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Background Papers
for the
Industrial Technology Acquisition Workshop

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KEY ISSUES INVOLVED IN SHAPING AID ASSISTANCE IN INDUSTRIAL TECHNOLOGY ACQUISITION BY DEVELOPING COUNTRIES

by
Dennis H. Wood

A. Introduction

The Workshop on Technology Acquisition for Improved Industrial Productivity has three objectives:

- To develop a broader consensus within AID on the relevant concepts, ideas and issues in the field of industrial technology acquisition;
- To identify key policy and institutional constraints to the acquisition of technology for improved industrial performance in developing countries; and
- To identify promising approaches to assist host countries help overcome these constraints.

The Workshop occurs in a specific context: that of rapid technological change that promises dramatic increases in international productivity and economic growth; changing requirements and international competitiveness led by industries with increasing technological intensity; a pressing need to achieve rapid increases in international productivity to redress growing problems of poverty, powerlessness, and inequity within and between nations.

The purpose of this paper is to identify and briefly discuss key issues involved in shaping AID project assistance in the field of industrial technology acquisition. The issues raised herein are not aimed directly at shaping Agency policy in this important area. Rather, they are designed to elicit discussion about how AID can effectively facilitate technological change that directly supports its mandate to achieve greater international development and equity. Another paper introduces existing Asia/Near East projects that are designed to achieve such results. A third paper invites comment on an analytical framework that may help guide AID analysis and activities in this important area.

The Agency for International Development has long been associated with assisting developing countries obtain new technology, industrial and otherwise, to enhance economic growth and an equitable distribution of that growth. There is a high degree of consensus within AID on this

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Note: Dennis H. Wood is Vice President of Devres, Inc. Marshall Bear, a Devres, Inc. Associate, provided special assistance on this project.

objective and on AID's involvement in the industrial technology acquisition process.

Specific purposes toward which AID's industrial technology transfer assistance should work are not as clearly agreed upon. Increasing developing countries' capacity to develop their own technology is important to some, who sometimes characterize technology as an end in itself. Many seek to help transfer already extant technology, US or otherwise. Arranging for the importation of capital embodied technology into developing countries is the primary concern of others, including many in the private sector in the US and in developing countries. Others are less concerned with technology transfer per se and much more focused on the development impact to be achieved with the technology.

The purpose emphasized by AID depends, in part, on the viewpoint taken with respect to the speed and impact of technological change for developing countries. If such change is especially rapid and significant, AID's technology transfer programs may be different than if such change is more modest.

Approaches to achieving agreed upon technology transfer purposes do vary within AID. Some emphasize a market orientation; others would have AID assistance focus more on a managed technology acquisition process. These different approaches may stem from different assumptions. Analyses of the constraints inhibiting industrial technology transfer or of the opportunities available if such transfers occur may lead to one approach rather than the other. Designation of technology transfer itself as being of major importance or of technology transfer being a means to specific development ends may also lead to different approaches.

AID's programmatic responses in developing its technology acquisition--mechanisms for delivering AID assistance, activities to be undertaken, resource levels to be used and beneficiaries to be helped--hinge on which combination of the above factors governs.

To consider further how to shape AID assistance in industrial technology transfer, a simple illustration is presented, after which each of the major issue areas briefly mentioned above is set out in more detail.

Figure 1 presents a simple schematic of the industrial technology transfer process. It suggests there is a technology supplier, a technology demander and a technology transfer process. The supplier and demander are usually private sector firms. They and the transfer process are all influenced by existing conditions--the context--and by intermediary functions involved with or surrounding each technology transfer. When technology transfer (of whatever kind and at whatever level of sophistication) is successful, all aspects of these key ingredients mesh satisfactorily. If the transfer process is difficult

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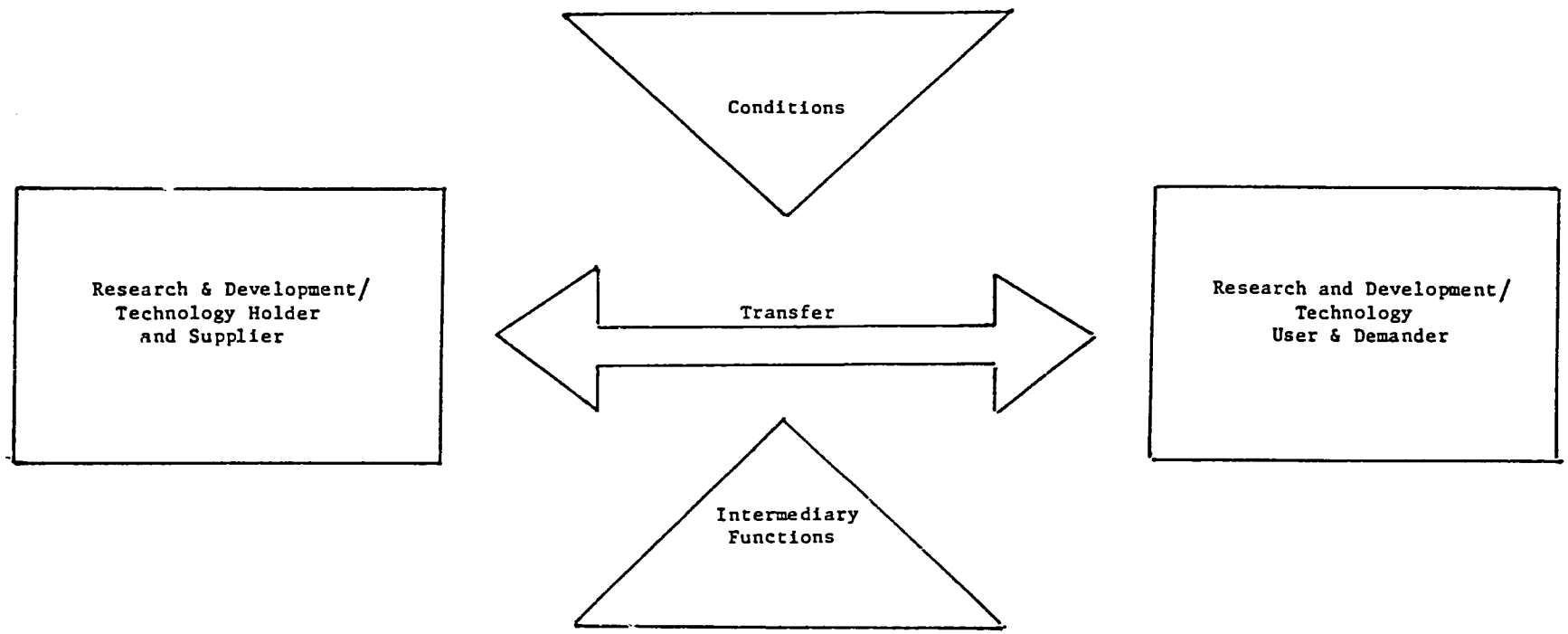

Figure 1: A simple schematic of the R&D and technology transfer process

or does not occur, some elements of these four basic ingredients are effective constraints.

What initiates and drives the technology transfer process? It may be market demand for the potential technology user's products and competition in that market by other producers; a developing country producer may have a problem that technology transfer can solve; perhaps it is a change in "conditions," such as a positive change in the investment climate or the transmittal of a new element of information; an intermediary may bring crucial opportunities to the attention of technology suppliers or users; the technology supplier may aggressively market its technologies.

What inhibits the technology transfer process? It can be a lack of institutional capacity by the users to absorb and manage new techniques; conditions, such as inadequate product standards in the market place, may preclude the use of technologies that would produce higher quality products; intermediary functions--such as locating markets or adequate financing--may be weak; technology suppliers may find it difficult to protect proprietary technology if it is transferred to developing country entities.

The content of the illustration in Figure 1 will vary depending on the industrial activity and country involved as well as on the objective of the transfer itself. R&D joint ventures may be applicable in one case, whereas transfer of capital equipment embodying needed technology may apply in another. Transfer of ability to become self-sufficient in technology development and application may be an important purpose in one instance; transfer and application of existing technology may be relevant in another. Likewise, conditions influencing the kind of technology transferred will vary from situation to situation. Cheap credit, for example, may encourage capital intensive technology transfer; a cheap skilled labor supply may encourage the transfer of labor intensive technology.

AID's role in facilitating the acquisition process can be directed to some or all aspects included in Figure 1. The role undertaken will depend on the Agency's generic assessment of what needs to be done to ensure successful technology acquisition and on the purposes sought in facilitating that process.

B. Technological Change and Future Development: What Pace and What Impact?

ISSUE: What does AID expect the pace and impact of technological change on growth and equity in developing countries to be? What implications does this expectation have for AID's assistance effort?

The expected pace of technological change and its impact on development should greatly influence AID's assistance in this area. When technology changes, it not only enables major productivity increases, it also makes some existing processes or products obsolete.

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When technology takes quantum leaps, it very quickly can eliminate markets, abort some areas of development progress, and undermine certain of AID's efforts to achieve growth and equity in developing countries. If such quantum leaps are frequent, AID programs and policies with respect to technology acquisition will need to prepare developing countries to deal with them. Emphasis would be on technology acquisition and management per se rather than on technology development. Developing countries would be taught to shift the risk of technology development to others, exploiting rapid obsolescence by acquiring technology and using it to develop products for existing markets at home and abroad. In this rapidly changing technological market place, emphasis would be on importing technology--not on technological self-sufficiency.

If technological change is slower, more emphasis can be placed on developing country capacity to create technology and apply it in making products for export and indigenous markets. In the context of a specific country, technology could be developed and applied to manufacture standard items more productively or to market them more cost effectively. New technology also could be used to capture the benefits of new product development domestically, although this is growing more difficult in today's technological market place.

C. Purposes in AID's Technology Acquisition Assistance: What is to be Achieved, for Whom and Why?

ISSUE: What principal purposes are to be achieved by AID's technology transfer efforts?

