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THE INTERNATIONAL TRANSFER AND ACQUISITION OF TECHNOLOGY

Final Report

DENVER RESEARCH INSTITUTE
UNIVERSITY OF DENVER

THE INTERNATIONAL TRANSFER AND ACQUISITION OF TECHNOLOGY

Final Report

Ronald P. Black
W. Murray Todd
Melinda Cain

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AND
ACQUISITION OF TECHNOLOGY

This report is contained in three separate volumes:

- Executive Summary
- Final Report
- Documentary Review

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PREFACE

In September 1982, the Denver Research Institute (DRI) entered into a contract with the U.S. Agency for International Development (AID) to examine the nonagricultural international technology transfer process. The project is designed to provide background data and analysis which will assist AID in the formulation of agency policy for technology transfer.

We have reviewed selected case studies, scholarly literature, commercial and industrial reports and writings, and reports and documents of the international development assistance community. In addition, and by AID request, we have formulated a set of hypotheses* about technology transfer which may have policy implications. This volume of the report consists of the hypotheses and provides supporting information. The last part of the report consists of our review of the literature and of current AID policy as it relates to technology transfer.

Throughout our study we have tried to retain a conscious awareness of the ever-changing and powerful forces influencing the nature of international commerce and the opportunities and constraints shaping U.S. global trade policies, for these forces inevitably will impose themselves on AID technology transfer activity.

We are very aware that technology transfer means many things to many people because the topic is so comprehensive. In the eyes of some, technology transfer is a process designed to achieve economic development and social justice in the form of equitable distribution of the world's goods. Others view it as a means to make a profit. In the broadest perspective, it is the extension of education to bring societies and economies into the mainstream of the industrialized twentieth century. We do not quarrel with any of these views, but we do ask the reader to suspend his or her personal affinity for any point of departure and bear with us as we try to present a snapshot of the landscape today.

Our experience leads us to the observation that ultimate responsibility for development-related technology transfer inevitably rests with the entrepreneurs and the officials responsible for a country's development. We see technology choice, acquisition, and diffusion as key elements of this process. The technology recipient is a dynamic force faced with classic problems in systems analysis and decision theory; there are options from which to choose, arrangements to be made, risks to take, and decisions to be made with too little information and in less than optimum time. From our review, it seems that this perspective has

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*In Webster's Seventh New Collegiate Dictionary, a hypothesis is defined as "a tentative assumption made in order to draw out and test its logical or empirical consequences."

not been fully explored in the technology transfer literature and documentation.

The technology transfer literature is also sparse in some fields of particular interest to AID. Primary health care, nutrition, fertility limitation, literacy and numeracy, vocational and technical training have not been viewed extensively from the perspective of their impact on technology transfer within societies nor from the standpoint of the impact of transferred technologies on the specific fields.

By the terms of the contract we have omitted discussion of agricultural technology transfer, although we do make some use of the findings of those who have studied this process.

We have purposely omitted several other types of technology transfer literature from our review. There is a vast body of material on technology transfer within the United States--much of which has been stimulated by the U.S. space program. This literature has been excluded as has military technology transfer literature, although in some developing countries induction of young men into military service may be their first introduction to the discipline of the machine and its maintenance.

Our objectives are:

- To formulate hypotheses with case support about the acquisition of technology in developing countries to assist AID's Bureau for Program and Policy Coordination (PPC) in the development of a technology transfer policy paper

- To provide the AID missions with insights into the technology acquisition process which will assist them in the design of institution building and private enterprise projects that involve the selection, adaptation and dissemination of technology

INTRODUCTION

What is Technology Transfer?

Jequier says: "The term 'technology' invariably suggests the idea of hardware. . . . Technology, however, goes much beyond the hardware, and also comprises what can be called, by analogy taken from the computer industry, the software. This includes such immaterial things as knowledge, know-how, experience, education and organizational forms."* If, as others have said, technology is "the application of human knowledge to the solution of practical problems,"** then it also encompasses research institutes, credit systems, and legal frameworks. It is within this broad perspective that we will examine the literature on technology transfer.

A useful definition is provided by a recent analysis by the Organization for Economic Cooperation and Development (OECD):

> Technology transfer differs from ordinary scientific information transfer in the fact that to be really transferred it must be embodied in an actual operation of some kind . . . transfer consists of the operation whereby knowledge is diffused.
>
> Whatever definition is used, the breadth and content of the technology transfer concept highlights the importance of its more qualitative aspects and the difficulties involved in attempting to quantify transfers.***

The Technology Transfer and Acquisition Process

"The technology transfer and acquisition process," while a cumbersome phrase, conveys the two principal perspectives from which the process may be viewed. The entity possessing a technology will view it as a transfer process. The entity desiring the technology will view it as an acquisition. These are the two principal actors in the process and both must perceive a benefit from it if it is to take place.

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*Nicolas Jequier, Appropriate Technology: Problems and Promises (Paris: OECD, 1976), p. 10-11.

**Fritjof Capra, The Turning Point: Science, Society, and the Rising Culture (New York: Simon and Schuster, 1982).

***OECD, North/South Technology Transfer: The Adjustments Ahead (Paris: 1981), pp. 18-19.

The two actors play their parts in a complex and dynamic environment which contains many entities with supporting roles--some hinder, some facilitate. This report is being prepared to assist AID in its preparation of a policy paper which will hopefully enhance the agency's role as a facilitator in the process.

A perspective of the process is illustrated in Figure 1, which emphasizes the key roles of the transferor and the acquirer. Either may take a predominant position in the process, possibly decreasing the significance of some of the activities of the other principal. A predominant role assumed by the transferor has been referred to as "technology push." "Technology pull" refers to the acquirer taking the dominant role.

The first thing that must occur is for the two principal parties to recognize that the other exists and that a mutually beneficial transaction may take place. There are ways that AID can facilitate this step.

Both parties must assess the costs and benefits of proceeding. A major concern of each in the feasibility studies will be the economics, with the acquirer having to pay special attention to the needs or market to be served with the technology. However, as we emphasize later, the process is a systems process and a lack of consideration or assessment of any of the critical elements can lead to problems. Again, AID can facilitate during this stage and has in the past conducted or arranged for some of the needed feasibility studies.

Favorable assessments will lead to negotiations, often accompanied by simultaneous assessments by each party of alternative courses of action. During the negotiations, there must be a detailed formulation of the transfer and acquisition process and the responsibilities and obligations of each party. In the past, AID has participated during this phase when public technologies were being acquired but rarely in commercial technology transactions. This may change with AID's new emphasis on the private sector. Indeed, we are aware of one AID project, in the conceptualization stage, which envisions funding organizations to facilitate firm to firm technology transactions, including the potential of facilitating negotiations.

An agreement to move forward on a venture will lead to the parties organizing their resources for the transfer or acquisition. This could be a major effort or trivial, depending on what is involved in the transfer.

The transfer and acquisition itself may take many forms, including turnkey operations, co-production, licensing arrangements, and training programs. In the past, AID has primarily been concerned with public sector technology acquisitions during this stage.

