National Center for Genetic Engineering and Biotechnology, and it has had some success in developing technology in areas such as tissue culture and growing algae from cassava waste. Some of its supported research has been commercialized by private firms.

There is a host of government research laboratories and industry-specific research organizations associated with unviersities. Some, such as the Metal Working and Machinery Industries Development Institute (MIDI) under the Ministry of Industry, have very directed objectives which are to increase the efficiency of small and medium-sized metal working machinery industries and carry out applied research. Others, such as the Thailand Institute for Scientific & Technological Research (TISTR), a state enterprise under the Ministry of Science, Technology and Engineering, have a broader mandate which includes research, services and general support (including testing) to government and private firms. The prevailing view is that linkage between these research organizations and the private sector is weak, generally, and needs to be strengthened, although at

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least one research and science center, the Energy Conservation Center, was established jointly by the Thai Government and Thai business.

Consulting services and general engineering development organizations exist, but the demand for their services on technology acquisition, adaptation and development is not widespread, and in some areas, such as electronics, private consulting firms did not exist until very recently. The Engineering Institute of Thailand, in 1987, published a list of engineers and Thai consulting firms which are mostly civil, mechanical and electrical, and according to one observer, "few had any relevance to processing." The AT&T Yellow Pages lists 56 consulting firms; some claim to do product quality and process design. Consulting firms are not a major vehicle for Thai firms acquiring technology.

Research and research coordination are improving, and the Thais recognize this as a problem that needs further attention including more involvement in the private sector. The USAID funded Science and Technology Development Board is an important innovation in improving coordination with the universities and the national centers under the Ministry of Science, Technology and Energy, and the recommendation in the NESDB Sixth Plan of establishing a subcommittee on science and technology under the Joint Public-Private Sector Consultancy Committee is another institutional innovation in the right direction.

Thailand is in Stage 2A in terms of scientific and technological infrastructure and is moving into 2B. To move to stage 2B, technical services have to be expanded and improved, consulting firms which can provide relevant services to private firms increased, and more cooperative work between the universities and private firms and coordination and administration of research must be encouraged.

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VII. Science and Technology Policy

The first explicit statement on the use of science and technology for development was stated in Article 61 of the 1979 Constitution (ref. ESCAP Technology Atlas, March 1987). Science and technology for development was mentioned in the NESDB's Fifth Five Year Plan (1982-86); a whole chapter was devoted to the topic with specific policy and program recommendations in the Sixth Five Year Plan (1987-1991).

Responsibility for science and technology policy formulation in Thailand rests primarily with the NESDB and the Ministry of Science, Technology and Engineering (MOSTE). Overall planning at the NESDB is assisted by a Joint Public-Private Sector Coordinating Committee (JPPSCC). The TDRI study recommends that a science and technology subcommittee be formed under the JPPSCC with public and private participation. Other important ministries, agencies, etc., are the National Research Council which monitors research and development budgets, Ministry of University Affairs which undertakes long-term planning for higher education, Bank of Thailand, Board of Investment, Ministry of Industry and Ministry of Agriculture.

Many laws pertaining to science and technology have been proposed and debated over the years; few have been enacted in the form proposed; e.g., Law for Establishment of a Science and Technology Council. Compared to Korea, Thailand has not enacted laws as a major instrument of government policy for promoting science and technology for industrial development. The proposed law for the Science and Technology Council, which was accepted in principle by the Cabinet, envisioned that a Council, chaired by the Prime Minister, would provide policy and planning advice and ensure implementation of policy by the various ministries and agencies. This was not enacted.

Thai business is represented and consulted by the government on developing science and technology policy, but this is not widespread and the effort generally is not considered serious. There are formal channels, such as the JPPSCC and private sector participation in the Board of the STDB, but there are also numerous informal mechanisms, particularly in dealing with the Board of Investment on technology transfer, and the Ministry of Trade and Industry and Ministry of Finance on tariffs and tax issues. Seminars abound where these issues are discussed and business associations take the initiative to work with government agencies. For instance, a subcommittee for the Development of the Electronics Industry for Export was formed by the BOI with private sector participation and, according to the TDRI study, supported the recommendations of the 1986 ADL study

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and was instrumental in restructuring the tariff systems and in promoting and organizing the Thai CRT joint ventures with Mitsubishi to produce cathode ray tubes for color television.

The technocrats in the government, and particularly professors at the universities, are cognizant of and knowledgable about technological development issues. One could not say, however, that they necessarily possess knowledge superior to that of the Thai private sector. Thailand has made some preliminary efforts to integrate technology with economic policies and industrial strategies. This trend is becoming stronger, particularly at the agency (e.g., IFC/T, BOI) level as compared with the national level.

Thailand has also made its first attempt at strategic investments in advanced technology, specifically in biotechnology, and both the establishment of the three research centers under MOSTE and of the STDB should intensify and broaden Thai investments in research on advanced technologies.

Thailand is clearly at stage 2A and moving into stage 2B. The greatest need is for more private sector participation in the formulation of science and technology policy, greater integration of science and technology as a component of economic policy and strategy, and better coordination among the various government ministries and agencies.