Most can agree that the objective of AID assistance in industrial technology transfer is to achieve increased productivity, growth and equity. At the purpose level, however, the aims of such assistance are less clear, perhaps even conflicting.

One purpose of AID assistance can be to help developing countries become more self-sufficient in technology development and application. This purpose may be aimed at helping developing countries protect their domestic markets from "high priced" foreign technology or to enable them to compete with export products in rapidly changing international markets. To build the capacity of these nations to acquire and use existing technology effectively can be another purpose; this is frequently geared to reducing inefficiencies that are apparent in certain industries. Or, AID can seek to advance the cause of and market for US industrial technology, whether as process or in the form of high technology products. In this same context, AID can seek to 1) increase equity between nations by helping less advanced developing countries do better vis-a-vis more advanced developing countries or 2) speed up the progress of more advanced developing countries in realizing benefits from international technology transfer. At another level, AID technology transfer assistance can be designed to assist small businesses or poor people in developing countries directly or to enhance the international competitiveness of well-advanced

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organizations in developing countries, thereby influencing the poor indirectly.

AID assistance also could be directed toward a structural change within a country (or among countries). Figure 2 shows a notional array of firm/organizational technology capabilities within a developing country (or among developing countries). The preponderance of existing firms are in Category 1. They are only able to buy and use high technology products such as capital goods encompassing new technology. Fewer firms are in Category 2--those which can buy and use technology in the form of processes in manufacturing, management and marketing. Still fewer firms are in Category 3. They can joint venture for R&D or otherwise develop and apply new technology in their national context. AID assistance could seek to shift more firms within a country or to shift countries from Category 1 to Categories 2 and 3.

Another purpose of AID assistance can be to facilitate the transfer of the "best" technology--that which meets criteria regarding safety, environmental impact, economic efficiency, etc. Still another purpose can be to transfer technology that will bring about specific development results or that will not create serious dislocations or wasted efforts. The latter could occur, for example, when processes are transferred that lead to products and effects not accepted by the marketplace or other social or political institutions.

D. Constraints, Problems and Opportunities: How Do They Influence Technology Acquisition?

ISSUE: What hinders or facilitates technology acquisition and what does this imply for AID policy and assistance?

Referring again to Figure 1, some of the elements within the R&D and technology transfer matrix will be **constraints** in both developed and developing countries. Other elements will be **problems** and still others will be **opportunities**. In part, AID's technology transfer programs should be aimed at reducing constraints, helping identify and solve problems and assisting in exploiting opportunities.

What are some of the **constraints** that inhibit R&D and technology transfer? Lack of sufficient skilled human resources is one. Inadequate institutional capacity--management, systems development, human resource depth, access to information, finance, technology or markets, etc.--is another. This lack of capacity may be evident for private firms, intermediaries and/or public sector firms involved in the technology acquisition process. An unsupportive network of standards, regulations and policies is sometimes a constraint. The tendency of suppliers to "bundle" all aspects of technology transfer together rather than to separate technical process, management, investment, marketing and information is frequently a constraint. Poor linkages between public sector and private sector institutions involved with technology development or transfer may inhibit the development or acquisition of technology. Lack of adequate foreign exchange may be a constraint.

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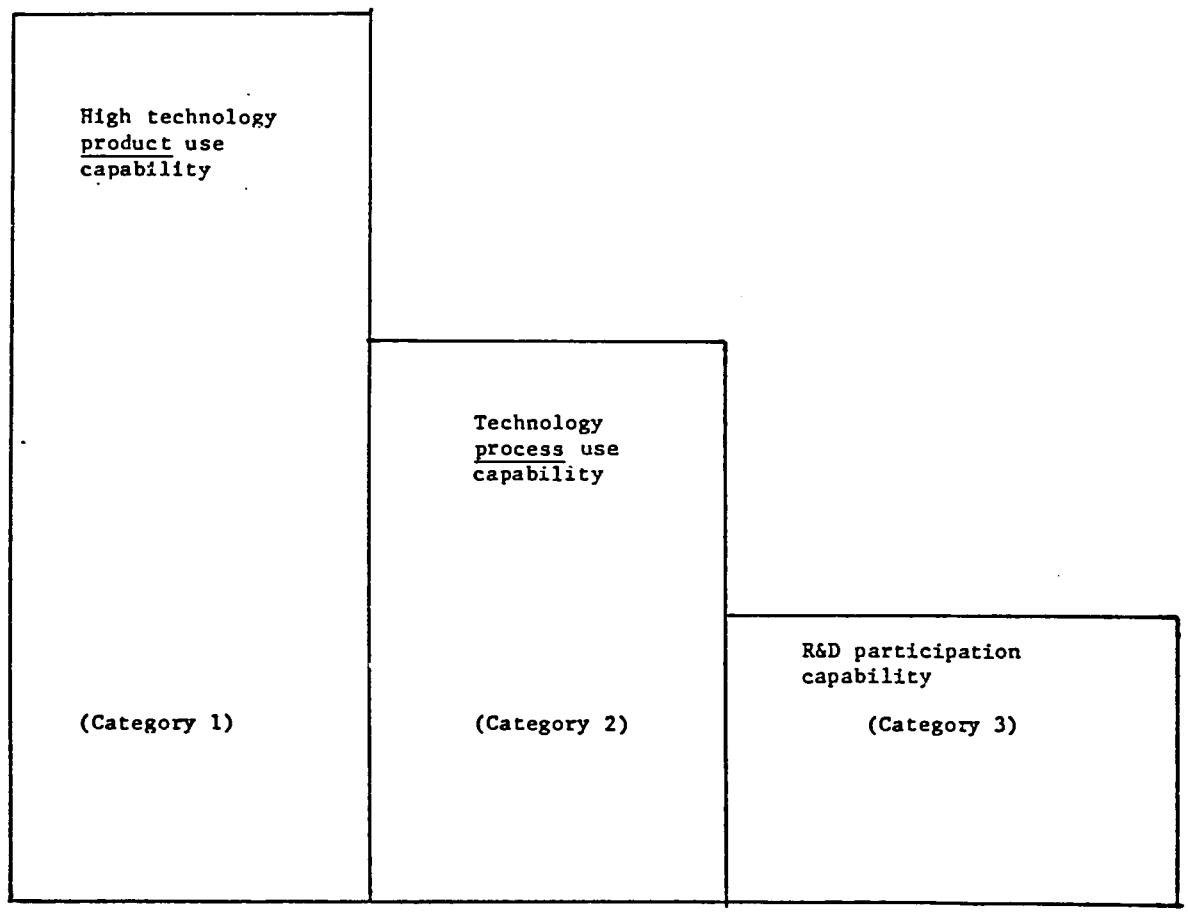

Figure 2: Illustrative distribution of types of technology development and transfer capabilities in developing countries

Problems also influence, and can drive, technology acquisition. A firm may experience a technical manufacturing problem which a new higher technology machine will enable it to resolve. Or, competing firms may have lower costs which a new technical process would enable a company to match. A country may lack markets for its products which, when located, lead to technology acquisition. A purchaser may require a different "coating" on a product which can only be obtained by technology transfer. More advanced imports into the market place may result in buyers demanding more reliable mechanical devices for which new instrumentation and training in how to use it must be obtained from abroad.

Opportunities usually exist in spite of constraints and problems, enabling some technology acquisition to occur regardless of specific AID or other special efforts to facilitate the process. These opportunities include market demand for new products, for old products with new characteristics or for existing products made or marketed with new systems. Bolstering the human resources in a firm may enable a company to take advantage of productivity increasing technologies, thereby lowering its cost and/or increasing its output vis-a-vis the competition. Changes in the availability of finance or in policies affecting intellectual property rights may open up new technology acquisition opportunities. Such opportunities may be able to be expanded upon and many others may arise if AID can effectively facilitate the technology acquisition process--principally by identifying and helping reduce existing key constraints.

E. Approaches to Effective Technology Acquisition Assistance: Marketplace, Management or Elements of Both?

ISSUE: What approach will be taken by AID in carrying out its technology acquisition assistance efforts?

One approach is to depend on market institutions--bolstered by supportive investment, trade, foreign exchange and other policies, access to information and human resource endowments--to determine the most rational use of technology in creating growth and equity in developing countries. This view holds the major factor in speeding and managing technological change to attain desired increases in productivity is that markets function well.

Another approach to AID's assistance effort is to "manage" the process of technological change. This view holds that appropriate roles should be assigned to public and private institutions; that some industries should be encouraged in a specific setting whereas others should not; that certain technologies fit better into national comparative advantage; that the dislocation brought about by technological change needs to be managed.

A blending of the market and managed approaches also is possible.

F. Mechanisms, Activities and Resource Flows: What Key Programmatic Efforts Can Maximize Success?

ISSUE: What AID programmatic efforts will maximize the transfer of technology to achieve agreed upon purposes?

Facilitating the transfer of technology can be attempted using different mechanisms. "How" AID should assist is therefore important. Mechanisms used include assisting in intermediary development; arranging for indigenous equity capital companies to be formed that also provide marketing, technical and management assistance in fostering technology acquisition; carrying out policy dialogue efforts aimed at supporting technology transfer; fostering training programs to enhance human resource skills important for technology acquisition; arranging for specific access to market and technological information; strengthening private sector R&D skills via joint ventures.

Some mechanisms have not been tried. AID has not used its resources to create a range of "development impact" entrepreneurial companies that would take equity positions, provide technical, management and marketing assistance and directly participate in the technology transfer process as both intermediary and participant. MNC's have not been approached programmatically to create linkages between their own activities and other private firms via subcontracting, licensing, etc. A global industrial technology access/information exchange has not been attempted.