In the final stage, as shown in the illustration, the acquirer will begin to benefit from its new technology. Often this will be

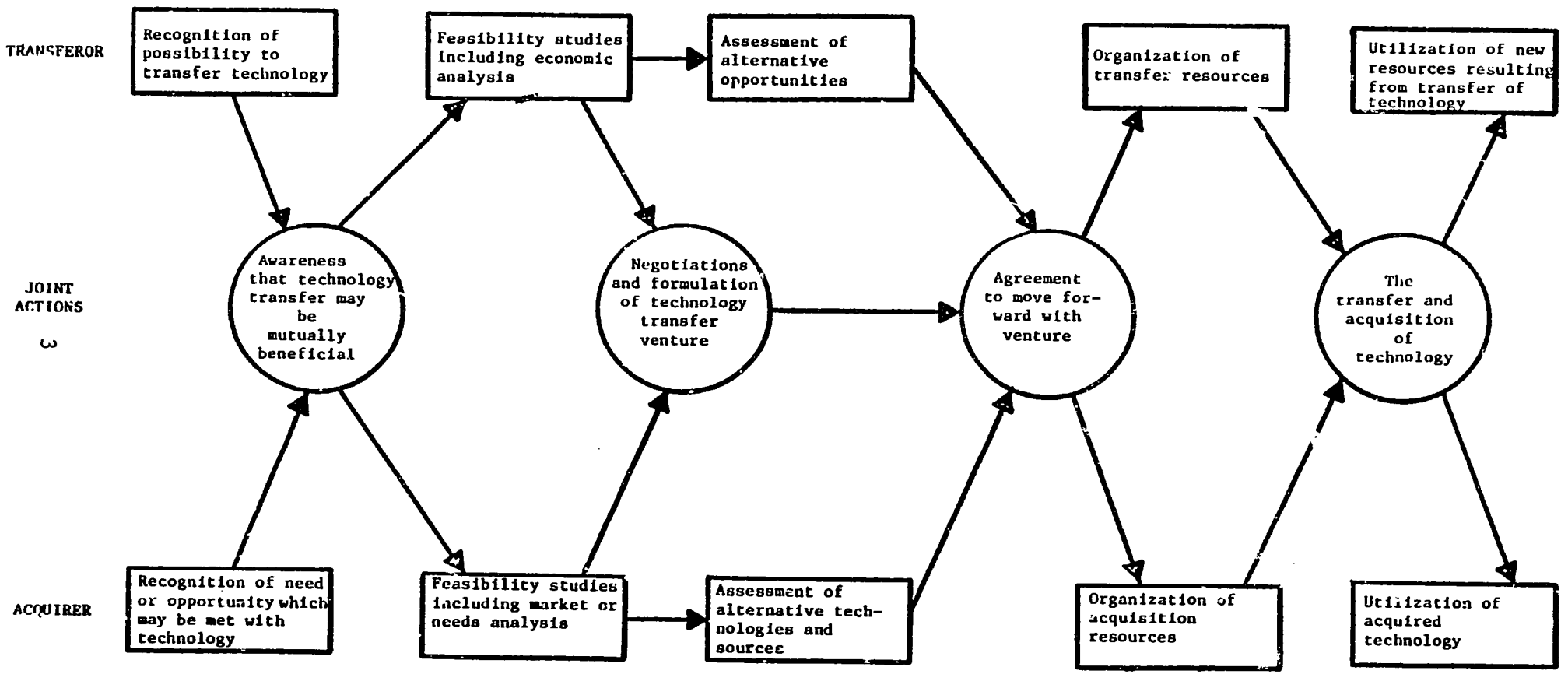

FIGURE 1. THE TECHNOLOGY TRANSFER AND ACQUISITION PROCESS

accompanied by adaptation of the technology. AID could facilitate this. Also, during this stage, the transferor will begin to reap the rewards and use its new resources, resulting from the transfer. Both parties have hopefully reached the goals that led one to transfer and the other to acquire the technology.

The Importance of Technology Transfer in Development

A U.S. background paper for the 1979 U.N. Conference on Science and Technology for Development noted:

> Development is concerned with two important goals: (1) eradication of extreme poverty by satisfying the most basic needs for food, shelter, health, employment and education; and (2) modernization and growth of national output both for domestic consumption and to earn income through export.*

Technology is critical to achieving both of these goals. No developing economy can wait until its people create the knowledge and the technologies required for modern life when much of this already exists in and is available from other countries. The logical approach to development is to acquire technologies from existing sources. The questions of which technologies to acquire, how to master and control them, how to adapt them to the specific resources and environment of a given country, and how to build upon them, become the central issues. While the history of development over the last several decades can be drawn upon to illustrate just about any point one wants to make about technological change, there is almost total agreement that for a nation to thrive in today's world, it must have the capacity to increase its technological sophistication rapidly.

The Technology Transfer Hypotheses

The hypotheses described in the next section are partially based on the literature review conducted earlier in this study. Also, a decade and a half of institutional experience in providing assistance to less-developed country (LDC) organizations in acquiring technology has provided an accumulation of thoughts on the process, and these were tapped on occasion.

We believe these hypotheses to hold a degree of general validity. However, in dealing with technology acquisition, one is concerned with

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*National Research Council, U.S. Science and Technology for Development: A Contribution to the 1979 U.N. Conference; a background study on suggested U.S. initiatives for the U.N. Conference on Science and Technology for Development, Vienna, 1979, p. 3.

human behavior, and in such situations there will always be exceptions. In the presentation of the hypotheses we have by and large put forth information to enhance the plausibility of the hypotheses. We have no doubt, however, that given sufficient resources and time we could find case examples which would run contrary to the evidence presented here.

Our purpose is not to "prove" the technology acquisition hypotheses as we do not believe that such hypotheses can be proven. Rather we do try to provide AID some generalizations that are logically supportable and which have policy or operational relevance for AID.

ANALYSIS OF TECHNOLOGY TRANSFER CASES

The premise for this study was that policy relevant hypotheses concerning the technology transfer process could be generated and then examined in the light of case experiences. We did not always find this to be the situation. The case literature of developing coun ry technology acquisitions is smaller than we had anticipated. And often when it exists, it does not reach down to the personal level--a level at which some of our hypotheses occur. We therefore have supplemented case experience with views and conglomerate data presented in the literature.

The Impact of National Policies

AID has committed itself to helping strengthen the industrial sector of developing countries. As one of AID's four strategic emphases is economic policy reform, LDC policy, as it affects the transfer of industrial technology, is an appropriate area within which to consider and examine a hypothesis.

Two policy orientations for promoting industrialization and for dealing with international transfers of technology have been described. Ranis has called these catalytic and interventionist.* Catalytic policies are export oriented with little intervention in foreign exchange rates and equal access to credit being provided at a uniform rate. There is little interference in negotiations between local and foreign firms in technology transfer transactions. By contrast, countries using interventionist policies promote import substitution by providing the "encouraged" companies access to cheap foreign exchange and protection from outside competition. These countries attempt to assist their firms in technology transfer transactions with foreign corporations by setting detailed rules and regulations as to what may and what may not be included in these international transfer agreements.**

Our first hypothesis is that *countries having catalytic policies will be more successful in (1) bringing about industrial and economic development, (2) acquiring technologies appropriate to the nation's*

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*Gustav Ranis, "Technology Choice and the Distribution of Income," The Annals: Technology Transfer: New Issues, New Analysis, special editors Alan W. Heston and Howard Pack (Beverly Hills, Sage Publications, November 1981), p. 52.

**These can be considered polar positions. Most countries employ some mix of catalytic and interventionist policies, and within countries emphasis may change with political shifts in government.

*factor endowment, (3) achieving an equitable income distribution, and (4) developing a "world class" group of of entrepreneurs.**

While most countries employ a combination of catalytic and interventionist policies, the Andean Common Market (ANCOM) countries are as purely interventionist as any, and Taiwan and Korea are perhaps the two countries which are most representative of the catalytic approach. The difference in development performance between these two groups of countries has been quite significant. Table 1 shows for these countries the average annual industry growth rates, the average annual growth in GNP per capita, and the percentage of household income held by the 20 percent of the population with the highest incomes.**

Even within the Andean countries there has been major disagreement over the extent to which the countries should interfere in negotiations between local and foreign firms in technology transfer transactions. Chile has had the widest swings in its support for interventionist policies. Peru reduced its support in the mid-1970s while at the same time Venezuela moved to a hard-line interventionist position. From the outset Ecuador and Bolivia have been less supportive of the Common Market's interventionist provisions.*** Ecuador's development has been further assisted by its petroleum resources.

In reviewing ANCOM's poor performance in attracting foreign investment during the 1970s, E.M. Graham noted: ". . . it is likely that future economic historians will see the implementation of [ANCOM's interventionist policies] as an action that was, for that region at that time, fundamentally unsound from an economic point of view."****

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*This is consistent with a view expressed in AID's agency-wide policy paper on "Private Enterprise Development." The paper notes: ". . . much of the poor performance of many low-income countries can be attributed to policies that have inhibited incentives to use markets (e.g., through price distortions, restrictive controls on private enterprise, unsound fiscal and monetary policies, and ineffective provision of public services)."

**As there are many differences in the two groups of countries beyond their policies that could affect their development performance, the numbers in Table 1 are presented not as proof of, but rather as evidence consistent with, our hypothesis.