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VIII. Financing of Science and Technology

The Thai financial system is fairly broad, although institutional small business lending, merchant banking and venture capital are relatively limited. The commercial banks dominate -- assets of $40 billion. The stock market has become increasingly important. About $400 million was raised on the stock exchange by Thai firms last year, and newly established off-shore equity funds will increase the activity on the exchange.

The only development bank is the IFC/T with assets of $1 billion. The IFC/T is rapidly moving into the new fields such as venture capital and small business lending, including the management of an Export Industry Modernization program for small businesses. They have the capability and the experience to assess the technology of proposed investments, although to date they have not financed technology development.

Commercial banks are also willing to finance the introduction of technology, but probably not technology development. In fact, the only funds available for financing technology development in the private sector are the MOSTE revolving fund and the STDB research and development program. Both these funds are relatively small to date.

Venture capital is just emerging. Business Venture Promotion Co., Ltd. (BVP) was established in 1978 with 160 million baht under management. The major sources of investment funds are six Thai commercial banks. They have made four investments (as of 1988). Thai Agri-business Venture Co. (AVC) with ADB, Bank of Agriculture and Agricultural Cooperative (BAAC), among others, will have $10 million under U.S. management by Ventana, a U.S. capital firm. SEAVI, Thailand, associated with Advent International of Boston and IFC of the World Bank, will soon begin managing an investment fund for Thailand, and an ASEAN venture fund initiated by a Japanese financial institution will soon begin operation with management participation by, among others, SEAVI and Hambrecht and Quist Asia Pacific. This fund is in the final stage of organization and registration with $150 million under management.

A government financing institution of some interest is The Bank of Agriculture and Agriculture Cooperatives with assets of $1.3 billion. They provide credit for agriculture and agro-businesses and have some capability to assess technology options. They probably have indirectly financed some commercialization of technologies. They are an investor in one of the newly formed venture capital firms (TAVC).

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Most financing of technologies in the private sector is done through internal cash flow of the firm and for entrepreneurs by family and friends. The government finances research in government laboratories within the ministries and at the universities, but the amounts are relatively small (except for agriculture) and most of it is late in the product development cycle. International agencies have been major financiers of basic research in Thailand.

Thailand's status clearly falls in stage 2A. To move into stage 2B ("transition to newly industrializing countries") the financial market for risk capital for start-up companies must expand and special institutions, in addition to the STDB and MOSTE programs, must emerge to finance technology development.

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IX. Conclusion and Recommendation

General State of the Economy

Thailand's international competitiveness has clearly benefitted from an adjustment in its exchange rate, liberalization of its tariff structure and reduction in price controls and quantitative restrictions on imported goods. Thailand was posed to take advantage of a growth in world trade and, from 1986 onward, she did. Continuation of these policy trends should be encouraged by A.I.D.

Human Resources

Thailand's human resources are one of its strong competitive advantages, but there are gaps. These pose potential constraints to Thailand's ability to use science and technology to further her economic development. Some specialty engineering and scientific disciplines are not adequately offered at the universities, and more emphasis on practical, as distinct from theoretical, training at vocational institutions is in order. It is unlikely that AID will be a major funding source for faculty expansions at the universities. On the other hand, cooperative programs between private businesses and both universities and vocational institutions in retraining and skill upgrading of technicians and engineers would overcome some of Thailand's human resources constraints and promote better linkages between educational institutions and productive businesses. Such programs are well within AID program strategy and funding levels. The Petroleum Institute of Thailand provides an interesting model that could be replicated in other areas. AID might also consider, through STDB, the funding of special cash awards for technological innovations and excellence in quality control demonstrated by Thai private conpanies.

Technological Capability in the Productive Sector

The technological capability in Thailand's productive sector is reasonably good, but must continually be improved for Thailand to remain competitive in international markets. Fiscal incentives for investments by private firms for upgrading staff capabilities, more seminars on managing quality control at the firm level and the acquisition and adaptation of technology are low-cost, potentially high-impact programs and AID could certainly be a funding source for these. The linkage between large and small companies has been hindered by a double taxation on inter-company business transactions; the Thai government has already rectified this problem by instituting a value-added tax system. Small firms lack the financial resources and depth

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of technical staffs to undertake more than operational refinements in technology. AID might consider the funding of a program on a pilot basis similar to the enterprise initiative program in England where the government finances a certain number of hours of advisory services from universities or consulting firms to small firms, followed by a certain number of hours on a 50/50 cost-sharing basis and, thereafter, the small firm is on its own. This has proven to be a very successful program.

Scientific and Technological Institutions, Science and Research

The two areas of opportunity for AID are support for diversification and expansion of engineering and consulting service firms (including calibration and testing of instruments) and greater participation by the private sector in the formulation of Thailand's scinece and technology policies and programs. The first could be addressed through partial guárantees provided by AID to IFC/T and commercial banks to invest in engineering and consulting service firms, and the latter, seminars and analytical work through STDB, in cooperation with MOSTE and NESDE, additional efforts beyond what AID already has contemplated under its Science and Technology for Development project through STDB.