Within existing and possible mechanisms, many AID activities could be undertaken to reduce constraints and facilitate technology transfer. These activities can aim at helping public sector entities, private sector firms, intermediaries, or others deal with specific constraints. Which activities are essential? Are these the same for all countries and circumstances? Which ones are not essential but still worth undertaking? Some of these potential AID activities are:

- Assisting in developing standards and specifications;
- Training;
- Provision of information/development of networks;
- Strengthening of institutional capacity--technical, managerial, financial;
- Creating access to finance;
- Fostering trade links--often the precursor to technology transfer;
- Improving policies that hinder technology transfer--trade, foreign exchange, patent protection, market control, etc.; and

- Analyzing the development impact of technology transfer--e.g. does it save capital or labor?

AID's contribution to the process of technology transfer is principally money, which can be directed at specific areas where AID has in-depth experience or the need is great (such as institution building). Private sector firms have technology and other private sector firms want it. The major requirement is for AID to program its money to facilitate this potential transfer. The level of resources needed depends on the relative importance of the impact of technology transfer vs. the development impact of other AID efforts. Also important is the ease or difficulty of achieving that impact in terms of resource requirements. The possibility of leveraging AID's public sector resources by tapping the dynamic of the private sector also influences the quantity of resources needed.

Finally, since technology transfer will not achieve the same results (have the same value) in all situations, the level of resources needed to facilitate it will also be governed by a AID's notional idea of the marginal value of its expenditures on the available range of technology transfer opportunities. AID may find, for example, that some of its programs result in lowering the R&D costs for developed country firms which then do not apply the technologies created in the developing country where the R&D occurred. Such results may be of such limited value that no further AID resources would be used to encourage them.

SCIENCE AND TECHNOLOGY STRATEGY FOR DEVELOPMENT
by
Marshall Bear

A. Technology Transfer in the Asia Near East Region

1. Introduction

"Technology is the new 'holy grail' of international economic competition."[1] Economic growth is no longer limited by a nation's factor endowments; indeed, a "technology endowment"--a nation's mastery of technical innovations in new products and processes--can be "created" to transcend the perceived limits to growth.

Technology mastery may become a crucial new element in development strategies. High technology industries--informatics, biotechnology, materials--are the cutting edge for competitiveness and trade performance in the global economy. These are industries that require global markets to achieve economic efficiencies; thus, they underscore the interdependence of all nations.

All nations--advanced and newly industrialized--face compelling and complex policy choices in setting a course to compete in this high stakes arena. Past strategies and programs for agricultural and industrial development may no longer be adequate to keep pace with rapid technological change. Should countries adopt policies to achieve indigenous technical mastery of sophisticated products and processes? Or, should countries pursue policies of selective indigenous technology development and acquire other technologies abroad? If the latter, which type should be developed at home? Which abroad?

Inextricably linked to policy choices are the strategies employed for industrial development. Are previous strategies for industrial growth pursued by Japan, Korea and Taiwan in the 1950's and 60's relevant to the changing nature of today's marketplace? Should countries adopt strategies of enhancing existing manufacturing strengths by technology acquisition leading to indigenous product and precess innovation? Or should countries adopt strategies that "leapfrog" to new stages in industrial development by designing whole systems through research and development?

The management of technology change requires governments to establish policies and programs that assign technology priorities, develop institutional linkages and incentives and clarify public and private sector roles and responsibilities. In most developing countries technology programs require some external assistance from

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Note: Marshall Bear is an Associate of Devres, Inc.

[1] National Policies for High Technology Industries: International Comparisons edited by Francis W. Rushing and Carole Ganz Brown, Westview Press, 1986.

bilateral multilateral donors. Thus, donors must also confront such questions in deciding how and when to provide assistance.

2. Why Now in the Asia/Near East Region?

The ANE region faces the challenges of technological change with past pride, great promise and great caution. Many countries in the region have experienced rapid economic growth because of their ability to efficiently apply productive technologies. But, economic growth has been accompanied in many countries by a wider and growing disparity between rich and poor, between resource abundance and scarcity and between access and opportunity. Technological change may hold the key to solutions in narrowing these gaps while still moving a nation further along the path of growth.

These compelling issues and circumstances introduce the context of AID bilateral assistance to the ANE region which follows a descriptive analysis of three selected ANE projects--PACT/India, S&T/Thailand and S&T/Egypt--designed to promote science and technology strategies for development. It is hoped that this analysis will offer some insight into how the Agency understands and embraces the emerging concept of "technology endowment" as a crucial element in development strategies. This analysis raises several important questions:

- What are some of the approaches taken and roles played by AID in support of host country technology development programs?
- What policy questions do these projects raise?
- Do they represent entry into a bold new policy frontier where past lessons offer little guidance?
- Do they provide a policy rationale for graduating middle income countries from AID support?
- Do they represent a means to promote US private sector initiatives at a time of dwindling public finance for development assistance?

The following paragraphs attempt to answer some of these questions.

B. AID-sponsored ANE Projects: Do they Respond to the Changing Context?

1. Clarifying the terms of reference

The ANE projects chosen for review refer frequently and sometimes interchangeably to the terms "science and technology" and "industrial technology acquisition." A clarification on how these terms are used is important to understanding both the projects themselves and this paper.

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"Science and technology" refers to a nation's technical resource base made up of policies, systems, institutions and people. The term refers to a nation's deliberately chosen course of action on how best to build and apply its technical resources to solve increasingly complex socio-economic problems. Setting a nation's S&T agenda is complex: it involves making difficult choices on the long term goals--between "broad based" and "strategic" technical self-reliance--and the short term strategies--between "indigenous technology innovation" and "acquisition and adaptation"--employed to achieve these goals.

Whereas "S&T" is a very broad concept and cuts across all sectors, the term "industrial technology acquisition" is more narrowly defined within the context of a nation's industrial sector. The term is used both to describe a product and a process. As product, the term refers to the acquisition--through direct purchase or learning--of non-indigenous technology, equipment and know-how to promote industrial development. As process, acquisition refers to one stage in a sequence of stages that comprise a process for industrial development (i.e. generation, acquisition, adaptation and application). The projects reviewed below use both terms in referring to industrial technology acquisition.

2. Projects Reviewed

The AID-supported projects reviewed in this paper--PACT/India, S&T/Thailand and S&T/Egypt--have been selected because they represent lead projects designed specifically by the respective AID missions to respond to a rapidly changing context for industrial development. The PACT/India project is the centerpiece of an emerging AID/India mission strategy to promote the indigenous development and application of advanced technologies for commercial application. PACT/India is expected to be joined by the Energy Research and Enterprise Project (ERE) designed to promote R&D joint ventures for new energy products and processes. A PACT-type project for the health industry is under review. A design team is currently in India to study the feasibility of establishing a "science city" concept within two Indian states. The "science city" concept would shift R&D activities from the state owned labs to the private sector with some form of state sponsorship, possibly tax holidays, grant finance and other incentives. Ohio's Thomas Edison Foundation has been studied as a possible model.

S&T/Thailand is designed as a comprehensive program to commercialize public sector research and development capability for private sector industrial development in advanced technologies (biotechnology, applied electronics and materials). The project provides the policy and program framework to link existing or future mission designed or centrally financed activities in advanced technology industrial development. This project is expected to complement other mission initiatives--in agricultural technology transfer and rural industries development--that work with different ministries.

S&T/Egypt, like the Thailand project, is designed for the purpose of redirecting public sector R&D capabilities in support of focused industrial (including advanced technology) applications. The project represents a third phase of AID/Egypt's interaction with the S&T community following two previous stages (1976-86) concerned with developing the Egyptian S&T infrastructure.

All three projects establish the policy and program framework that enable them to tap into centrally financed activities. Two Science and Technology Bureau projects appear most relevant.[2] The Market and Technology Access Project (MTAP) is an investment promotion project designed to promote joint business ventures--through licensing, trading, or manufacturing--for export oriented industries. The MTAP project hopes to demonstrate the key role (and commercial viability) of "intermediation"--a package of services beyond matchmaking to "dealmaking"--in brokering joint ventures. The choice of technology, industry or product is determined by the interested parties. Intermatrix, through its trade subsidiary, is the MTAP contractor for the Asia Region. Although no specific joint ventures have been finalized, Intermatrix has recently signed an agreement with the PACT/India project to undertake up to twenty (20) technology information searches. It has also been active in Thailand and Indonesia where its services are seen as complementing the missions private sector initiatives.

Appropriate Technology International (ATI), also centrally financed by the S&T Bureau, is relevant in this context as the purpose of its program is to promote the commercial application of appropriate technologies. In Thailand, ATI has supported projects designed to develop promising technologies (i.e., protein enriched cassava and rhizobium inoculant) for rural industries. It is also experimenting with "venture capital" mechanisms, managed by indigenous non-profit organizations, to promote joint ventures between local entrepreneurs and the local S&T community. Its Thailand and Indonesia programs have been pursued with mission concurrence; ATI is currently exploring an India program.

The three projects reviewed (PACT/India, S&T/Thailand and S&T/Egypt) share some common characteristics different from their predecessors in "S&T" or "private sector" or in "investment

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[2]A third centrally financial project--"Program in Science and Technology Cooperation" (PSTC)--is administered from the Office of the Science Advisor. This project seeks to finance new research ideas within six "research models": biotechnology/immunology, plant biotechnology, chemistry for World Food Needs, biomass resources and conversion technology, biological control, and diversity of biological resources. The project invites collaborative research between US and developing country scientists. A related research grants project--"Applying Science and Technology To Development" managed by NAS's BOSTID--is reserved for developing country institutions only.

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promotion."[3] Whereas many AID-supported projects integrated "S&T" as a "problem solving" component of a larger sectoral project, these projects view "S&T" as a cross-cutting sector of the economy whose unrealized potential, if properly directed, can have long term benefits for all sectors of the economy. These projects also reflect an impatience with the S&T community in not applying its expanded capacities to real problems. They are designed to pick-up where previous investments--in facilities and equipment, in participant training, in technical exchanges, conferences and workshops--left off. They are not as concerned with solving the problems in the S&T community but in applying its capacities in new ways, with new institutions and with new measures of performance.