***E.M. Graham, "The Terms of Transfer of Technology to the Developing Nations: A Survey of the Major Issues," North/South Technology Transfer: The Adjustments Ahead (Paris: OECD, 1982), pp. 69-70.

****Ibid., p. 71.

TABLE 1. PERFORMANCE INDICATORS FOR HYPOTHESIS ONE

Country	Average Annual Industry Growth Rates (1960-1980)	Average Annual Growth in GNP per Capita (1960-1980)	Percentage of Household Income Held by 20 Percent with Highest Incomes
Bolivia	4.3	2.1	--
Chile	0.2	1.6	51.4 in 1968
Colombia	4.9	3.0	--
Ecuador	12.1	4.5	--
Peru	3.7	1.1	61.0 in 1972
Venezuela	2.7	2.6	54.0 in 1970
Korea	15.4	7.0	45.3 in 1976
Taiwan*	12.9	6.6	39.2 in 1971

*Data for Taiwan is from World Development Report 1980, and the averages cover the period 1960-1978.

Source: World Development Report 1982 (Washington: The World Bank, 1982).

From the point of view of their market size, the ANCOM countries and Korea and Taiwan do not have the bargaining power of the larger countries such as Brazil and India, nor are they as fortunately endowed as the richer OPEC countries. These latter countries may be better positioned to use interventionist policies to their advantage. For example, while Brazil has been among the most aggressive in seeking technology and very pragmatic in its dealings with foreign suppliers of technology, it also intervenes in technology transfers when it is deemed to be in the national interest.

Jack Baranson and Harald B. Malmgren relate the case of how Brazil developed an indigenous, integrated aircraft industry.* In 1974, the largest export market for U.S. light aircraft manufacturers was Brazil, and 60 percent of this market was held by Cessna Aircraft. At that time the Brazilian government gave an ultimatum to the country's suppliers of general aviation aircraft: ". . . continued participation in the Brazilian market . . . was made contingent upon a firm's willingness to take on a Brazilian partner and begin a light aircraft production program in Brazil."

While Cessna had an advantage due to its market position, it was Piper which was more prepared to accommodate to the Brazilian government's conditions. Under a five-year Piper-Empresa Brasileria do Aeronautics, S.A. (EMBRAER) agreement, the desired technology was acquired by EMBRAER. In 1975, the tax on imported small aircraft was increased from 7 to 50 percent. Cessna's sales in the Brazilian market fell from over 400 in 1973 to five in 1976.

Baranson and Malmgren conclude:

> At the time of the negotiation, Brazil stated that its primary goal in developing a domestic aircraft industry was to achieve foreign exchange savings by reducing aircraft imports. Yet, as subsequent events have proven, Brazilian authorities were equally concerned with three other objectives: (1) to take advantage of the significant multiplier effect which the development of a domestic aircraft industry can have on an economy's overall technological development (some 40 to 45 percent of the cost of an aircraft is represented in parts purchased from supplier industries); (2) to move progressively up the ladder of technological sophistication; and (3) to acquire internationally competitive technology for its export potential. (EMBRAER is now successfully marketing an internally developed and produced small transport aircraft, the Bandeirante, around the world, including to U.S. feeder airlines.)

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*Jack Baranson and Harald B. Malmgren, Technology and Trade Policy: Issues and an Agenda for Action (Washington: Developing World Industry and Technology, Inc., and Malmgren, Inc., under contract for U.S. Department of Labor, 1981), pp. 121-123.

Although Brazil was successful in using the size of its market as a bargaining tool to acquire aircraft technology on its own terms, most LDCs do not have the luxury of this option. Even a large market may be an insufficient inducement to a private company to release control of its technology. When India rescinded IBM's right to own 100 percent of the equity in a local subsidiary, the company withdrew from India.*

Also, some Brazilian interventions may not have worked as the government wished. John H. Sanders and Vernon W. Ruttan have analyzed the effects on technical change of overvalued exchange rates and subsidies to mechanization in Brazilian agriculture.

> They conclude that the distortion in factor prices that resulted from these policies has affected both the choice of available technology and the direction of technical change. The consequences have included more rapid mechanization and less rapid growth in the demand for labor in rural areas than would have occurred in the absence of governmental manipulation. The primary beneficiaries of these policies appear to be the larger farmers of the South. An additional effect has been the widening of income disparities among regions.**

As a result of an examination of Latin American and East Asian cases, Gustav Ranis makes the following observations:

> When control over scarce inputs such as foreign exchange, credit, and so on, diminishes, as it does when a country moves from import substitution toward export orientation, it is much easier to avoid discrimination against rural, medium- and small-scale enterprises that, in combination with the existence of rural infrastructure, permit poorer farm families to augment their income from agriculture with increasingly important income from rural nonagricultural service and industrial activities.***
>
> If a government has somehow decided to shift to a relatively catalytic rather than a directly interventionist or dirigiste role, this materially improves the chances that millions of dispersed decision makers in both sectors of the economy will be motivated to search for more appropriate technological choices.****

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*E.M. Graham, op. cit., p. 81.

**Hans P. Binswanger, Vernon W. Ruttan, et al. Induced Innovation: Technology, Institutions, and Development (Baltimore: The Johns Hopkins University Press, 1978), p. 8.

***Gustav Ranis, op. cit., p. 50.

****Ibid., p. 52.

The shift from an import substitution to an export promotional stance not only brings in additional foreign exchange to fuel development, it provides the nation's entrepreneurs the competition they need to further develop their skills. Carl J. Dahlman and Larry E. Westphal, after analyzing a number of Korean export activities, concluded:

> As a result of exporting, Korean firms have enjoyed virtually costless access to a tremendous range of information, diffused to them in various ways by the buyers of their exports. The resulting minor technological changes have significantly increased production efficiency, changed product designs, upgraded quality, and improved management practices. Exporting thus appears to have offered a direct means of improving productivity, in addition to the indirect stimulus derived from trying to maintain and increase penetration in overseas markets. The Korean experience also suggests that this beneficial externality of export activity may partly explain why countries following an export-led strategy have experienced such remarkable success in their industrialization efforts.*

In summary, we found case evidence for small countries that lent support to the hypothesis, stated earlier in this section, that a catalytic policy would be more successful than an interventionist one in (1) bringing about industrial and economic development, (2) acquiring technologies more appropriate to the nation's factor endowment, (3) achieving an equitable income distribution, and (4) developing a "world class" group of entrepreneurs.** The evidence supporting the hypothesis as applied to a country with a large national market, such as Brazil, was less conclusive. The use of a major resource--a large market, or oil--in conjunction with an interventionist policy may on a selective basis speed up industrialization as well as increase the benefits accruing to a country from technology transfer. Such interventions, however, are unlikely to stimulate the overall growth and prosperity of international trade.

The Acquisition Process

Originally we believed that much of policy significance could be learned by examining specific developing country technology acquisitions.

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*Carl J. Dahlman and Larry E. Westphal, "The Meaning of Technological Mastery in Relation to Transfer of Technology," The Annals: Technology Transfer, op. cit., p. 24.

**Some have argued that entrepreneurs in countries on the "bottom rung of the development ladder" need a period to develop their capabilities prior to being subjected to international competition. This assertion was not tested by experiences examined in this section.

Our premise that the ultimate responsiblity for such acquisitions must rest with the entrepreneurs and officials responsible for their own and the country's development led us to formulate the following hypotheses:

- *In international transfers of technology, the ability of the parties to establish good interpersonal relations is often as important as their technical expertise.*

- *Technology acquisitions involve uncertainties and often have significant barriers to overcome before they reach fruition. To shepherd a venture through this process often requires someone with a strong belief in the venture's ultimate success--a "technology champion" willing to push ahead in the face of resistance.*

- *In the public sector, interest groups assume an important role in supporting and in resisting acquisitions of technology.*

- *Developing country entrepreneurs seldom make a thorough search for the optimum technology from the perspective of a technology's maximum profitability based on the country's factor endowments because of (1) the complexity of and uncertainties associated with the process of commercial technology acquisition in LDCs, (2) technological optimization being only one of many ways to increase a venture's profitability, (3) the lack of technological choice if a venture is to proceed at all, (4) the pressures resulting from shortages of time and funds, (5) the costs associated with international searches for technology as well as a lack of knowledge as to how to conduct such a search, and (6) the desire to move swiftly to counter perceived threats from competitors and to existing arrangements.*

- *Many developing country technology acquisitions founder as a result of a lack of management skills.*

Each of these hypotheses seemed in accord with our own experiences with and observations of developing country technology acquisitions. When we started looking for case studies of specific technology acquisitions, including the perspectives of the developing country entrepreneurs, we were surprised at the sparseness of the literature. Documentary evidence that we could find follows.