Science and Technology Policy

Greater participation by the private sectors in the formulation of science and technology policy has already been mentioned, and AID's role, at a minimum, is to encourage such coordination. But AID can help to strengthen the capability of industrial and business associations, and the public at large, in understanding the stakes in investing or not investing in science and technology, by financing analytical work and open discussions of the issues involved and the policy and program adjustments needed to harness science and technology for equitable growth. The U.S. is strong in this area and could help Thailand become intellectually, and perhaps institutionally, stronger in the policy area. USIA, in addition to AID, can also be helpful through financing and replacing of U.S. television programs on science and technology, preparation of video presentations and guest speakers.

Financing of Science and Technology

Thailand's financial markets are relatively broad and innovative retail banking services, merchant banking and venture capital are surfacing. The stock market is well established except for a secondary market, and access for

small companies is still limited. With the exception of a small program administered by the STDB, there exists no institutional credit for financing technology development with the private sector and the Thai tax system provides no special incentives for companies to increase expenditures on RD&E. The multilateral and bilateral assistance agencies are major contributors to the financing of science and technology development at the universities, though the amounts are relativedly small. AID could sponsor and provide seed capital for a facility to finance technology adaptation, development and diffusion by the private sector and a separate facility to encourage collaboration between universities and private firms on technology adaptation and transfer. In these two areas, Thailand is weak compared with other Stage 2b countries.

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APPENDIX D

SCIENTIFIC AND TECHNOLOGICAL CONSTRAINTS TO ECONOMIC DEVELOPMENT:

An Analytic Cross-Country Framework

PILOT COUNTRY STUDY #2: TUNISIA

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Summary

This appendix provides a brief assessment of the scientific and technological development of Tunisia, and its contribution to the country's economic development. It is primarily intended as a test case for the cross-country analytic framework set forth in the main body of the paper.

According to this analytical framework, Tunisia is at stage 1c in its overall scientific and technological development, i.e., it is at the stage of "islands of modernization," as evidenced by the following profile:

General State of the Economy	1c
Human Resources	1c/2a
Technological Capacity in the Productive Sector	1c
Scientific and Technological Institutions, Services and Research	1b
Science and Technology Policy	1c
Financing of Science and Technology	1c

Tunisia has a relatively high per capita income, but as can be seen from the above assessment, it is by no means an advanced country from the point of view of science and technology. Its economy was until recently sustained by exports of oil and phosphates, tourism, and workers' remittances. Of these, only tourism continues strong.

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Tunisia is only just emerging from a long period during which its industry was heavily regulated and almost totally protected from competition, and hence had little reason to improve its technology. Its systems of banking and education are inflexible and poorly suited to the demands of an internationally competitive economy.

But the ice is now breaking. Top leaders of the Tunisian government and business community realize that the country cannot sustain its standard of living without far-reaching economic reform and without substantial improvement in the country's ability to manage science and technology. They have begun to give explicit attention to science and technology and are receptive to new ideas in this area. They regard the U.S. as an important source of science and technology and also as an institutional model for the some of the institutional reforms they need to undertake.

Investments in science and technology are useful points of leverage for AID in Tunisia, even though they are unlikely to lead to a rapid economic breakthrough. AID should help Tunisia to effect needed changes in institutions and attitudes and to build capabilities in fields of science and technology that will be needed in the long run. It should seek program opportunities in supporting reform in science and technology education, should assist small industry to improve its marketing and technological intelligence, and should explore the services sector for leverage points in which the private sector (perhaps in collaboration with

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U.S. business) can provide needed technology-based business services, e.g. in informatics and management consulting. It should assist the Tunisian government to develop an overall strategy for scientific and technological development, and should support the efforts of the World Bank to promote the liberalization of the economy and the rationalization of the tax system.

PILOT COUNTRY STUDY #2: TUNISIA

General State of the Economy

Economic Geography. Tunisia is very close to Italy and France, and is near enough to any part of Europe to make it possible for an investor, a supplier, or a customer to feel close to his business collaborator and to visit him quickly if necessary. It is connected to European markets by quick and efficient roll-on/roll-off water/surface transportation. It is thus well-suited geographically to providing quick turn-around in response to rapidly changing markets.

Tunisia has major reserves of phosphates. Its known reserves of oil are expected to be exhausted in the early 1990s, although exploration is continuing. Its sunny climate and excellent beaches are the basis of a substantial tourist trade.

Only a small portion of Tunisia's area is arable, and only 5% of that is irrigated. Low mountains block the progress of rain-bearing clouds from the Mediterranean, giving rise to semi-arid steppes that merge with the Sahara. Tunisia exports dates and olives, and imports 50% of its cereals. Expansion of agricultural output is possible and desirable through improvements in technology, introduction of new crops, and increase in value-added, but is ultimately limited by geography.

Political Economics. Tunisia is emerging from a long period during which an inefficient, dirigist, inward-oriented economy was supported by foreign exchange earnings from exports of oil and phosphate, workers' remittances, and foreign aid. 22% of total GDP (compared to 38% of investment) in 1984 came from overstaffed, inefficient government-owned enterprises. Industrial production was totally protected from foreign competition, and entry of domestic competitors was severely restricted.