Additionally, these projects are neither product nor industry specific; their primary rationale is aimed at improving the environment and systems--institutional linkages and incentives--needed to support and efficiently manage the course of technological change. They address, directly or indirectly, the formulation of industrial policy, a strategy for industrial development in technologically intensive industries, changed roles and responsibilities of and between the public and private sectors, and, of course, an effective role for USAID.

Finally, these projects are without "track" records--they are only now in their early stages of implementation or in the final stages of project negotiation with the host governments. Thus, at this point, there are few lessons learned from their implementation that can be applied elsewhere.

All three projects raise one fundamental question: Why do the abundant S&T resources of a country go underutilized in promoting industrial growth? By way of introduction, a thumbnail sketch of each is presented below.

a. Program for Advancement of Commercial Technology/India (3086-0496)

The project paper for this five year project was completed in August 1985. The amount of $11.1 million in grant funds was obligated in order to "accelerate the pace and quality of technology innovation for products and production processes in industry, agriculture, health, energy and other areas important to Indian development." A development finance institution, the Industrial Credit and Investment Corporation of India (ICICI), is selected to

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[3]Other related AN/E projects not featured in this paper include: PRE's Serum/India designed to transfer specified US vaccine technologies to Indian pharmaceutical manufacturers; and the BOSTID/Indonesian National Research Council project which features workshops and technical exchanges in biotechnology, renewable marine resources and science and technology management policy.

manage the PACT project. Policy guidance and promotion is provided by two councils, one in India and one in the US, set-up specifically for this project. The principal feature of the PACT project is a "venture capital" revolving fund managed by ICICI to promote and finance research and development joint ventures between Indian and US private sector firms. Selection criteria for project funding includes innovation in new products or processes, a $500,000 cap on costs, a three year turnaround time and the ability of the joint venture to take to the marketplace the development results.

b. Science and Technology for Development/Thailand (493-0340)

The project paper for this seven year project was completed in June 1985. An amount of $35 million was obligated in order to "assist the Thais in government and the private sector to reach newly industrialized country (NIC) status by expanding the contribution of S&T to the development process." A new sub-unit, the Science and Technology Development Board (STDB), was created within a state enterprise (Thailand Institute for Science and Technology Research), to manage this comprehensive project with the assistance of a long term technical contractor (National Academy of Science). The STDB is expected to succeed in promoting the commercial application of indigenous technological innovations in the areas of biotechnology, applied electronics and materials. Project resources will be used to finance research and development activities, to undertake policy studies and to establish industrial development service centers. Its design concept borrows from the Korean Institute of Science & Technology (KIST) model as the STDB will act as an intermediary between the public and private sectors without itself engaging in product development or commercial sale of technologies.

c. Science and Technology for Development/Egypt (263-0140)

The project paper for this eight year project was completed in July 1985 (and subsequently updated in mid-1986). An amount of $131.6 million was obligated in order to "enable the Egyptian S&T community to solve national development problems and constraints through applied research and technology in the fields of health, productivity and science and technology." This paper is concerned with one of the projects three components, "S&T Cooperation." This component is designed to promote a system for interdisciplinary and interorganizational user-oriented research and development for industrial and other sectors. AID funding for this component totals $36.6 million. Management responsibility rests with the National Science and Technology Committee (NSTC), a newly created steering committee. The project features two components: a grant program to finance research in advanced technologies and applied research to solve selected national and local development problems; and financing to decentralize the technical information services available from the Egyptian Academy of Scientific Research and Technology (ASRT).

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C. Comparative Descriptions of ANE Science and Technology Projects

1. Introduction

The thumbnail sketches on each project reveals some of the similarities and the differences between the projects. Differences in scope, scale and funding levels are obvious; what is less obvious are the ways the projects treat the issues of S&T policy and strategy for industrial development, the roles and relationships between public and private sector institutions, the program approaches taken by the projects and the choice of management structure in relationship to the program approach.

Descriptive analysis of these projects is presented in two ways: The contents of the project papers (as augmented by interviews with AID/Washington officials) are condensed for quick review in Table 1. The contents of this are further elaborated by a narrative analysis of the project designs. This presentation is intended to be descriptive; it extracts and summarizes the contents of the project papers. Judgments have not been made about the relative merits of the project designs or the potential of these designs to achieve their designated objectives.

The categories in the Table need some explaining. **Policy rationale** relates the project design to a perceived or desirable S&T policy of technology development; **Strategy** relates the project to a preferred choice on how best to manage the process of technological change; **Constraints** refers to the bottlenecks addressed by the project to implement the strategy; **Program approach** discusses the interrelationships and causal links between the major components of the AID project; **Management structure** describes the parties involved and their management responsibilities; and, finally, **Lesson learned** highlights the central theme for future project evaluation.

2. Analysis of project designs

a. Relationship between S&T policy and a strategy for industrial development

All three projects emphasize the correlation between S&T policy and the future course of a nation's industrial competitiveness. They assert that macroeconomic and investment policies should be formulated that enable the country to aggressively pursue mastery of sophisticated technologies. The policy rationale offered for the India and Thailand projects is couched in terms of the future competitiveness of their economies; it is implied that failure to adopt favorable policies will relegate the nation to non-competitive status in the global economy. The Egypt project policy rationale is stated in terms of redressing critical balance of payments deficits. All three countries possess the necessary human and institutional resource base upon which this policy rationale can be pursued.

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Table 1: Comparative Descriptions of Three ANE Science and Technology Projects

Project / Category	Pact/India 5 Years $11.1 Million	S&T/Thailand 7 Years $35 Million	S&T/Egypt 8 Years $36.6 Million
Policy Rationale	Indian industry will fail to keep pace with rapidly changing standards of global competitiveness unless it accelerates the pace and expands its capacity to manage the process of technological innovation in new products and processes.	Thailand's entry into the status of "newly industrialized country" could be seriously hampered unless steps are now taken to aggressively pursue a policy of technological self-reliance.	Limits to agricultural expansion underscore the importance of the industrial sector in helping to alleviate Egypt's balance of payments deficits.
Strategy	A shift away from the public sector to India's private sector to manage the process of technological change is vital to an industrial development strategy encouraging local technology development as well as acquisition of foreign technology.	Effective public and private sector collaboration in commercially useful research and development will inform policy makers on the optimum balance between technology generation and acquisition strategies for Thailand's industrial growth.	No statement of strategy is presented. However, it can be inferred that public sector research and academic bodies can re-orient their research priorities to meet the needs of the production sectors.
Constraints	Lack of risk-sharing financial mechanisms and a private sector R&D know-how to develop new products and processes will retard the pace of industrial modernization promoted by the liberalizing Indian policy and regulatory environment.	Lack of institutional and financial mechanisms is the key constraint to industrial modernization in a country with abundant trained human resources and a policy context favoring export-led growth.	Lack of coordination and cooperation between the many academic and research institutions is the key constraint in deploying the country's S&T resources to solve national and local problems.
Program Approach (Interrelationships)	Direct Indo/US firm-to-firm collaboration is promoted by a local financial intermediary using AID grant funds to subsidize the promotion and conduct of R&D joint ventures in new products and processes. Eligibility requirements include $500,000 cap on costs, maximum three year turnaround and joint venture firm capable of taking results to the marketplace.	Public sector intermediary provides subsidies to commercialize R&D services from public sector research and academic institutions. The combination of program elements—research grants/loans, policy studies, industrial support services—is expected to induce private sector demand for the services needed to modernize existing processes or to develop new products and processes.	Public sector coordinating body in consultation with AID manages a competitive research grants program designed to facilitate public sector collaboration on preselected areas for technology development, applied research and/or technology transfer. Public sector technical information services are decentralized and linked to US databases.

Table 1: Comparative Descriptions of Three ANE Science and Technology Projects

Project / Category	Pact/India 5 Years $11.1 Million	S&T/Thailand 7 Years $35 Million	S&T/Egypt 8 Years $36.6 Million
Program Approach (Causation)	The crucial link between technology development and its commercial application is demonstrated by involving the future actors of commercialization—finance institutions, business firms and government—at the earliest stages in product and process development.	New roles and critical links between key public sector and private industry are fostered to demonstrate the benefits that can result when: public sector R&D services are market driven; effective private sector demand exists for R&D services; and government offers a package of incentives for new product and process development.	Accommodating user needs in setting and carrying out research priorities will demonstrate the critical role academic and research institutions can play in solving socio-economic problems.
Management Structure	A new unit is set-up in an established development finance institution (ICICI) to manage the PACT project. Two business councils, in India and the US, provide policy guidance and promotion. An independent screening committee approves/rejects joint venture proposals assessed by ICICI. Due diligence assisted by outside technical resources including US National Bureau of Standards.	A new, sub-unit (STEB), set-up in an existing state enterprise (TISTR) is responsible for overall project management and decision making. Public/private sector board guides policy. Information and industrial service centers managed, on contract, by a private sector association of manufacturers.	Joint US/Egyptian team is responsible for project management. A newly created steering committee, the National Science and Technology Committee, advises on policy. The committee has a standing technical secretariat and an industrial/technical liaison service to disseminate research findings.
Lesson Learned	Can the R&D joint venture portfolio be operated on a commercially viable basis? Will Indian firms undertake riskier R&D efforts and diversify business activity away from safer protected markets? Are US firms willing to undertake R&D investments in India?	Can a public sector intermediary succeed in shifting the starting point for technology development from the source of the technology to its end-user? Will Thai private firms purchase the R&D services from public sectors institutions? Will they diversify into riskier ventures?	Can a coordination committee succeed in reorienting the research priorities of public sector institutions to meet the needs of the productive sector? Will a demand for services be established? Will new technologies be developed? Will existing know-how get applied?