Interpersonal Relations

In 1978, a U.S. university team visited an Asian country to pilot test a new management tool--a computer model for resource allocations. It was hoped that the model would subsequently be used by a planning bureau in one of the ministries. The professor leading the U.S. team was eminent.

Within the planning bureau there was a senior planner who had been developing a planning information system. In a meeting of senior

ministerial personnel, including the senior planner, and AID officials, the U.S. team leader described why the indigenous system was inadequate. Reportedly, convictions were put forward emphatically with "raised voice and the pointing of fingers."

In short, the U.S. team soon left the Asian country, never to be accepted back, even though U.S. funds were available to assist the Asian country in transferring the management technology. Today, five years later, there are indications that the Asian country may, on its own, utilize a resource allocation model similar to the one tested in 1978.*

An example of more successful interpersonal relations took place in Brazil. In 1973, USAID loaned $15 million to the State of São Paulo to strengthen industrial research. The following year, the Instituto de Pesquisas Tecnológicas (IPT) and the State of São Paulo signed a contract with a U.S. organization to transfer industrially applicable explosive metalworking technologies to IPT. The U.S. party was at the forefront of the desired technology.**

In two years the project was evaluated and proclaimed successful. Brazilian industry was already contracting with IPT for explosive metalworking services.*** But more to the point, IPT had gained confidence in the U.S. organization with which it was working, partially as a result of the close interpersonal relationships that had developed.

This led IPT and the State of São Paulo to contract with the U.S. organization to provide IPT with technical assistance to build its capabilities in packaging technology, and later to assist it in transferring modern railway technology and fertilizer-related technologies. In the latter two cases, the U.S. organization had no in-house expertise. IPT contracted with the U.S. organization to act as its broker in obtaining these technologies because of the confidence generated over a long period during which a close set of interpersonal relationships had developed which promoted the rapid transfer of desired technologies.

Philippe Lasserre recently analyzed 33 cases of technology transfer in the chemical and pharmaceutical sectors from European to Association of Southeast Asian Nations (ASEAN) companies. As perceived by the ASEAN partners, the largest source of problems was "the behavior of European

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*Contractor project files. AID contract: OTR-0082-C-00-2316-00.

**James M. Miller, Jim D. Mote, and Henry E. Otto, "Brazil: Explosive Metalworking Program," Appropriate Technology for Development: A Discussion and Case Histories, edited by Donald D. Evans and Laurie Nogg Adler (Boulder, Westview Press, 1979), p. 276.

***Ibid., pp. 276, 288.

managers."* Lasserre went on to note that "although some attention is given to the training of local managers and employees in order to fulfill the contractual requirement, very little if anything is done for the training of the transferor's engineers, technicians and managers in order to acculturate them to the socio-cultural, political and economical conditions of the country they are going to. . . ."**

The Technology Champion

Within the developed country literature on technological innovation, it has long been recognized that to maneuver and manipulate a particular innovation through all the obstacles it is likely to encounter on the way to becoming a successful product often requires someone assuming the role of product champion.*** In developing country technology acquisitions a similar person often emerges. This person is intensely interested in and involved with acquiring the technology; an individual who dominates acquisition events, overcoming technical, financial, political, and organizational obstacles. The technology champion often succeeds by the sheer force of will and energy. Typical of technology champions are Ahmed Keskes, Sayed Ajmal Hussain, and Amir Khan.****

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*Philippe Lasserre, "Training: Key to Technological Transfer," Long-Range Planning, Vol. 15, No. 3, June 1982, p. 56.

**Ibid., pp. 55, 57.

***For example see: Donald A. Schon, "Champions for Radical New Inventions," Harvard Business Review, March/April 1963, pp. 77-86; Materials Advisory Board, Report on the Ad Hoc Committee on Principles of Research-Engineering Interactions (Washington, National Academy of Engineering, 1966); Alok K. Chakrabarti, "The Role of Champion in Product Innovation," California Management Review, Vol. XVII, No. 2, Winter, 1974, pp. 58-62; Paul Jervis, "Innovation and Technology Transfer --The Roles and Characteristics of Individuals," IEEE Transactions on Engineering Management, Vol. EM-22, No. 1, February 1975, pp. 19-27; and Harvey F. Kolodny, "Matrix Organization Designs and New Product Success," Research Management, Vol. 23, No. 5, September 1980, pp. 29-33.

****The case histories on which this section draws are for Ahmed Keskes: Richard S. Roberts, Jr., "Tunisia: Bottled Gas for Automobiles," Appropriate Technology for Development: A Discussion and Case Histories, edited by Donald D. Evans and Laurie Nogg Adler (Boulder, Westview Press, 1979), pp. 83-93; for Sayed Ajmal Hussain: James W.D. Frasche, "Pakistan: Ball-Point Pen Manufacturing--A Case of Technology Transfer," Appropriate Technology for Development, op. cit., pp. 151-165; for Amir Khan: Ronald P. Black, "The IRRI Agricultural Equipment Program," (Denver: Denver Research Institute, November 1976), and Ronald P. Black, "IRRI Management Compares IRRI with Other LDC Research Institutes," (Denver: Denver Research Institute, June 1976).

While a student at a technical institute in Belgium between 1967 and 1971, Ahmed Keskes of Tunisia learned about the use of butagaz as an automobile fuel. Approximately seven years later, Keskes called a press conference in Sfax, Tunisia, to display his own butagaz system.

In the preceding three years, Keskes imported two different butagaz systems which he adapted and tested in Tunisia. The system finally selected was modified to run a car on gasoline as well as butagaz for the system to be marketable in Tunisia. The adaptation, testing, and efforts to work out technical problems were all done in Keskes' spare time with his own money. He was also busy running a family woodworking and washing machine repair business, the source of his and his family's livelihood.

At his press conference Keskes reported that his system would cut car operating expenses by 42 percent. The press gave Keskes encouraging support, and later that year his system drew the attention of the Prime Minister at an industrial fair. Nonetheless, his early installations sometimes failed, local bankers appeared to have little enthusiasm for homegrown innovations, and butagaz was not legal in France (the Tunisian role model) until 1978.

Initially he was unsuccessful in introducing his system on a large scale through local auto importers and governmental agencies. However, private taxi owners bought them, and he also extended his reach by training mechanics in other towns to install and maintain his systems.

In early 1979, when the Keskes case study was prepared, it was not clear whether his technology would become a major financial success; but he was further improving the technology and exploring new sources of expansion capital. What is clear is that Keskes was a technology champion.

Sayed Ajmal Hussain is another example of a technology champion. With first-class honors in mechanical engineering from Loughborough, England, he returned to his home in Pakistan and assessed 50 possible business ventures. After an appraisal of marketing, finances, skilled manpower, raw materials, and other input requirements, he decided on ball-point pen manufacturing. The technical challenge of making the brass tip for the pen cartridge was sufficiently complex that Hussain felt it would prevent competitors from entering the market before he was established.

He placed an order for tip-making machines with the world's foremost manufacturer--Albe, S.A., of Lugano, Switzerland. The response shocked Hussain. Albe refused to fill the order on the basis that the equipment was too sophisticated for a developing country.

Hussain, while hurt by the Albe response, was not beaten. He studied all the technical literature he could find on tip making, injection molding, and other processes involved. With this knowledge, he

persuaded Albe to sell. Hussain went to Switzerland to participate in the selection and assembly of the units for his factory. He learned Albe's equipment design, operation, maintenance and repair, and even proposed modifications which Albe incorporated.

Hussain recruited and trained technicians, personally supervised the installation of equipment, designed injection molding machines, and had them built by a Pakistan engineering firm. In 1968, after three months of test production, Hussain's company, Sayyed Engineers, began commercial production.

Pakistan pen wholesalers were not interested in Hussain's product because profits were higher on cheaper, imported ball-point pens. Hussain mounted an aggressive marketing campaign aimed at the government and large private organizations, and wholesalers soon started getting orders for Tempo pens (Hussain's first model).