The Tunisian dinar was devalued in early 1986 and the exchange rate has been relatively realistic since then. Non-oil exports responded strongly to devaluation, as did workers' remittances, while real wage rates did not increase between 1985 and 1987. Since 1987, the money market has expanded and rates, now determined more by supply and demand than by government administrative decree, are positive, although a cap imposed on bank lending rates limits their profits and their ability to service other than well-established, credit-worthy borrowers.

During this period, private investment in industry was encouraged, but the instruments used distorted the choice of technology by favoring large at the expense of small and medium

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industry, by favoring investments in new plant over the expansion or modernization of existing facilities, and by encouraging the creation of excess capacity and undue capital intensity. At the same time, the structure of compensation created a wage squeeze that destroyed the incentive of unskilled workers to acquire skills and to become supervisors.

The social results of this regime, however, were favorable. Unemployment was averted by extensive featherbedding of public enterprises, and a network of social services was established, including free medical care (a system which is now heavily overburdened and underfinanced) and universal education through the sixth grade. As a result, the pattern of income distribution is relatively equitable, and indicators of the quality of life have improved dramatically since independence.

The decline in oil and phosphate prices (along with the imminent exhaustion of oil reserves), together with the decline in workers' remittances from Europe and the Persian Gulf, convinced the new leadership of the country that it is necessary to carry out a major structural reform to encourage the development of a competitive manufacturing sector based on market prices. A decision was taken to begin to liberalize imports, to reduce regulations inhibiting market forces, and to privatize the major industrial holdings of the parastatals.

While the need for such measures is clear to top officials, it will be some time before this realization trickles down to officials at lower levels, whose attitudes were shaped by the 35 years of dirigism. Within the government, the President, the planning authorities and the Central Bank strongly favor the reform. Officials in the ministries which control the large budgets of the parastatals see reform as a threat and strongly oppose it. Many of these are graduates of the French-style Ecole National d'Administration, and are in close communication with each other via its closely knit old-boy network.

Since the basic policy direction is towards an economy that will create a greater demand for improved technology and management, this pervasive attitude at the working levels of government may ultimately prove to be more of a constraint than the formal liberalization of stated policy. Within the business community, there is general recognition that competitive pressures are about to increase, and many welcome this as essential to Tunisia's economic future.

Tunisia's relatively high per capita income means that it cannot simply follow the development model pioneered by the newly industrializing countries of the Pacific Rim, beginning with simple, low-paid assembly work and gradually moving up the ladder of productivity. It can sustain its standard of living only if it takes advantage of its ample supply of educated

people, its proximity to European markets, and its low wage rates relative to Europe.

Tunisia is at substage 1c as regards the general state of the economy, as is apparent from the following rationale. The basic road network is complete throughout the country, and parastatal companies are active in mining, industry and agriculture. (Indeed, the privatization of these companies is a major item on the national policy agenda.) Modern small industry is well established, and indeed flourishing in the protected environment. Manufactured exports based on labor-intensive technology (especially garments) are growing rapidly from a small base.

AID can assist the structural adjustment that is essential to scientific and technological development in Tunisia by promoting increased understanding in the ranks of the Tunisian government, and its academic, banking, business and scientific and technological communities, of the manner in which liberalization, privatization, and deregulation contribute to the development of Tunisian scientific and technological capability by increasing the demand for improved management and technology in the productive sector.

This task is analogous to the efforts of AID to promote the idea of privatization in Tunisia, and can be carried out through seminars, conferences, visiting lectures, and study tours to the US and to free-market developing and newly industrializing countries, such as Turkey, Thailand and Taiwan.

Technological Capability in the Productive Sector

With the exception of large firms devoted to natural resource extraction and conversion, Tunisian industry consists of small to medium firms (up to 300 workers) which operate conventional technology transferred from abroad. Much of this industry consists of simple assembly or transformation, using technology embodied in machinery purchased from abroad, usually from convenient suppliers and without extensive consideration of alternatives. Few of these businesses use advanced technology, even in production.

The outstanding example of indigenous technological innovation in Tunisian industry is a process to concentrate phosphate ore which was developed to deal with Tunisia's unique ore deposits and which is now being exported by a Tunisian parastatal firm. Most Tunisian manufacturing firms, on the other hand, are too small to carry out research and development. Some of these small firms are able to design "low-tech" machinery. Others receive help from the engineering institutes in Tunis (ENIT) and in Sfax (ENIS).

In the section of the report devoted to scientific and technological institutions, services and research, we describe two government initiatives designed to launch Tunisian software capabilities. These useful institutions suffer from a lack of a natural clientele among firms offering business-related services.

Tunisian small and medium business displays a vigorous entrepreneurial spirit, despite the policy problems discussed earlier. This is especially true in the commercial city of Sfax, which has always prided itself on its independence from the more political atmosphere of the capital in Tunis.[1]

The major limitations on small and medium firms are market size and access to credit. They are geared to the local market. Now that this is no longer to be protected, they must achieve full utilization of capacity and levels of productivity commensurate with wage rates. This in turn means a major improvement in management and the development of staff capabilities. For this many smaller entrepreneurs lack the training and the resources. It also means a major effort to develop new markets, mostly outside of the country, to develop new products to the demands of these new markets, to maintain and adapt machinery and equipment used in production, and to keep up with changes in markets and technology. Analogous problems are faced by new graduates at the bachelier or university level who wish to launch new businesses.