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Devising an S&T strategy for industrial development requires matching or manipulating the elements that comprise the structure (the source and end users of technology) and the process or sequence by which S&T resources are applied. The Thailand project paper has a simplifying description of strategy formulation. The sources can be divided by those who generate new knowledge (universities, research labs), those that store knowledge (information banks), those who deliver or transmit knowledge (extension systems), those who provide technological services (testing, standards), and finally the end user. The sequence or process includes the stages of research (r), product development (d) and enterprise application (e).

The Thailand project paper also suggests two S&T strategic models. One model follows the traditional process of research and product development leading to commercial application. The starting point in this process places emphasis on the source of the technology (research institutions) with relatively little emphasis placed on the end-user. The term "technology push" is often used to describe this model. A second model--"demand pull"--shifts the order of the sequence and the emphasis on the actors. The process starts with the end-users' demands followed by technology acquisition and minor adaptation for enterprise-level application. Technological service enters early in the process where institutional research and development grows out of enterprise level demands for increasing technical content of products and processes.

A choice of S&T strategy is stated directly or is implied in each of the project designs. All three appear to subscribe to the "demand-pull" model by attempting to shift the starting point of the process from the source of the technology to the end-user. In the Thailand and Egypt projects this shift is expected to occur incrementally, through the services of a public sector intermediary. The PACT/India project starts the process with the end-user by promoting direct firm to firm collaboration. Priority is placed on indigenous research and development of new products and processes but with a strong emphasis on the "D," development. This emphasis indicates that these projects see technology acquisition as central to the strategy by shifting its locus from foreign to indigenously developed products/processes.

b. Choices on how best to manage the process of technological change

S&T strategy biased in favor of sophisticated technology development requires the country to make conscious choices on how best to manage this process. Here is where the three projects are quite different. The India project nominates the private sector for the role of managing technological change. Mechanisms and incentives are established to demonstrate the superior capacity of the Indian private sector to translate post bench research into commercial application. External partners--US high tech firms--are critical to this pattern of development. The logic of the project therefore suggests that the best

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role for government is establishing incentives and protections for private sector management of commercial R&D.

The **Thailand** project appears to "reserve" its decision on the preferred roles of the private and public sector in managing this process. The Thailand project does not intend to shift the focus of commercial R&D <u>from</u> the public <u>to</u> the private sector but instead it <u>promotes public/private sector collaboration</u> in R&D. The private sector is cast in the role of providing industrial services--technical/business information, diagnostic and technical advise--by demonstrating the financial viability of the Technical Information and Access Center (TIAC) and the Diagnostic Research and Development Service (DRDS). The project promotes collaboration between private US firms and Thailand's S&T community, but primarily for the purpose of making Thai service entities more attractive in the burgeoning market for technology and management services. The project appears to reserve two roles for the public sector: industrial policy formulation and setting in place a mechanism for the generation by consensus of industrial standards and specifications.

The Egypt project does not attempt to involve the private sector in the management of technological change. The public sector is dominant and will remain so. The project seeks management reforms by emphasizing much greater up-front involvement by the end-user (the production sector) in setting the agenda and undertaking R&D.

c. <u>Program approaches taken</u>

The institutional linkages favored by each project indicate how AID has interpreted its role in the process of the commercialization of R&D. Two distinct program approaches are at work in these projects. The **investment promotion approach**--which guides the PACT/India project--focuses on firm-to-firm collaboration by means of an intermediary. In concept, this project borrows much from AID's Market and Technology Access Project (MTAP) but goes somewhat further: Like MTAP, the project sets up an intermediary mechanism (the ICICI and its US and Indian business councils) to promote R&D joint ventures but further supports firm-to-firm collaboration by capitalizing a special account to co-finance joint ventures. (Ninety (90) percent of the project budget is for the special account.) Much of the project analysis centers on the potential for the commercial operation of the special account.

S&T institutional development is the approach favored by the Thailand and Egypt projects. Commercialization of R&D is seen as a necessary pre-condition for industrial development: thus, the projects aim to build public sector capacities to meet this need. The Thailand project sets-up a powerful centralized intermediary (the STDB) to "market" public sector capacities in commercial R&D by making these services "attractive" to Thailand's private sector. The "marketing strategy" features STDB's research grants program (60% of AID's project budget). Institutional specialization in technologies (centers of

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excellence) is promoted by designated research grants. Competitive research grants will be used to reorient institutions to focus on demand-driven R&D problems. The company-directed research will enable private firms to purchase R&D services from the public sector. The provision of industrial development services is the other element in the marketing strategy promoted by the Thailand project. Technical information and industrial diagnostic service entities are set-up to further promote links between local S&T research capacities and private industry.

While investment promotion is not a central theme of the Thailand project, investment links between US and Thai firms are possible. The project provides funds to sponsor technology transfer "events" (in Thailand or the US) between US firms which could result in US business activity in one form or another. However, the US/Thai links form part of the "marketing strategy" as they are likely to focus more on making Thai research bodies attractive to the Thai private sector.

Lack of information in the project paper does not permit a detailed review of the program approach of the Egypt project though it is conceived in a similar fashion as the Thailand project. (The project paper places more emphasis on the management structure than on the program approach.) A research grants program is the principal project element used to foster links between Egypt's academic and research bodies and the productive sectors (mainly the public sector). A technical information network established under another AID project, is decentralized and expanded to include direct access to on-line services of major US data base vendors.

While the program approaches differ, all three projects are <u>process</u> rather than <u>product</u> oriented. They are not bound by specific technologies, or industries; by specific products or by specific problems. The Thailand project identifies priority technology areas--bioscience/biotechnology, applied electronics and materials--but the range of new products and processes that can result is limitless. Egypt only provides an illustrative list of the types of technologies given preference (construction materials, plant biotechnology, wastewater systems). The India project makes no mention of priority technologies or products it will support; joint venture proposals are invited as long as the resulting products are relevant to India's development priorities.

The <u>products</u> of these projects are stated in terms of the effectiveness of the mechanisms they enhance, modify or create: Can the ICICI R&D joint venture portfolio be operated on a commercially viable basis? Can a public sector intermediary (STDB/Thailand) succeed in shifting the starting point for technology development from the source of the technology to its end-user? Can a coordinating committee succeed in reorienting the research priorities of public sector institutions to meet the needs of the productive sector?

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The two approaches taken by the AID projects imply two different perspectives on how best to manage the process of technological innovation for industrial development. At first glance, the projects appear similar in that they place priority on indigenous development of new products and processes. And, they both attempt to shift the locus of technology development from public sector institutions to the private sector firms. Where they are different--precisely in the assignment of public and private sector roles--points to two differing perspectives on the process of technological change.

The PACT/India project implies a perspective that might be labeled the marketplace perspective; the marketplace will lead the way in managing the process of technological change provided a supportive policy and regulatory environment exists (monetary, fiscal, investment, trade, custom) to permit private sector firms to develop, adapt, and acquire profit maximizing technologies. The market for technology--both products and services--will become more robust as local private firms enter the competition previously dominated by public sector facilities or external suppliers. Choices of technology, of industries and of specific products for export and domestic markets will be determined by the private sector based on market forces. The public sector role is to insure that the market works.

A second perspective--which might be labeled the S&T perspective--is implied in the Thailand and Egypt projects. This perspective suggests that the process of technological change should be managed by the interplay of institutions--marketplace, standards/specifications, consumer advocacy, environmental protection consultancy services--in the public and private sector. The Thailand project advocates this perspective by creating a public sector intermediary (STDB) as a centralized institution set-up to guide the process of technological change. Rather than allowing the market to be the sole arbiter of "equity vs. efficiency" in choice of technology for industrial development, this approach entrusts a centralized body--independent of proprietary interests--to guide the process through policy and program direction.

d. Project designs treatment of policy environment

As an input to project design, each project treats the policy and regulatory environment in different ways. PACT/India studied in detail the potential effects of the Indian regulatory environment (trade laws, patent rights, customs, market reservations, tax policy) on the market for R&D investments. The Thailand project notes a supportive macroeconomic policy environment for export-led growth. The Egypt project treats the issue of policy similarly. All three projects respond to the policy and regulatory environment indirectly. They create or strengthen private and public sector institutions or firms entrusted to adopt agendas and secure a louder voice in the policy arena. The Thailand project contains a policy dialogue component; however, the policy agenda to be addressed--whether S&T or macroeconomic--will be determined during project implementation.

e. Management structures employed

The management structures proposed relate directly to the program approach taken by each project. PACT/India, which uses an investment promotion approach, selected the ICICI, (an existing development finance institution) to manage the project. A new unit (the Technology Development Division) is established within the ICICI to implement the R&D joint venture program. New management systems--an independent screening committee, resource panels and two senior advisors (one based in India and one in the US)--are created to permit implementation of the experimental venture finance window without delays that might have been caused by integrating project management within existing systems. Two councils--one in India and one in the US--are set-up specifically to provide both policy guidance and promotion for the program. Thus, the link between project planning and implementation should be shortened by investing project management within an existing institution.

By contrast, the S&T/Thailand project, which takes an institutional development approach, calls for setting-up a whole new management structure to implement the program. A new-unit, the Science and Technology Development Board (STDB), is created within an existing state enterprise (TISTR) but endowed with special authorities and waivers to act on its multidimensional mandate. A public/private sector board, independent of TISTR, provides policy guidance for the STDB. This super-agency is in fact designed as a temporary mechanism to initiate the program; its future administrative and organizational structure is expected to change over time. The management structure chosen reflects a key assumption in this program approach: control and authority are necessary in order to change, enhance or create the desired institutional linkages and incentives. The causal link between project planning and project implementation will be a factor of the difficulty or ease in securing the management authority and control.