After two years, production was halted because the steel balls corroded in the harsh climate of Pakistan and the ink had too short a shelf life. Working with the Pakistan Council for Scientific and Industrial Research (PCSIR), Hussain developed materials tests that allowed Sayyed Engineers to find sources of raw materials that met Pakistan needs and maintained quality control.

After analyzing pricing structures, Hussain stockpiled raw materials in 1974 before prices rose due to higher costs of petroleum products. He then calculated his foreign competitors' costs of production and, by keeping his price low, Hussain held a monopoly position in Pakistan for about a year.

Chinese and Pakistani competitors reentered the market in 1977. And when this case study was being prepared, Hussain was bringing out two new models and sponsoring a contest at an art college in Lahore to design packaging for his two new products.

The pen factory stimulated local production of equipment, and new technological capabilities were created. The machines now manufactured in Pakistan include pigment mixers, printing machines, injection molding machines and molds, and automatic tapping machines. Many were designed by Hussain, and he takes pride in using PCSIR, local engineering firms, and consultants to produce the machinery he needs.

Dr. Amir U. Khan of the International Rice Research Institute (IRRI) is a different type of technology champion. He developed a successful approach to the design, commercialization, and diffusion of appropriate agricultural equipment technology in developing country environments.*

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*This work was largely funded by AID.

Prior to Khan's arrival at the Agricultural Engineering Department of IRRI, the Department had been trying to induce multinational farm machinery firms to design and produce farm machinery appropriate for small and relatively poor farms. Khan believed IRRI should design such equipment so that it could be produced by local metalworking firms.

Khan stressed the importance of the market, the compatibility of design with local manufacturing capability and local materials, close relationships with manufacturers, and reducing uncertainties to proportions acceptable to the manufacturers who would produce the equipment. They were provided a prototype of a readily marketable product.

The IRRI staff traveled extensively and knew the equipment in areas of interest. The majority of IRRI's most successful designs were modifications of existing equipment--that is, they were technology transfers with adaptations.

The one thing that differentiated the IRRI approach was the close and continuous relationship among IRRI staff members and Philippine metalworking firms. IRRI staff continually dropped in on metalworking firms to exchange ideas and see what was happening. At the time this case was prepared in 1976, industry people visited IRRI perhaps as much as the reverse.

IRRI's attempt to reduce market uncertainty led, in some cases, to initial purchases of the first few models of a piece of equipment from several firms to give the firms experience with constructing the equipment and bearing some of the expense for tooling up. This provided for a limited test of the market, as IRRI permitted the firms to sell the equipment IRRI had ordered if the firms received other offers. By and large, the firms that produced the IRRI equipment also marketed and popularized it.

Farm equipment based on IRRI designs, many of them Khan's own, is now produced in most countries of Asia and a number in Africa and Latin America. At the time the IRRI case was prepared, there was a budding engineering design capability developing in Philippine metalworking firms that was largely attributable to interaction with Khan and his staff.

We believe these three technology champions are representative of a special class of entrepreneur greatly needed in developing countries. These are highly creative people with a belief in their ideas and a determination and tenacity in carrying them to fruition.*

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*As we believe this section makes clear, technology is only one of the concerns of the technology champion. Therefore, we hope the term "technology champion" does not mislead readers into thinking that this is a person obsessed with technology. He is, rather, an individual obsessed with the transfer or acquisition goal.

Interest Groups

Just as in developed countries,* interest groups or coalitions play major roles in supporting and opposing developing country public sector technology acquisition.

Baindoang lies on the southern slopes of the rugged Saruwaged mountain range in Papua New Guinea (PNG).** First outside contact occurred around 1917 when Lutheran missionaries arrived. Governmental contacts began about 1929. In 1975, three interest groups became responsible for the introduction of electricity into Baindoang.

The Appropriate Technology Development Unit (ATDU) at the University of Technology (Unitech) in Lae was interested in the potential of small-scale hydroelectric plants for village use.

Within Baindoang, a coalition interested in the development of the village had recently constructed an airstrip which reduced the time required to travel from Lae to Baindoang from two days to 15 minutes. The village coalition was looking for new projects.

The Baindoang school serves about seven other villages in the area. The parents in this school "district" had a strong desire for their children to obtain a good education.

The Baindoang micro-hydroelectric project was conceptualized when a radio program on rural electrification was broadcast from Unitech and heard by Johannicus Yang, the Baindoang primary school headmaster. Yang wrote to the university describing the potential at Baindoang and inquiring into the possibility of initiating a small hydroelectric project there.

The result was a three-year project through which the three interest groups worked together to bring electricity to Baindoang and particularly to the school and its supporting facilities. Yang emerges at a number of points as a key person--in one case mobilizing the villagers of outlying villages to form work forces to perform tasks that would bring electricity to their school, in another arranging for necessary work to be completed between Unitech-ATDU staff visits.

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*For example, see: Ronald P. Black and Charles W. Foreman, Technological Innovation in Civilian Public Areas (Falls Church: Analytic Services Inc., for U.S. Arms Control and Disarmament Agency, 1967), and W. Henry Lambright, Technology Transfer to Cities: Processes of Choice at the Local Level (Boulder: Westview Press, 1979).

**Ed Arata, "Papua New Guinea: Micro-Hydroelectric Projects for Rural Development," Appropriate Technology for Development, op. cit., pp. 397-409.

Yang was not a technology champion, he was a community leader who helped to develop and bring together the critical interest groups.

An example of how interest groups can stop, or substantially alter, a technology acquisition was illustrated in Thailand in the early 1960s.* The government of Thailand had requested the services of an expert for one year ". . . to advise on the most suitable approach to the development, promotion, and planning of applied scientific research in Thailand." The resultant plan envisioned making the National Research Council (NRC) a new umbrella organization. Under it would be the laboratories and scientific activities currently existing in the various ministries. While the plan received considerable attention, the NRC did not have the political clout to wrest control of laboratories and activities from major ministries.

AID evaluation literature has many references to the importance of interest groups in successful acquisitions of technology. For example, in the evaluation of the Institute of Agricultural Science and Technology (ICTA) in Guatemala, the report notes that a coalition of Guatemalan scientists, emerging from an AID predecessor research-education program, ". . . played a major role in the creation of ICTA."** The evaluation goes on to note: "Both AID and the Rockefeller Foundation played major roles in developing and implementing the new organizational structure."

In the evaluation of the Thailand mobile trade training school project, the team observed that a coalition of administrators, teachers, and students had much to do with the success of the program. "Mutual respect and affection marked the interpersonal relations observed."***

In an evaluation of rural roads projects, it was noted that "local people began building more constructive relationships with higher levels of government and organized more effectively to protect their

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*Ronald P. Black, The Applied Scientific Research Corporation of Thailand: A Case Study (Denver: Denver Research Institute, for U.S. Agency for International Development, 1974).

**J.K. McDermott and David Bathrick, Guatemala: Development of the Institute of Agricultural Science and Technology (ICTA) and its Impact on Agricultural Research and Farm Productivity (Washington: AID, 1982), p. 2.

***Ray San Giovanni, Larry T. Armstrong, William H. Jansen, Thailand: Rural Nonformal Education: The Mobile Trade Training Schools (Washington: AID, 1981), p. 8.

interests. . . . In the three cases where projects included significant involvement of local people, the benefits were high."*

The community water supply projects evaluation concluded, "systems that are managed by communities tend to be more reliable than those without local management."**

An evaluation of the small farmer market access roads project in Colombia reported that the success of the program depends on both the initiative and ongoing participation of the rural residents. In most cases, informal village organizations, existing to speak and act for the community as a whole, initiated action. Further, "the custom of cooperation in the construction phase is often carried over to other community activities and joint agricultural activities."***

Finally, while the IRRI agricultural equipment design and development program does not represent exactly a public technology program, it is a publicly supported program and allows us to illustrate a potential form of coalition that we believe could be important in leading to successful public technology acquisitions. In the IRRI case the critical interest group was a coalition of metalworking firms that made and distributed the IRRI-designed equipment. This coalition was also effective in obtaining local, and continued AID, support for the program. We suspect that if the profit motive can be built into public sector technology acquisitions--for example, through local manufacture--a strong interest group will have been created and that will make success more probable.