The provision of these services -- management, marketing, market and technological intelligence, technology adaptation, technological information -- is both a major challenge and a major opportunity. These business-related services are not now strongly represented in Tunisia, largely because there was little demand for them in the days of protected markets.

Normally, these capabilities develop inside the firm and are augmented by outside service vendors, whether private or governmental. In the particular case of Tunisia, the liberalization is likely to call forth a sudden need for more capability than the firm itself can muster and hence a demand for outside help.

More generally, the consulting industry is not strongly represented in Tunisia, except in engineering and techno-economic analysis related to construction and to public sector development projects. This industry may be expected to develop as the economy is liberalized. It represents both a requirement for

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1. Sfax is located about 150 miles south of Tunis. The consultant spent two days there.

technological development in Tunisia and an opportunity for U.S. business, and deserves encouragement from AID.

The government of Tunisia is now considering a draft law for the promotion of services, analogous to the law for the promotion of manufacturing industry and (presumably) taking into account the fact that many service industries rely on people and working capital, rather than on large amounts of fixed capital.

Given that Tunisia's future is likely to be tied as much to services as to manufacturing, there is a need for a broad, techno-economic study of the present and future needs of Tunisian industry, in the light of available technology and Tunisian capabilities for using it, for such technology-related business services as marketing, market and technological intelligence, technology assessment, management and engineering consulting, as well as technological information services and other technology-based business services. Such a study would then identify further policy changes and institutional programmatic initiatives needed to ensure their success. It would also recommend specific proposals for AID initiatives to build Tunisian capability in this area in collaboration with U.S. business.

The Tunisian government would also benefit from the availability of a vigorous local consulting industry that can carry out studies that will improve the conception and implementation of policies and programs, but for which there is no need for permanent staff capability within the bureaucracy. The growth of such an industry is at present hampered by widespread reluctance on the part of government officials to go outside their own staff for such studies, and by policies and procedures that make it difficult for them to do so. A reexamination of these policies and practices would benefit both the government and the local consulting industry, which is itself an important element of local technological capability.

In the agricultural sector, the development of scientific and technological capability has also been inhibited by the dirigist economic framework. Limits on producer prices and other regulations have discouraged investment in capital improvements and inputs needed for the application of technology needed for improved productivity, as well as for soil conservation. This in turn has limited the ultimate effectiveness of the work of the institutions responsible for agricultural research and extension, independently of its quality. These issues are being addressed in the context of the Agricultural Sector Adjustment Loan now being implemented under the auspices of the World Bank.

In summary, the scientific and technological capability of the Tunisian industrial sector -- which we take as a proxy for the agricultural sector as well -- corresponds to substage 1c of

the framework elaborated in the main paper, i.e., "islands of modernization." This assignment is justified by the following rationale.

Except for civil works construction, in which local engineering capability is well established, modern technology for public sector and larger private sector plants is normally imported, mainly as equipment or turnkey plants, and usually as specified by subcontractor or joint venture partner.

AID should examine the program possibilities for building up this capability through support to technology-oriented business services as defined in the preceding paragraph. AID should specifically support the establishment of a service to assist Tunisian small and medium industry with overseas marketing and with technological and market intelligence. Such a service should receive partial funding from the government, but should be directly responsive to its clientele in small and medium industry and should preferably be privately managed.

AID should also support a review of policies and programs affecting the Tunisian consulting industry, as well as study tours and perhaps technical assistance and seed capital to nascent Tunisian consulting firms. This should be combined with efforts to inform US consulting firms regarding opportunities for collaboration with Tunisian counterparts.

Financing of Science and Technology[2]

There are nine development banks in Tunisia and a large number of commercial banks. Tunisia has historically discouraged foreign investment and foreign banks, so that the Tunisian banking system has been the only formal source of investment and of working capital in the country. There is, to be sure, an active informal capital market based on ties of family and friendship.

Tunisian banks are by all accounts extremely conservative and risk averse. They lack confidence in their ability to assess projects and their decisions to lend or not to lend hence depend much too much on security and collateral. (Tunisia being a small country, they also depend on personal and family ties.)

What is more, in part because of high tax rates, Tunisian entrepreneurs do not expose their real financial situation for others to see. This discourages banks (other than Islamic banks)

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2. Despite extensive efforts, the field study did not succeed in meeting with any active Tunisian lenders. This section is based on comments by bank customers and government officials.

from taking equity positions. Finally, the spread in interest rates is limited by regulation, so that there is no advantage to the bank in investing in risky projects.

The relative underdevelopment of Tunisian capital markets presents a strong obstacle to the introduction of innovative technology, which almost inevitably involves risk and requires a lender to appraise the business prospects of a project and a business plan rather than to rely solely on the character of the borrower and the value of collateral.

Top Tunisian government officials recognize the need to liberalize the banking system, and are looking for new sources of capital, foreign or domestic, that will take business risks and will thus begin to fill the gaping hole in the capital market. While their natural inclination is to turn to French investment companies, they are thus receptive to the idea of "venture capital" from the US.