The management structure proposed in the S&T/Egypt project paper calls for a high powered, inter-institutional steering committee to be set-up. It would provide overall policy guidance for the project. Under its direction, a new secretariat is to be created to provide day-to-day management. Like the Thailand project, two points are similar--new agenda's require new structures; and new structures require lengthy up-front negotiations.

f. Designing for sustainability

The designs for the India and Thailand projects address the issue of sustainability. The central evaluation criteria for the PACT/India project is whether or not the R&D joint venture portfolio can be operated on a commercially viable basis. Financial and economic analysis explored the tension between the demonstration of venture finance as a higher risk investment option and the sustainability of the special account. The financial terms that would protect the special account against unreasonable risk of loss--such as conditional

loans at market rates of interest--would make the fund unattractive to prospective higher risk investors. The project design resolved this tension in favor of preserving its "venture finance" appeal by capitalizing the special account with grant instead of low interest loan funds. While this raises the issue of using grant finance to subsidize the investor it does promote the future sustainability of the special account.

Three elements of the Thailand S&T program were analyzed for their revenue generating ability to cover future operational costs. The two centers--Technical Information Access Center (TIAC) and the Diagnostic Research and Development Service (DRDS)--are expected to charge user and/or consultancy fees to generate an income. Fee structures will be set below market values to stimulate private sector use of these services. While cost-recovery analysis was done, the findings are notional outside any operating experience. The company-directed research grants program expects to generate revenues back to the STDB by providing funds on a "venture capital" type basis. AID funds will be used to enable the STDB to take up to a 25% equity share with royalties as a percentage of sales. What impact this will have on the future sustainability of the company directed research grants program is only notional.

3. Implementation status

Almost two years have passed since the project papers were written and the funds were obligated for these projects. What is their implementation status and are there some early lessons that can be reported here?

Of the three projects, only the PACT/India project is in the implementation stage. Following Government of India approval, agreements were signed between ICICI and USAID to initiate the project. The two joint councils, formed in 1986, have met twice (August 1986 and February 1987). Long term advisors have been appointed. Battelle Memorial Institute was selected to be ICICI's US partner. While no joint ventures have yet been approved, the high level of interest expressed by Indian firms before the project officially began has continued. So far, 30 joint venture proposals have been submitted for review by the joint councils. The councils have recommended to ICICI three joint venture proposals for financing. New proposals are expected to follow from a workshop on biotechnology hosted by Battelle at San Francisco in February 1987.

Implementation of the S&T/Thailand project has not yet gotten underway. The Science and Technology Development Board (STDB) has been created and staffed. The National Academy of Sciences has been selected by USAID/Thailand as the long term US contractor for the project. It is currently negotiating its contract with the STDB and other Thai Authorities. It is expected that the project will start implementation in mid-1987.

AID/Washington reports that the Egypt S&T project remains under design and it has not yet been formally presented to the government of Egypt.

AN ANALYTIC FRAMEWORK ON TECHNOLOGY ACQUISITION:
DESCRIPTIVE ANALYSIS AND IMPLICATIONS FOR AID PROGRAMS[1]

by

Allen G. Turner

I. INTRODUCTION

Technology transfer is one of the "four pillars" upon which AID's development efforts are based. Recently, a number of AID projects have been designed to enhance the acquisition of new technology--particularly industrial technologies--by developing countries. To date, however, AID has embraced no particular model to guide its development strategies for such projects. AID's Center for Development Information and Evaluation (PPC/CDIE) has developed a framework of technology transfer as part of its recent field studies of AID's experience with technology transfer. Although developed as an evaluation tool, the framework may be useful for assessing particular situations in which AID contemplates developing assistance programs or projects. The following discussion briefly describes the framework and the potential for applying it usefully in AID's industrial technology transfer activities.

Note: Allen G. Turner is an Associate of Devres, Inc.

[1]This paper is based on conversations with Peter Delp and others in AID and on drafts of portions of an AID evaluation special study currently in preparation entitled Technology Transfer and Marketing Systems--Synthesis of the Technology Series Studies by Peter Delp and Laurel Druben. Interpretations of this model, however, are the sole responsibility of the present author.

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II. DESCRIPTIVE ANALYSIS OF THE PPC/CDIE ANALYTIC FRAMEWORK

A. Overview

The CDIE framework is oriented to describing specific cases, where individual actors and specific technologies can be identified. It was originally designed to guide evaluations and not to predict the effects of specific interventions by AID or other public sector agencies. However, it does provide a systematic way to examine and express assumptions about the roles, functions, and linkages upon which technology transfer depends. The systems approach which it employs helps broaden one's horizons and permits a consideration of the entire range of factors affecting technology transfer. Most other models treat a much more limited number of factors--albeit often in more detail.

Four characteristics of the framework set it apart from other models which have been used to describe technology transfer:

- It focuses attention on the full range of key players, including the recipient as well as the source of new technology. In this range of players, there are generally multiple recipients, sources, and channels linking each;
- It relates the key players--including any intermediaries and end-users--to key environmental dimensions such as markets, the resource base, and government policies/regulations;
- It focuses on the process of transfer--the development of two-way communication flows and feedback between the sources of technologies and the recipients of the same; and
- It explicitly distinguishes between "hard" (product) technologies and "soft" (process or information) technologies.

The interplay of all of these factors is an ongoing dynamic. Each of the key aspects--the key players, the environment, and the process chains linking players to each other and to the environment are described below.

B. Two Basic Processes of Technology Acquisition and Use

1. The flow of technologies between sources and receivers

Successful technology transfer is an on-going two-way process, not a one-time transaction between a source and an end-user of a given technology. The essential elements of this process are the source of the technology, which is part of the system which generates the technology; the end-user of the technology, which is part of the receiving system; the flow of technologies and of feedback between

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these two; and any intermediaries which facilitate the flow and feedback. Thus, technology transfer can lead to:

- Growth and change in the recipient system which acquires the technology, adapts it to its own use, and benefits from it--either through direct consumption or through utilization in a productive enterprise; and to

- Change and adaptation in the source system. For industrial technologies, such changes generally reflect, directly or indirectly, market or user responses to given products or manufacturing processes.

The boundaries of, or barriers between, the source and recipient systems can be very diverse. Both the source and the recipient systems may be located within the same country, the same urban center, or the same economic sector, or each system may be located in distinct geographic regions or development sectors. This is a broader view of the technology transfer process than that often taken, i.e., that technology transfer generally takes place between developed and developing nations. The key actors in the technology transfer process include persons or institutions who help span the boundaries which constrain the process.

Technologies can be developed, acquired, and adapted in a number of "hard" or "soft" forms--product or material technologies, information or process technologies, and knowledge technologies. This, too, is a broader view of technology transfer than that often taken of limiting technology to the first of these--specific "hard" products or manufacturing processes. It takes into account "soft" technologies, which can include improved ways of managing industrial production at the firm level, improved techniques for marketing end-products, or basic research which informs both "hard" and "soft" applied technologies.

Various types of intermediaries can be involved in the dynamic interaction between source and recipient systems. In technology transfer involving large firms, most of the intermediary functions are carried out by actors within the firm. As discussed below, these intermediaries play a variety of linking roles in the forward flow of technologies to end-users and in the feedback process. Two crucial linkages which must be made are the linkage forward to the end market, which helps develop effective demand, and the linkage backward to the knowledge base, which ensures that technology is applied in ways that profit from the characteristic constraints and advantages of the recipient system, e.g., locally available raw materials and maintenance, repair, and operating requirements that are appropriate to local talent, infrastructure, and supply systems.

The technology flow aspect of the CDIE analytic framework is depicted as a horizontal set of relationships in Figure 1. It is important to recognize that this diagram does not represent a linear

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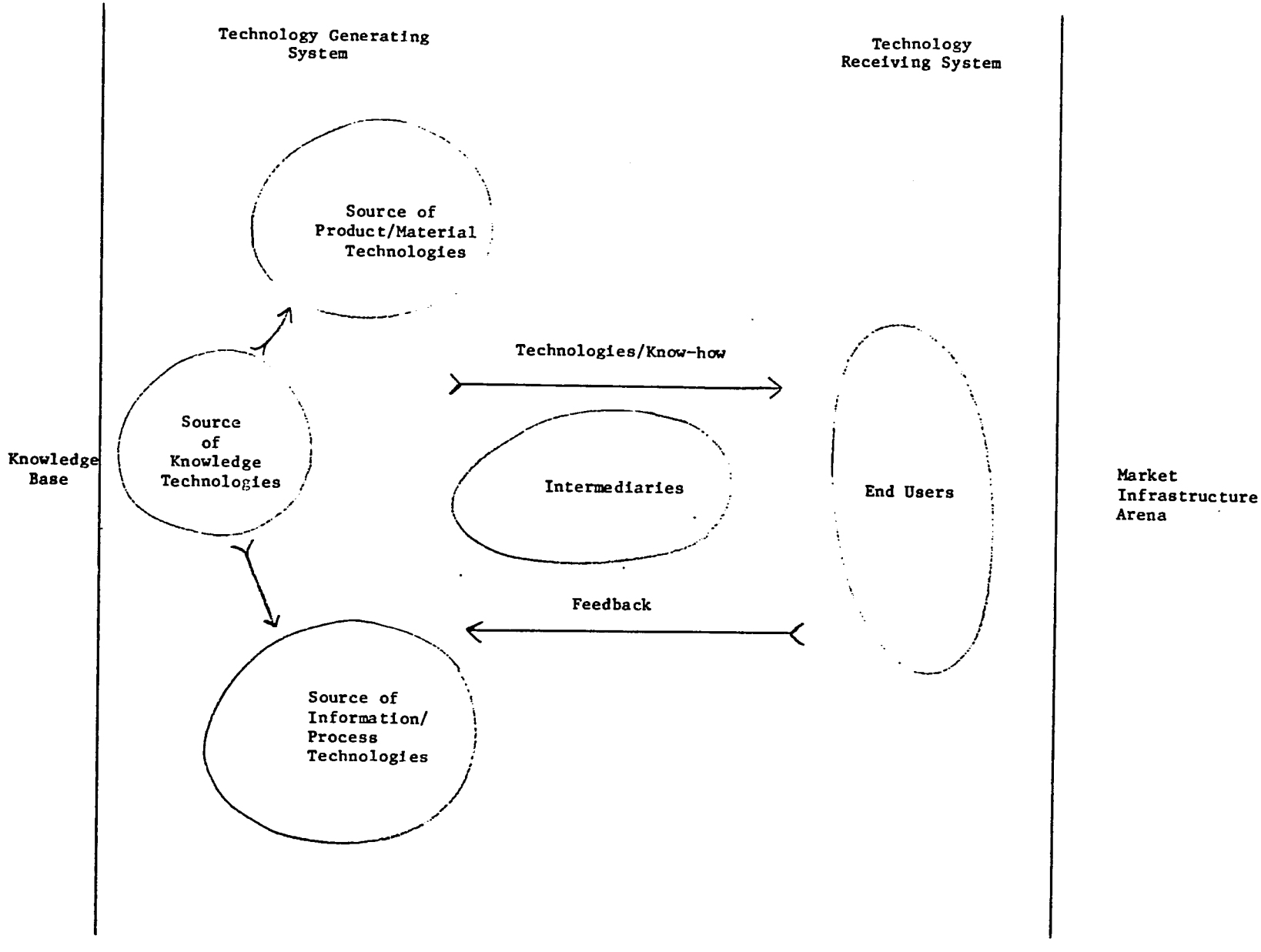

Figure 1: The Flow of Technologies Between Sources and Receivers

relationships; rather, it represents a dynamic process with on-going momentum.