The Search for Appropriate Technology

The appropriateness of technologies to local conditions is only one of many determinants with which LDC entrepreneurs are concerned, and perhaps from their viewpoint not the most important one. A few situations will illustrate.

Situation one: An entrepreneur in a Southeast Asian country was approached by a foreign technology vendor with an opportunity to participate in a venture that involved the transfer of marine technology. He

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*G. William Anderson, Charles G. Vandervoort, Charlotte M. Suggs, and Cynthia Clapp-Wincek, Rural Roads Evaluation Summary Report (Washington: AID, 1982), p. 28.

**Daniel M. Dworkin, Community Water Supply in Developing Countries: Lessons from Experience (Washington: AID, 1982), p. 26.

***G.R. van Raalte, Steve Singer, Benjamin Severn, and Jose C. Colon, Colombia: Small Farmer Market Access, (Washington: AID, 1979), pp. 10-11.

was approached because of his connections with the government and his relationship to the market. He suspected he was only one of a number of local entrepreneurs so approached. Obviously he was in no position to dictate a search of the "technology shelf" to find the version most suited to his country's endowment and environment if he wanted to participate in the venture.

Situation two: Another Asian entrepreneur perceived a market in his country that he could meet profitably if he could find a suitable food processing technology. The entrepreneur had capital but no technical expertise. He would have to negotiate agreements with the government, and he wished to find other sources of capital to spread his risk and bring in others with needed expertise and contacts. Simultaneously, he initiated the search for a technology source. He had never searched for sources of technology internationally and did not know what the opportunities were or how to learn about them other than by writing friends in developed countries. This approach brought him a list of potential sources whom he wrote. All of this he did under the pressure of time, realizing that others could have been planning a similar venture. It would have been surprising if the entrepreneur managed to identify the optimum source of technology for his country's factor endowment, and was successful in negotiating an acceptable transfer arrangement.

Situation three: A petrochemical firm in a Latin American country wanted to add a new process and products to its line. Major extension of the firm's technical capabilities was not required, and while management did not know of all the possible sources of technology available, they did know how to search for the possibilities. Because of past acquisitions of technology, the firm had links with an international company which had the desired technology. The acquiring firm concluded a transfer agreement with this firm without much thought as to whether or not the specific technology to be transferred was optimum for the country's factor endowment. In their eyes the suitability of the technology for the country was not as important as dealing with a familiar international supplier.

Howard Pack has described well some of the difficulties and costs associated with obtaining information needed to make the optimal choice of technology.

> Usable information about production alternatives, including machine and product specifications, raw material and power requirements, and typical complements of labor of various skills, is generally not readily available despite the textbook simplifications all economists use to represent technical choices. . . . In general, it is time-consuming and expensive to determine relevant technical alternatives--attendance at trade fairs, careful examination of large numbers of trade publications, and ascertaining the performance in operation, as contrasted with the specification of machine manufacturers, from understandably secretive competitors in one's own country or abroad--all require

> large monetary outlays or a considerable expenditure of managerial time. . . . Plant managers themselves will be reluctant to allocate much of their own or staff time to the necessary search unless the prospective payoffs--in terms of reduced costs--are very large, since many alternative uses exist for their time, including improvement of current levels of efficiency, finding lower-cost suppliers of raw materials, and eliciting more favorable treatment from all-important government agencies.*

In a study of technology choice in the brick and men's leather shoe industries in Colombia, Mary Ann Baily concluded that it was hard to determine what the profitable choice for an entrepreneur was.

> One can (if one can get the basic data) make some broad judgments. But at the level of minor adjustments (which we professed ourselves to be interested in at the start of the study) it is hard even to conceptualize the problem of profitability.
>
> The individual entrepreneur's actions will depend on his position vis-a-vis things that are difficult to incorporate in an economic model and on his expectations about the future course of economic variables. Since variability is so great and optimization is not free, especially at the level of determining the effects of minor adaptations, there is a real question as to how worthwhile elaborate optimization is. The outcome may depend so heavily on "luck" (happening to have made decisions that happen to be optimal given the way things turn out) that it is suboptimal to optimize. . . .
>
> One can, of course, introduce uncertainty into one's analysis, and this is often done. The point being made here is that there is such a large amount of uncertainty in the system that it is hard to reduce it to something manageable in an optimization framework. . . .
>
> . . . if optimization itself costs something and the variation in profits from small changes in the efficiency of the use of the technique can only have an effect on profits which is dwarfed by the normal month-to-month variation in profits because of the

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*Howard Pack, "An Appropriate Industrial Technology: Benefits and Obstacles," Technology Transfer: New Issues, New Analysis, op. cit., pp. 38-39. Pack in this article notes other barriers to entrepreneurs choosing the most optimum technologies for acquisition. Some are the absence of correct factor prices because of government policies, and a noncompetitive industrial sector sheltered by tariffs which provide massive profits regardless of the technology employed.

instability in the environment, then it will not attract the entrepreneur's attention.*

In spite of the barriers, entrepreneurs like the technology champions described earlier will acquire technologies. The question is: are there policies and programs that would aid this special breed of men and women in acquiring factor appropriate technologies while operating in difficult environments?

The Need for Strengthened Management

Our hypothesis, as stated earlier, is that "many developing country acquisitions founder as a result of a lack of management skills." The skills to which we refer are not limited to those of the technology buyer or recipient, although there tends to be a prejudice that this is the case. The management skills of the seller or donor, and those of any intermediary institutions are also part of this complex equation. In general we are persuaded that technology transfer is successful in so far as the managers on both sides of the transaction are up to the task. Just as matching technologies to resource bases and factor inputs is critical, so is matching management methods and techniques.

Acquiring technology is a complex process. In developing economies it is doubly so. There are problems of identifying sources of technology, initiating programs or ventures, and overcoming obstacles. To successfully traverse the course requires great luck (including that resulting from the class or position into which one is born) and good managerial skills.

Professor W. Arthur Lewis in considering industrialization in Africa noted:

> It is a common error, in the developing nations, to believe that entrepreneurship requires mainly technical knowledge and capital. The truth is the reverse. If people really have management capacity, they will in most cases be able to find technical knowledge and capital to work with. What makes business successful is the efficiency of its management.**

The international acquisition of technology is a special class of activity that magnifies the need for management skills. This was

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*Mary Ann Baily, Technology Choice in the Brick and Men's Leather Shoe Industries in Colombia (New Haven: Economic Growth Center, Yale University, 1977), pp. 259-260.

**Reported in Benjamin Prasad, "Manageralism and Economic Development in Africa," Management International Review, Vol. 7, No. 6, 1967, p. 91.

evident in Lasserre's analysis of 33 cases of technology transfer from European firms to indigenous ASEAN companies. European executives repeatedly identified poor managerial capabilities in their counterpart firms as being a problem.* In 31 of the 33 cases there was a provision, on paper, for management training to be a part of the technology transfer agreement. Lasserre notes, however, that this "training" was perfunctory and that the results were far from satisfactory.**

In our examination of AID evaluation material, we noted that there was particular emphasis on the key role played by management of supporting services in water and sanitation projects, primary health care, and rural roads programs. It was clear from this substantial body of case and project evaluations that public administration (or public management skills) were essential to the success of the activity.

Writing in a recent unpublished paper, Simon Fass has pointed out that:

> . . . the difficulties of implementation are the same as the vicissitudes of life. Another barrier, blind obedience to quasi-scientific imperatives precludes analysts from dealing with the essence of implementation--moral and ethical dilemmas involved in making decisions in a world of imperfect knowledge, and responsibility for the consequences.***

Speaking of a case with which he was personally familiar, Fass declared:

> Had Machiavelli, for example, observed UFRD [Urban Functions in Rural Development] in Upper Volta and Cameroon, he would have simply drawn upon his prior experiences to suggest that AID could improve projects by selecting staff and consultants with care . . . by allowing the implementation process to adapt to changing circumstances . . . by learning a great deal about existing conditions in proposed areas before initiating a project . . . and

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*Philippe Lasserre, op. cit., pp. 52-53. The remarks from European managers about problems with poor management were not made with regard to their relations with Singapore companies.