It is important to avoid misunderstandings here, since the word venture capital may mean very different things in the US and in Tunisia. In the US, venture capital means long-term, high-risk equity investment capital, often for state-of-the-art technology carrying both technological and market risk. As Tunisian industry develops, there may well be a few projects that require this kind of capital. But the more usual requirement will be for investors willing to assume ordinary business risks not particularly connected with technology.

There may well be a need for a risk-taking, promotion-oriented investment company specializing in introduction or development of technology new to Tunisia. This technology may involve innovative solutions to particular problems, but is unlikely to involve state-of-the art technology. But this requirement is likely to obtain only in special cases. What is more, the absence of a well-developed stock market in Tunisia means that there would be no convenient exit mechanism to realize the profits from a successful investment.

In summary, Tunisia is at substage 1c as regards the financing of science and technology. The rationale for this assignment is as follows. Tunisia has seven development banks, whose staffs are said to be reasonably competent in reviewing business plans and in economic and financial aspects of project analysis. (We were unable to visit any of these.) These have a virtual monopoly of investment capital markets, their spread is closely regulated, and (perhaps for this reason), they are extremely averse to risk. The Tunisian stock exchange is a small operation, and lists only large companies.

AID should explore ways in which to encourage risk-oriented investment which will bring new technologies and new capabilities

to Tunisian industry, but should not insist that these investments involve advanced technologies.

Science and Technology Policy

Until the 1980s, Tunisia's policy makers paid little explicit attention to science and technology, except in education and university research. The 1980s saw the establishment of several infrastructural institutions and the launching of the informatics initiatives mentioned in the preceding section of this report, as well as the beginnings of consideration of the need for serious educational reform. But there was still no single locus in the government where the relationship of science and technology to the economy could be considered systematically at a policy level.

In 1985, a high-level Commission on the Mastery of Technology made recommendations which led to the establishment of a new directorate of industrial technology within the Ministry of Industry. This directorate is still new, but it is the logical focus for study of the issues of technology and employment discussed in an earlier section of this report, as well as for study of the challenges and opportunities presented by high technologies such as informatics.

A major effort was launched in the mid-1980s to try to establish Tunisia as a major center of science and technology in the Arab world through the establishment of the Carthage Institute of Technology as a nucleus of a "science city." A project in support of the Carthage Institute is described in the AID budget submission for 1990. This ambitious and worthwhile proposal received important support in the previous government, but was stalled by the economic crisis of the time, as well as by opposition in the Ministry of Higher Education and Research. It will be some time before it can be revived.

In summary, Tunisia is at substage 1c as regards technology policy. The rationale for this assignment is as follows. Tunisia's dirigist economic policies have been holding back its scientific and technological progress for many years. The first explicit attention to overall policy regarding industrial technology took the form of a high-level commission, which recommended among other things the establishment of a new post of Director-General Adjoint for industrial technology in the Ministry of Industry.

USAID should identify the key players in this area, inside and outside the government, and find ways to promote a clearer understanding on the part of Tunisian officials, academics. bankers, and businessmen, of the relationship between Tunisian industrial policy, its technological development, its

unemployment problem, and its future competitiveness, productivity and standard of living, through seminars, conferences, and research.

Human Resources

The educational investments made during the time of high oil income have left Tunisia with a wealth of highly trained people. However, the industrial policies described in the previous section result in insufficient demand for trained people, and hence an increasing problem of brain drain and educated unemployment.

The Tunisian educational system follows a rigid, antique French model, whose products at all levels are poorly suited to the economy and whose cost is beyond the means of the country. The outdated system is a major ultimate cause of the Tunisian unemployment problem.

Briefly stated, the successful products of the system -- the graduates of the best universities -- can hold their own with their peers anywhere. But the main products of the system are failures: failures to enter secondary school (50%), failures at the bac (70% of the remaining), failures to enter the most desirable university curricula (80% of those who pass the bac), failures to complete the university (about 50% of those who matriculate). At every level, students are forced into procrustean beds, and are branded mediocre if they do not fit. At every level, teachers focus on the elite. And it is the small percent who do succeed who end up administering the system!

Top educational officials understand the need for a thorough reform and regard the U.S. as a desirable source of ideas for institutional change. This reform is apparently to start at the bottom, with primary education. Negotiations are now underway with the World Bank for a sector loan to support a thoroughgoing reform which would extend the current universal six years of primary education to nine, and establish a coherent curriculum covering these first nine years. Entrance to the last three years of secondary school would be by a competition similar to that currently controlling entrance to seventh grade.

As part of this reform, a new curriculum for the 7th-9th grade would be established, covering both science and technology in an integrated way. The U.S. has ample technical resources in this area, and collaboration and technical assistance would probably be welcome.

At the same time, a major effort is underway to introduce microcomputers and generally improve the 7th-12th grade (lycee) curriculum in science. Two pilot schools which have been

operating successfully along these lines for several years are to be expanded to 450 in the next few years. This ambitious program probably overemphasizes computers at the expense of other needed equipment, but on balance will be worthwhile if the necessary teacher retraining can be carried out.