2. How technology is applied: The flow of commodities from producer to end user

Improved technologies may be applied at a variety of points along the physical commodity flow from a commodity source or producer to an end-user. The intermediate set of processing and distribution activities affected may include assembly, processing, grading, storage, transport, and wholesale/retail operations, depending on the specific commodity system chain. Technology innovations at any one point in the system may depend on parallel innovations at other points in order for the overall system to prove commercially viable.

The commodity flow aspect of the CDIE analytic framework is depicted as a vertical set of relationships in Figure 2. Each stage of this vertical flow is related most closely to the market and infrastructure aspects of the immediate environment. Market links affect the source of commodities, the end-users, and all stages in between.

C. Environmental Dimensions of Technology Transfer

1. Introduction

A number of interacting environmental factors greatly affect technology acquisition and assimilation. The preceding section noted the significance of two of these--the base of available knowledge, given principal importance in traditional models of technology transfer, and the market arena, the importance of which has been more recently recognized . Two others are represented in the CDIE framework--the human, financial, and physical resource base and the political/regulatory arena (See Figure 3). The social-cultural context is not represented graphically but is also a very important environmental factor. In applying the framework, each of these environmental dimensions should be partitioned as appropriate in order to map specific linkages. Each dimension is discussed briefly below.

2. The market arena

The market arena provides the principle incentives for technology transfer. Technologies enable changes in recipient enterprises which make them more competitive in local, regional, or world markets. The market creates a great pressure for continuous transfer of technology to maintain the competitive advantage. The pressure for new technology can be related to demand characteristics, e.g., consumer preferences, or to supply factors, e.g., locally available raw materials. In the framework, the recipient system, including the commodity processing chain, is located along the border with the market arena. If desired, competing systems within a given industry can also be depicted along this border.

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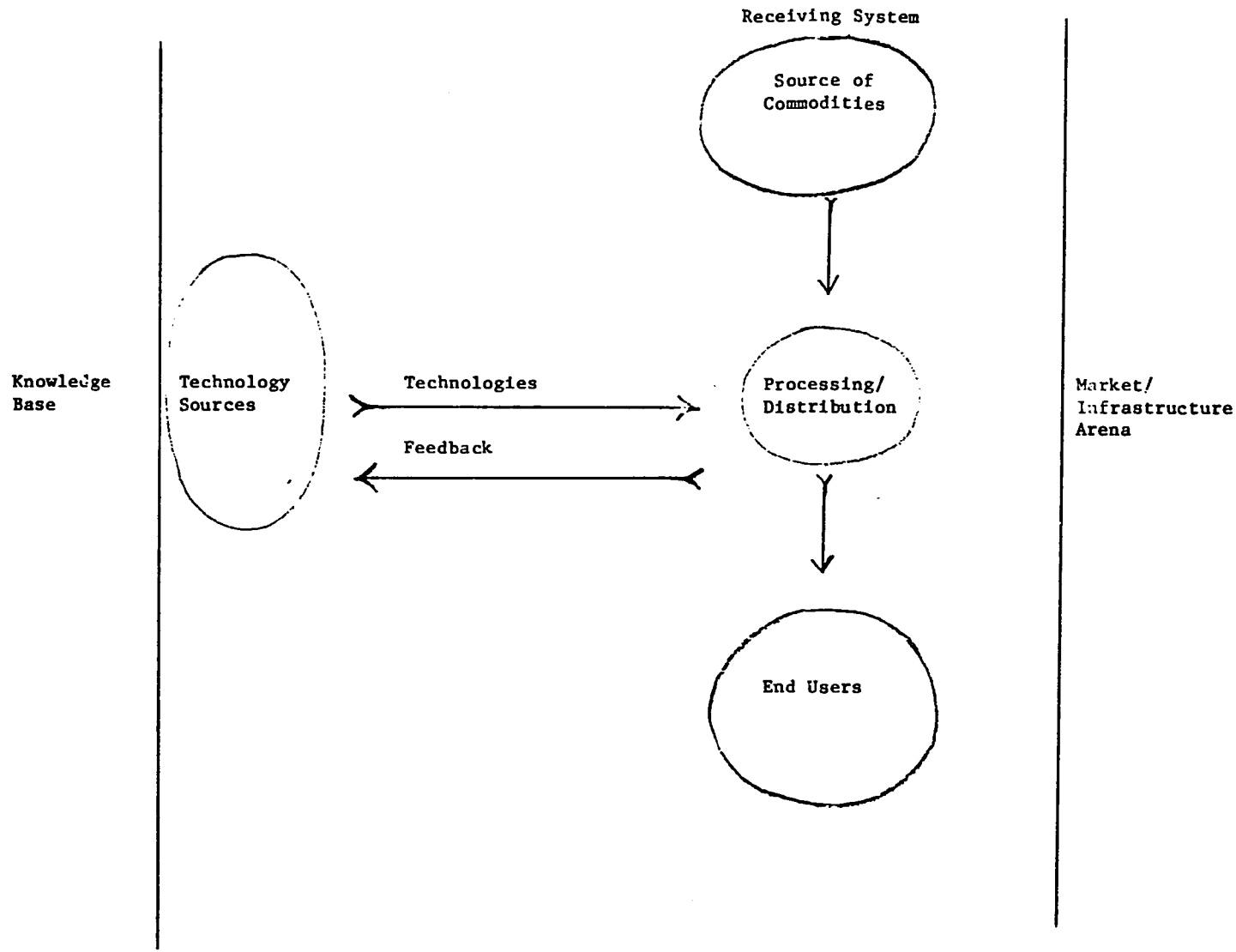