**Ibid., pp. 55, 57.

***Simon Fass, Implementation Revisited: Ruined Hopes and Great Expectations in Africa (Minneapolis: Hubert W. Humphrey Institute of Public Affairs, December 20, 1982), p. 4.

by establishing clear administration and communication systems to manage project progress. . . .*

Current AID interest in private enterprise is paralleled by a renewed interest in management training and education. This has been stimulated, in part, by the reports of reconnaissance teams sent to the key Bureau for Private Enterprise (PRE) countries by AID and by follow-up investigations conducted with the assistance of the National Research Council's Manufacturing Studies Board. The news delivered to Washington has been that there is a dearth of management skill, weak management instruction, and a great need for institutions of management instruction in the target countries. The careful observers have also noted that in most cases it is a combination of public and private management improvement that is needed to overcome obstacles to private enterprise expansion.

Technology acquisition and management share a common behavior: they are matters of choice and choice implies decision-making. The noted scholar of organizational behavior and decision-making, James G. March has made the following comments on this topic:

> Standard theories of choice view decision making as intentional, consequential action based on four things:
>
> (1) A knowledge of alternatives . . .
>
> (2) A knowledge of consequences . . .
>
> (3) A consistent preference ordering . . .
>
> (4) A decision rule . . .

and he presents evidence that these standard theories do not conform with reality.

> (1) Theories of choice presume two improbably precise quesses about the future: First, a guess about the future consequences of current actions. Second, a guess about future sentiments with respect to those consequences. Actual decision situations often seem to make both guesses problematic.
>
> (2) Theories of choice either ignore conflict with respect to objectives or assume that the conflict can be resolved by trade-offs or contracts made prior to the making of decisions. Actual decision making frequently involves considerable conflict at all stages.

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*Ibid., pp. 30-31.

(3) Theories of choice underestimate both the pervasiveness and sensibility of an alternative decision logic--the logic of obligation, duty, rules. Actual decisions seem often to involve finding the "appropriate" rule as much as they do evaluating consequences in terms of preferences.

(4) Theories of choice underestimate the confusion and complexity surrounding actual decision making. Many things are happening at once; technologies are changing and poorly understood; alliances, preferences, and perceptions are changing; problems, solutions, opportunities, ideas, people, and outcomes are mixed together in a way that makes their connections unclear.

(5) Theories of choice assume that the primary reason for decision making is to make choices. It ignores the extent to which decision making is a ritual activity closely linked to central Western ideologies of rationality. In actual decision situations, symbolic and ritual aspects are often a major factor.*

The points March makes are reinforced by recent hearings before the Subcommittee on Science, Research, and Technology of the House Committee on Science and Technology. The hearings were on "The Human Factor in Innovation and Productivity" and produce the following statement:

> U.S. management is still traditionally hierarchical. Decisions are made at the top with little, if any, consideration of the value of on-the-job knowledge acquired by employees. This approach, developed to ensure efficiency of production, no longer appears to be effective in the current work environment where cooperative motivation has been shown to be more successful in improving productivity and innovation."**

In this context the phrase "cooperative motivation" means Japanese management style, and the case studies of the differences between U.S. and Japanese management style abound.

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*James G. March, "Theories of Choice and the Making of Decisions," comments delivered as a public lecture at the annual meetings of the American Association for the Advancement of Science, Washington, D.C., January 5, 1982.

**Congressional Research Service, The Human Faccor in Innovation and Productivity, Including an Analysis of Hearings on the Human Factor, report by the Subcommittee on Science, Research, and Technology, transmitted to the Committee on Science and Technology, U.S. House of Representatives (Washington: U.S. Government Printing Office, October 1982), p. 18.

By now the reader perceives that in the context of our hypothesis, technology transfer and management are an omelet, and it is impossible to unscramble eggs. Our perception is that without suitable and careful analysis of the management factor in any technology transfer transaction, the prospects for success diminish rapidly. Furthermore, without a matching of transferor and transferee management styles and methods, difficult as this may be, especially when intermediaries such as donor agencies add an extra dimension, those prospects may evaporate entirely. Clearly, there are no universal management panaceas any more than there are technological fixes in the long run.

R&D Institutions and Technology Transfer

In its four new strategic emphases, AID singles out institution building, technology transfer, the private sector, and policy reform as foci for AID attention. R&D institutions may be important in each of these areas. For example, industrial research institutes have the demonstrated potential for strengthening the private sector through international technology transfer process by identifying technology sources,* negotiating agreements,** and adapting technologies to local factor endowments.*** They have also worked with ministries of industry and national planning organizations to set national policies and procedures for the acquisition of technology from international sources.**** More and more these services are being offered to industry and government commercially, thus creating a new national industry--contract research. R&D institutes in public works, health, communications and agriculture have contributed in similar ways.

Our hypothesis is that *developing country R&D institutions have a potential for effective assistance to local industry, entrepreneurs, and government agencies in acquiring technology. The building and strengthening of local R&D institutions create indigenous capability to acquire and adapt technology on a commercially self-sustaining basis. This capability will continue to serve the country long after donor programs have ceased.*

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*For example, see: Donald D. Evans, "The Republic of Korea: An Example of Integrated Regional Development," Appropriate Technology for Development, op. cit., p. 414.

**For example, see: Ronald P. Black and James W.D. Frasche, LDC Industrial Research Institute Effectiveness (Denver: Denver Research Institute, 1980), p. 37.

***For example, see: Ibid., pp. 87-88.

****For example, see: Donald D. Evans, KIST Case Study (Denver: Denver Research Institute, 1975), p. 23.

The importance of agricultural research institutes in the acquisition of agricultural technology is now well established and supported.* The value of R&D institutions in other sectors has not been as persuasively demonstrated, nor have they received the level and continuity of support of the agricultural research institutes. Part of the lack of performance is due to lack of sustained support. Part, however, has been due to a lack of economic conditions which create a demand for research and development. In many countries this situation is changing with a concurrent market for R&D services emerging.

When countries are in an import substitution phase, there appears to be little need for the services of a research institute. With capital underpriced for purchases of foreign technology in areas receiving a "promotional" status, there will be little incentive to develop the technologies locally. With labor overpriced in nonagricultural sectors, as a result of minimum wages being set too high, there is little incentive to make imported technologies more labor intensive. With enterpreneurs in the technologically sophisticated areas--the same areas that can afford and aggressively use the services of a research institute--operating in a protected market and making very large returns on their investments, there is little incentive to use the services of an R&D institute to make the technology optimal for the factor environment the firm faces.

However, when a country moves aggressively toward an export promotion mode, it competes in the international marketplace, and needs change. Costs need to decrease. Quality needs to improve. Product differentiation is needed. Local materials need to be employed. The technology must be optimized for the country's factor environment. In short, there is a demand for the contractual services of a research institute.

In the early 1960s, the Korean government made its move to become integrated into the world economy. This is a major reason for the success of the Korea Institute of Science and Technology (KIST)** which was established in 1965. There was a market for its services.***

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*For example, see: Paul R. Crawford, AID Experience in Agricultural Research: A Review of Project Evaluations (Washington: U.S. Agency for International Development, 1982), p. 2.

**Subsequently, KIST has been merged with the Korea Advanced Institute of Science to become the Korea Advanced Institute of Science and Technology.

***Ronald P. Black, "Considerations in Selecting Appropriate Technology Projects," Warta: Pengelolaan Penelitian dan Pengembangan, Vol. 1, No. 5, 1980, p. 25.

The Union Research Institute in Taiwan is well recognized for its contribution to the Taiwan economy. And again this is an export-oriented economy.

The State of São Paulo in Brazil has been aggressive in the development of export industries. The state's research institute, Instituto de Pesquisas Tecnológicas, is among the best reseach institutes found in developing countries.

In the early 1970s, Thailand began to move toward an export orientation. The Applied Scientific Research Corporation of Thailand (ASRCT)* increased its income from contract research by 1,200 percent between 1975 and 1979.** This trend has continued.

As more countries reach a level of industrialization that permits them to become export oriented, the greater the contractual demand will be for the services of R&D institutions; much of this demand will be related to technology acquisitions and adaptations. The degree to which AID is successful in bringing about economic policy reforms will also have an impact on the demand for R&D institutional services in the technology acquisition process.