At the university level, the Tunisian educational system has up to now prepared its graduates for the relatively predictable requirements of the government bureaucracy and the parastatal sector. It must now respond to the needs of a competitive industrial sector.

In any case, as things now stand, the system is financially unsustainable. The fact that passing the bac automatically conveys admission to the university, forces on the university a growth rate of about 5% in student capacity and at least twice that in operating expenses.

Major reforms are being considered at the university level, although these are not yet at the same stage of consideration as those at the elementary level.[3] But recognition of the need for reform is apparently not widespread within the universities themselves. The directors of the engineering institutes visited by the consultant expressed pride in the system as it is and regarded the educated unemployed as a "political" problem outside their control and interest.

Tunisian university officials expressed a uniform desire for increased collaboration with their U.S. counterparts and for USAID support to their activities. Their priority request was for equipment to begin new programs or to strengthen old ones. They do need new equipment -- but their getting it will support development objectives only if it is coupled with major policy and institutional reforms.

In summary, Tunisia is at substage 1c as regards human resources. The rationale for this assignment is as follows. A substantial majority of the younger male population is literate. Many Tunisian universities turn out graduates of outstanding international quality, but their structure is extremely rigid and ill-suited to the needs of a modern economy in which the

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[3]. A leading proposal would allow successful matriculates to pursue the program (filiere) of their choice, instead of being assigned to a program mostly on the basis of their grades. Students who do well in these first two years would then compete to enter either a "bac + 3" or a "bac + 5" program, either of which would lead to a recognized diploma. This proposal was put forward to the consultant by the rector of the University of Tunis, who is the senior official in Tunisian higher education in the absence of a Minister of Higher Education and Research.

government is no longer to be a primary employer of technical personnel. The problem of the educated unemployed is a serious one. Despite the high quality of the best Tunisian graduates, Tunisia does not qualify for substage 2a, since the demand for its technical manpower is low and stagnant.

The education sector is an excellent vehicle for AID support to scientific and technological development as it relates to employment and competitiveness. As things now stand, a large proportion of the discretionary funds available to the AID Tunisia program is devoted to the (perhaps inaptly named) technology transfer program, by which top Tunisian students are supported for undergraduate and graduate degrees in the U.S. This program is intended to orient some of the most successful Tunisian students to US technology and to the U.S. model of scientific and technological development. The program is extremely competitive and is very popular in Tunisia.

In response to criticism that the degree-holders it produces are not well suited to the needs of the Tunisian economy, the program is being reoriented toward support of graduate studies in engineering and management and away from undergraduate engineering. This is a useful change, particularly if, as is expected, the Tunisian economy continues to liberalize and its demands for trained manpower increase.

But at a time when fundamental change is brewing in the Tunisian educational system, and when the US model of education is widely seen as a useful counterpoint to the antique French model that predominates in Tunisian thinking, AID should examine the possibility of using its money in ways that would more directly promote the kinds of fundamental changes that are essential in the Tunisian educational system.[4]

Specific program possibilities include:

(1) Technical assistance to the science and technology curriculum for 7th-9th grade as part of the overall reform of primary education supported by a World Bank sector loan; this might be coupled with

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[4]. A further limitation on this program is the exclusion of the Ecole National d'Ingenerie Tunisienne (ENIT), the premier engineering school in the country, reportedly because it is receiving assistance from Eastern Bloc countries. The consultant understands this restriction to be the result of a Congressional directive. It might be worthwhile to review the extent to which this restriction serves present US interests under the specific circumstances of Tunisia.

(2) Promotion of the establishment of a hands-on museum of science and technology, as a complement to this improved curriculum and as a contribution to general awareness of science and technology. Such a museum might be patterned on the Oregon Museum of Science and Industry, and complemented by a program of radio and television shows and travelling exhibits mounted on trucks.

(3) Increased exposure of Tunisian educational administrators and senior faculty to the U.S. educational system through study tours, faculty exchanges, visiting lecturers, conferences, etc.

(4) Technical collaboration and provision of equipment to selected university programs in the context of a general reform of higher education, e.g. under the aegis of the planned World Bank sector loan;

(5) Review of the planned revision of the educational system from 7th to 12th grade (perhaps based on the review underway at the World Bank) with a view to ascertaining the desirability of providing technical assistance to the expanded pilot lycees, not necessarily in computer-related areas.

Scientific and Technological Research, Institutions and Services

The strongest element of Tunisian scientific and technological infrastructure is research as an adjunct to graduate and undergraduate teaching. Many institutions of higher education do good "small science" -- high-quality graduate theses at masters and Ph.D. level, carried out with minimum equipment and maximum self-reliance. This "small science" suffers from serious under funding. The entire academic research budget for the country is reported to be about $2 million/year.

On the other hand, the field study did not find any applied research which was at the same time first-class in quality, linked to a practical objective, and carried out with resources and mandate sufficient to carry a solution (if the research is successful) through to a practical conclusion. The field study was informed of, but could not visit, crop breeding research in the government agricultural laboratories which AID funded and regards highly. Medical research was revived a few years ago after a long hiatus. Such an absence of first-class applied research would be a major gap in a country with serious scientific aspirations.