Figure 2: The Flow of Commodities from Producer to End User

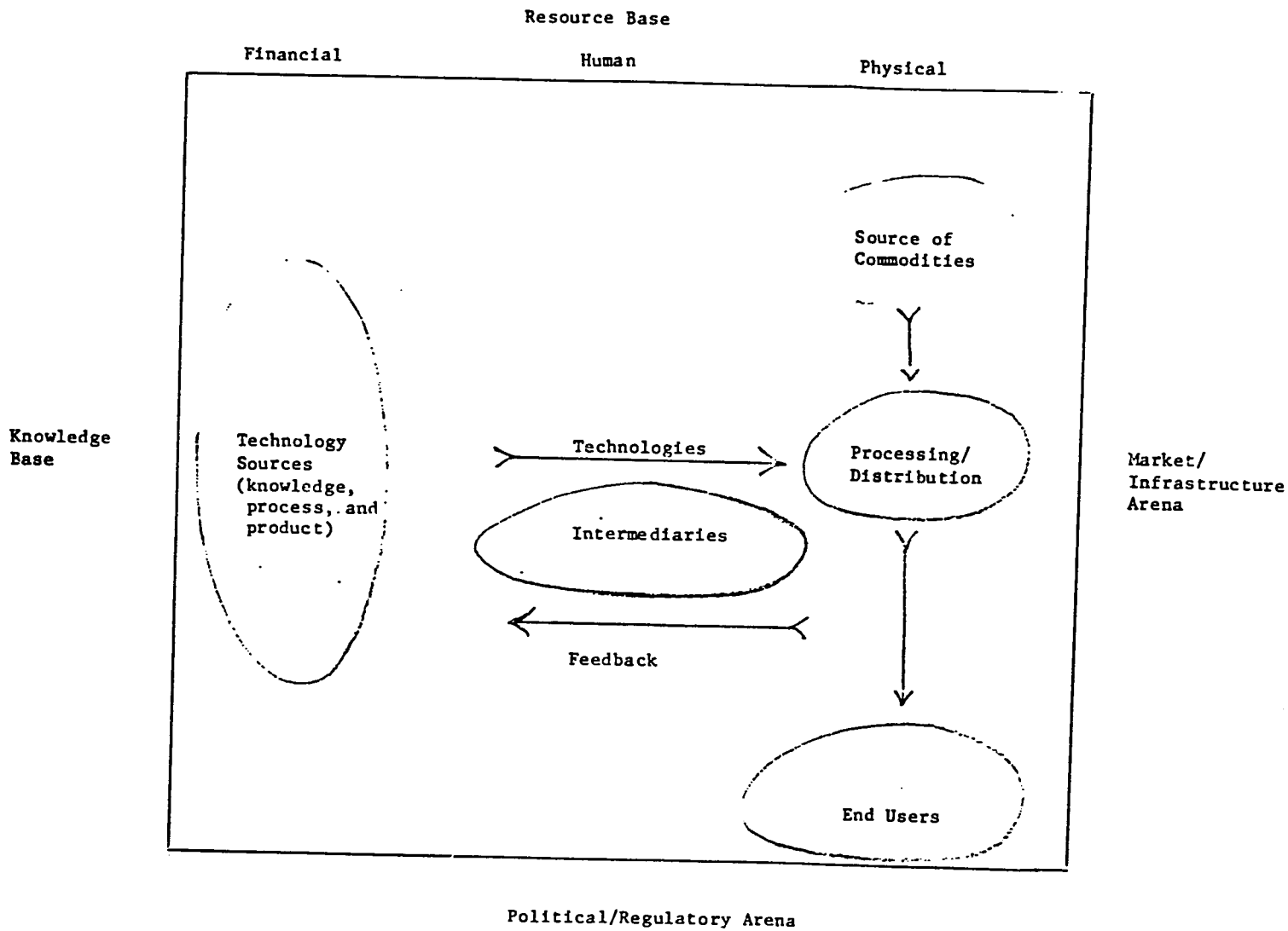

Figure 3: A System Representation of the Technology Transfer Process

3. The knowledge base

Technology is knowledge applied. Whether embodied in a material artifact or product, or in a process, procedure, or skill, technology draws from a base of accumulated knowledge--both modern scientific and traditional know-how. The former is more often what is sought in technology transfer, and is continually expanding. One approach to technology transfer in the past has been efforts to remove bottlenecks to the dissemination of scientific and technical information. A more recent approach, described in one of the companion papers, is to help develop technology generation capability within developing countries. In the framework, the source system is located along the knowledge base border.

4. The resource base

The resource base includes the financial, human, and physical (including natural) resources upon which productivity depends. The relationships of the technology and the key players to the particular resource endowments of the technology are critical to the technology transfer process. The resource base is shown at the top of the framework diagram.

5. The policy/regulatory arena

The policy/regulatory arena affects the technology transfer process both directly, through incentives or disincentives to sources or recipients of technology, and indirectly, through intervention in markets, control over resources, or even control over knowledge generation and dissemination. It is generally dominated by the public sector, but in certain cases, e.g., technology transfer by very large firms, it may be useful to consider the source of technology as a sub-unit of the large firm which is, however, affected by its policies and operating procedures. In other cases, certain powerful private sector players may control policy decisions which affect smaller recipient firms. The policy/regulatory arena is depicted at the bottom of the framework diagram.

6. Socio-cultural context

The larger socio-cultural context can greatly affect technology transfer and many environmental factors. As it is much more difficult to identify specific functional relationships between socio-cultural factors and the key technology transfer players, this dimension has not been shown as one of the sides of the framework. It might best be pictured as a circle embracing all of the other elements of the framework.

D. The Players

1. Introduction

It is generally agreed that human factors are the key to successful technology transfer. Formal and informal roles, face-to-face contact, and continuous, on-going relationships have all been shown to be important. It must be kept in mind, that although the diagram of the framework looks static, it represents this on-going dynamic process of linking relationships. In applying the framework, one should treat not only who the players are, what they do, and how they are linked to particular environmental dimensions; one should also observe how they go about making their decisions. In this regard, it is useful to think of them not just as players, but rather as stakeholders, each of whom faces different risks and different opportunities for reward.

2. Intermediary roles

Intermediaries serve to link technology receivers and end-users to sources of technology and to the larger environment. They help bridge gaps or boundaries between source and recipient systems and between these and the surrounding environment. Independent intermediaries are not essential to successful technology transfer, but the linking functions of intermediation are. In some cases, these functions are carried out by members of the source or recipient systems.

a. Technological gatekeepers and knowledge brokers

The technological gatekeeper plays a role within a given recipient institution. He picks up technological information from outside knowledge sources and translates it into a form which others within the organization are better able to understand and apply. A knowledge broker performs a similar function to the technology gatekeeper, but from outside the institution receiving the technology. Knowledge brokering can take two forms--that of the original technology acquisition and that required to adapt a technology to work effectively under local conditions.

b. Channel captains, traders and diffusion agents

Channel captains (a term borrowed from the literature on agricultural commodity systems) and traders are diffusion agents who help spread the use of technologies through for-profit market mechanisms. Typically this role is assumed by an individual who is able to dominate the commodity system chain or commodity distribution channels at some key point (e.g., transport, processing, or storage) and thus influences the adoption of technological, organizational, and financial innovations. The role of public sector diffusion agents is

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also tied to market considerations, even when the technology product is a free good.

c. Financial intermediaries

Financial intermediaries provide the financial resources--e.g., funds for capital investment, working capital, credit, and loan guarantees--which enable the technology transfer process to tap into human and physical resources, acquiring the technical assistance, management capabilities, and training needed to make effective use of new equipment, processes, or other physical resources.

d. Legal and political intermediaries

Legal and political intermediaries help technology recipients and other players work in the policy and regulatory environment which promotes or inhibits technology transfer processes. Often this role is tied closely to that of the financial intermediary.

e. Technology champions

A technology champion is typically someone closely associated with end-users of a technology product or service who plays a variety of roles depending on the nature of the bottlenecks or barriers. Unlike the technology gatekeeper, who translates knowledge into meaningful terms for the end-user, the technology champion often plays a more active role in feeding back the needs of the user to various environmental factors and ensuring that a variety of environment factors are in place to aid the technology transfer process.

3. End-users and beneficiaries

The recipients of technology are often located at more than one level. An improved technological process may be employed by a small recipient enterprise to manufacture an improved consumer good benefits a much larger number of end-users. In Thailand, for example, two different technological processes are being developed for the production of rhizobium inoculant for soybean and other legume production. Basic knowledge was transferred from such research centers as the Nitrogen-fixing Tropical Agricultural Legume project (NifTAL) to two Thai institutions (the first-level recipients). The inoculant is sold to farmers (the second-level recipients) who use it to improve their soybean yields. The soybeans, in turn, are sold to consumers (the final beneficiaries).

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III. APPLYING THE ANALYTIC FRAMEWORK IN DESIGNING INDUSTRIAL TECHNOLOGY TRANSFER PROGRAMS FOR AID

The analytic framework developed by PPC/CDIE provides a structure for defining problems related to the flow of technologies within a comprehensive set of environmental dimensions. The CDIE framework is a tool for "strategic" rather than "operational" or "tactical" management of technology transfer. As such it can be used by AID project managers to develop a set of pertinent questions about the choice of technologies and of key actors to be targeted by project activities.

With respect to technology, it provides a framework for structuring the answers to the following kinds of questions:

- What are the needs, problems, and opportunities and how are they related to each of the key players;
- What are the sources of technological know-how;
- What financial, physical, and human resources are needed and available; and
- How does the policy/regulatory environment affect the technology source and recipient systems?

With respect to actors, it can help direct questions to discover who has the needed skills or financial resources; who has access to what markets; and who is linked to other key aspects of the environment. The framework helps define the ways in which different actors relate to each other and to various aspects of the environment.

In applying the framework, one should begin by selecting <u>one</u> of the key actors, generally the intended immediate beneficiary of the project--often the entrepreneur or end user of the technology. One then identifies who that actor is (key characteristics about that population of actors), what that actor does (the key functions that that actor must carry out in order to be successful), and key linkages (what other players and what factors in each of the four environmental dimensions must that actor deal with or depend on). After these basic questions are answered, it is useful to discover how the target actors make decisions--what objectives do they have, what risks do they perceive, what resources do they think they need to achieve their objectives?

This approach should then be repeated with a second key actor and then a third, and so on until all existing and/or potential actors have been covered. The identification of each of these actors generally comes quite naturally from the inquiries surrounding the preceding first actor. In very complex, multi-player situations (which is generally the case) each of these actors and the key relationships for each should be mapped within the environmental dimensions on a one-by-one basis, giving a separate diagram for each. Following this, a

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comparison of the diagrams may well reveal missing, redundant, or directly competitive functions and/or roles. This will serve to identify directions for further study and potential project interventions. Finally, a diagram should be prepared showing all actors and linkages together.

Used in this way, the framework can enable development managers to better frame key questions and/or address key problems of technology transfer, e.g.:

- How will different interventions affect particular kinds of entrepreneurs or intermediaries in carrying out key functions?

- How will targeting different groups of entrepreneurs, technology sources, or intermediaries affect a given industry's or nation's competitiveness in world markets?

- How can the existing patterns of private sector industrial/trade activity be better built upon to utilize the existing skills/experience of target firms or intermediaries in the "relearning" process needed for acquiring new technologies?

- What has been left out? What key functions have not been addressed by a given project? What potential actors have been ignored?

The framework does not provide methodologies for in-depth analysis of each of the environmental dimensions or the characteristics of each of the actors. Detailed analysis of these requires applying well-developed tools from a variety of disciplines--manpower needs assessments, financing mechanisms, market survey and analysis, and others. The framework can, however, help define which studies are most critical and can relate the results of each study to the results of the others. Thus, it is not "just another layer" of analysis; rather, it can cut through different layers of analysis and make each more relevant to the others.

The framework is less useful as a tool for examining source, recipients, and intermediaries in the abstract. However, using it to analyze a set of specific cases can help one draw out generic patterns much more clearly than would be otherwise possible. Thus, it can be helpful in addressing some of the key global issues facing AID with respect to technology acquisition, adaptation, and assimilation. In particular, as noted above, the framework highlights a number of features of the technology transfer process that should inform AID as it develops a coherent global strategy for industrial technology transfer. Among other things, it:

- Focuses attention on the full range of <u>multiple</u> players and channels linking each;

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- Relates these key players to four key environmental dimensions;

- Focuses on the <u>two-way</u> process of transfer; and

- Distinguishes explicitly between "hard" (product) technologies and "soft" (process, information or knowledge) technologies.

Each of these characteristics deserves AID's attention in either developing a coherent strategy or identifying promising approaches.