Institutions offering technology-based services to industry are relatively new in Tunisia. There is no government owned

industrial research and development laboratory. INNORMI, the standardization service, is vigorous though relatively new. CETIME, the Tunisian Center for Electrical and Mechanical Industries, likewise enjoys a favorable reputation. Other government-owned technological service centers serve the leather, ceramics and glass industries. There is no agency set up for the specific purpose of providing technological information for industry. INNORMI subscribes to Dialog and other data bases and offers limited technological information services to industry.

A recent AID project supported efforts to sell the services and documentation of the National Technical Information Service (NTIS) in Tunisia and other countries in the Middle East. The project in Tunisia proved that such efforts could be profitable if backed by a vigorous sales effort. There are, however, many needs for information on industrial technology in Tunisia that can be met only by a more broadly based effort.

Two important new initiatives in informatics are the National Informatics Center (CNI) and the AID-sponsored Regional Institute for Informatics and Telecommunications Science (IRSIT). CNI is primarily a regulatory and service body, with a small applied research and development program. IRSIT does applied research and services involving relatively advanced computer applications.

Both institutions now serve the public sector predominantly, and indeed the Tunisian government is said to be well ahead of the governments of other Arab governments in applying informatics to internal management functions. Both institutions also have the worthwhile ambition of developing new commercial software products for the Arab market. In this they are hampered by the weak demand for improved management on the part of the Tunisian private sector, and by the small size of the management consulting industry which should be the natural clientele of an informatics service.

The forthcoming liberalization of the Tunisian economy should alleviate both of these problems. On the other hand, the two institutions should begin now to plan for the changes they will need to make if they are to find their niches among the many private firms that will be offering computer-based services to the public and private sectors in Tunisia.

In summary, Tunisian scientific and technological infrastructure falls in the relatively early part of substage 1c according to the analytic framework elaborated in the body of the report. The rationale for this assignment is as follows.

"Small science" at universities is of good quality, but is seriously underfunded. Research coordination is said to be very weak. There are subsectoral service institutes for a few

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subsectors (electrical, mechanical, ceramics, leather) but coverage is far from complete. Research in agriculture is said to be of good quality, but technology diffusion is hampered by national agricultural policies. Further review is needed to ascertain the status of applied research in other sectors, such as environment, and the role of non-governmental or other organizations active in diffusing low-cost technology suited to poor and disadvantaged people.

From the point of view of AID, this offers an opportunity to experiment with a private sector approach to the provision of technology-based industrial services, a point elaborated in more detail in the previous section of this study.

Recapitulation of Recommendations

This section of the appendix gathers together the various action recommendations made earlier, and classifies them according to whether they are designed to affect economic growth in the near or the long term.

Science and Technology investments with near-term payoff. The following investments in science and technology in Tunisia, taken from the text of this appendix, are recommended to AID for their near-term impact on economic growth:

(1) Technological Capacity in the Productive Sector. AID should specifically support the establishment of a service to assist Tunisian small and medium industry with overseas marketing and with technological and market intelligence. Such a service should receive partial funding from the government, but should be directly responsive to its clientele in small and medium industry and should preferably be privately managed.

AID should also support a review of policies and programs affecting the Tunisian consulting industry, as well as study tours and perhaps technical assistance and seed capital to nascent Tunisian consulting firms. This should be combined with efforts to inform US consulting firms regarding opportunities for collaboration with Tunisian counterparts.

(2) Technology Policy. USAID should identify the key players in this area, inside and outside the government, and find ways to promote a clearer understanding on the part of Tunisian officials, academics. bankers, and businessmen, of the relationship between Tunisian industrial policy, its technological development, its unemployment problem, and its future competitiveness, productivity and standard of living, through seminars, conferences, and research.

Science and technology investments with long-term payoff. The following investments in science and technology in Tunisia, taken from the text of this appendix, are recommended to AID for their fundamental, long-term impact on economic growth:

(3) Human Resources. Specific program possibilities include:

(a) Technical assistance to the science and technology curriculum for 7th-9th grade as part of the overall reform of primary education supported by a World Bank sector loan; this might be coupled with

(b) Promotion of the establishment of a hands-on museum of science and technology, as a complement to this improved curriculum and as a contribution to general awareness of science and technology. Such a museum might be patterned on the Oregon Museum of Science and Industry, and complemented by a program of radio and television shows and travelling exhibits mounted on trucks.

(c) Increased exposure of Tunisian educational administrators and senior faculty to the U.S. educational system through study tours, faculty exchanges, visiting lecturers, conferences, etc.

(d) Technical collaboration and provision of equipment to selected university programs in the context of a general reform of higher education, e.g. under the aegis of the planned World Bank sector loan;

(e) Review of the planned revision of the educational system from 7th to 12th grade (perhaps based on the review underway at the World Bank) with a view to ascertaining the desirability of providing technical assistance to the expanded pilot lycees, not necessarily in computer-related areas.

(4) Financing of Science and Technology. AID should explore ways in which to encourage risk-oriented investment which will bring new technologies and new capabilities to Tunisian industry, but should not insist that these investments involve advanced technologies.

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