The British Ministry of Overseas Development has concluded, with concurrence in Public Policy and Technology Transfer: Viewpoints of U.S. Business:

> The development of "software," particularly its organizational and institutional aspects, is essential for the growth of an innovative entrepreneurial class without which neither intermediate nor any other technologies are likely to advance far. "Software" may well therefore be more important in the long run than the introduction of individual pieces of hardware."***

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*Subsequently, ASRCT was renamed the Thailand Institute of Scientific and Technological Research.

**Ronald P. Black, ed., Mechanisms for Strengthening Applied Research Institutes in Developing Countries (Denver: Denver Research Institute, 1980), p. 104.

***Clarence J. Mann, "Technology Transfer to Developing Countries: Enhancing U.S. Private Sector Participation in Economic Development," Public Policy and Technology Transfer: Viewpoints of U.S. Business, Volume 4--U.S. Environment and Technical Assistance Programs (Washington: Fund for Multinational Management Education, Council of the Americas, United States Council of the International Chamber of Commerce, and The George Washington University; 1978), p. 114.

Multinational Corporation Contributions to the AID Program

In 1969, James Brian Quinn noted: "Two forces have newly emerged as critical in international economic affairs. One is technological advance. The other is the multinational company. Each has dramatically reshaped long-established commercial and political relationships among sovereign nations. The junction of these two forces raises important questions for business executives and national policymakers alike. . . ."* In addressing these questions, policymakers and executives have reached various answers but few have challenged the importance of the multinational corporation (MNC) to the international flow of technology. A recent OECD report noted that MNCs carry out 80 percent of the technology transfer to nonsocialist countries.**

Our hypothesis is that *AID may be able to find synergistic ways to work with multinationals in transfers of technology which could lead to the local acquisition of supporting technologies, thus providing a development multiplier effect.*

The driving force for MNCs is profit. Taken in long-range perspective, achieving profit can be compatible with, if not dependent upon, MNC contributions to the overall development of the environment in which it is operating. Some examples which led to enhanced flows of technology to host developing countries follow.

- Approximately nine Sears de Venezuela executives accept positions in other Venezuelan companies each year. Sears estimates that on the average these executives would have obtained 3,000 person-days of management development training from Sears. Thus, this enhanced management capability is contributed to the broader Venezuelan environment and will likely increase the Venezuelan acquisition of technology.***

- IBM reported in 1973 that its "plants in Buenos Aires and Campinas have found and developed about two hundred new suppliers

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*James Brian Quinn, "Technology Transfer by Multinational Companies," Harvard Business Review, November 1969, p. 147.

**J. Delorme, "The Changing Legal Framework for Technology Transfer: Some Implications," North/South Technology Transfer, The Adjustments Ahead (Paris: OECD, 1982), p. 90.

***Clarence J. Mann, "Sears, Roebuck and Co.: The Technology of Mass Merchandising," Public Policy and Technology Transfer: Viewpoints of U.S. Business, Volume 2--Industry Characteristics (Washington: Fund for Multinational Management Education, Council of the Americas, United States Council of the International Chamber of Commerce, The George Washington University, 1978), p. 265.

in Argentina and about one hundred in Brazil. Of these more than one hundred and fifty have become involved in completely new products or processes, or have made significant improvements in their capabilities. . . . IBM provided extensive manufacturing engineering, quality assurance, standards, product engineering, and cost accounting support to these vendors to help them develop these new and improved capabilities."*

- "Sears laboratory testing facility has assisted Sears' manufacturing sources in Spain to improve the inner coating of dishwashers. In Venezuela, the Sears laboratory has overcome several technical difficulties in the operation of a refrigerator. . . . In countries such as Brazil, Colombia, Mexico, Peru, and Venezuela, where Sears has maintained retail operations for 20 to 30 years, the number of product improvements initiated by Sears, both small and large, would reach into the thousands."**

- Sears affiliates in developing countries purchase much of their goods locally. Assistance is provided these local sources in the form of production planning, manufacturing techniques, financial support, and management know-how. An example of this was in Peru where a men and boys garment factory was begun as a small tailor shop and within 20 years expanded into one of Peru's largest apparel manufacturers with an employment of 600. "Sears supplied over the years technical advice, engineering know-how, market studies, and production designs to facilitate this expansion."***

- "Within its eight scientific centers around the world, IBM engages in researching problems of special concern to the local area, for example, air pollution in Spain. . . . This research is done in cooperation with the local government and the university scientists. The costs are shared by IBM's local partner."****

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*G.W. Allen and L.A. Howard, "A Model for Introducing Technology into Developing Countries," U.S. International Firms and R,D&E in Developing Countries (Washington: National Academy of Sciences, 1973), p. 71.

**Clarence J. Mann, "Sears, Roebuck, and Co.," op. cit., p. 257.

***Ibid., pp. 269-271.

****Clarence J. Mann, "Technology Transfer to Developing Countries," op. cit., p. 157.

These examples from Sears and IBM are illustrative of contributions which some multinational firms can report. They are contributions that should enhance the acquisition of technology in LDCs and are indirect benefits that accrue as a result of this type of MNC doing business in a country.

Our hypothesis assumes that many instances of this type occur or that they can be stimulated to occur. Because the MNC involvement in technology transfer is so great and the potential for support to AID-mandated development could be so significant, it would seem remiss not to explore the possibility for a synergistic AID-MNC relationship.

Such a search patently would have to take cognizance of the different motives and management styles of MNC executives and donor agency development officials, the AID mandate to reduce the impact of poverty in developing countries, and the potential for real or perceived conflict of interest situations inherent in public-private enterprise mixtures.

Should AID elect to pursue an MNC-related program, a first step could be to conduct a study to determine which are the most probable development activities that AID could stimulate MNCs to undertake. These would likely differ as do the natures of the MNCs. The study could result in guidance to missions on the generation of joint development projects with multinational firms.

A Systems Process

Only part, and sometimes a small part, of the technology acquisition process is concerned with technological questions. Other factors that may require attention and action are: inputs from infrastructure support mechanisms such as research institutes, financial institutions, communications and transportation systems, legal requirements and potential legal and policy shifts, behavioral patterns and customs, incentives and discincentives, organizational considerations, the market, and myriad similar system components. If attention is paid to all system components, the probability of a successful acquisition will be increased. While sometimes called common sense, this has also been called a "systems approach."

What is "sufficient attention"? And how is this "systems approach" carried out? The systems approach is a philosophy, or a way of doing things. It is not a formula or a technique that can be learned as network analysis techniques can be, although the systems approach often employs such techniques. Simply stated, the systems approach is one that takes into account in a rational manner all significant factors that affect reaching your goal within your resource and other limits.

Since the systems approach is dependent upon an entity's goal and resources, the approach varies from one entity to another. It also

implies that the process of reaching a goal, for example the acquisition of a technology, be reconsidered as changes occur in the goal, the resources available to achieve it, and the factors in the environment significant to its obtainment. In some ways the systems approach resembles art in that the more often one does it, the more natural it becomes and the better one gets at it.

The importance of taking a systems approach in the technology acquisition process is illustrated by case examples.

A Second Generation Appropriate Technology Organization

Appropriate technology organizations have long specialized in transferring suitable technologies into local environments. The systems approach has implications for these organizations.

In one Southeast Asian country with which we are familiar, sugarcane farming and processing is a major national agro-industry. In this country, it is possible to improve the sugar yield by using sugarcane varieties which yield higher sugar content, special fertilizers, and improved harvesting and processing equipment. This is not done, however, because millers purchase cane from farmers simply by weight. Farmers grow cane varieties that are heavy but which do not have high sugar content. They use only ammonium sulfate fertilizer, which spurs luxuriant growth but does not greatly increase the sugar content. Because of the juice's low sugar content, there is little incentive for the millers to buy processing equipment with higher extraction efficiencies.

A conventional appropriate technology organization would see that the sugarcane processing equipment had a low extraction efficiency and proceed to design and develop prototype models of equipment with higher efficiency only to have the prototypes sit unused because environmental factors eliminated incentives for an equipment supplier to produce the equipment, or for a miller to purchase it. If the present day appropriate technology organization was unusually perceptive, it might recognize that there were barriers to the commercialization and use of more efficient processing equipment and thus would move on to look for other opportunities.

A "second generation appropriate technology organization" would react differently. It would select projects in major economic sectors by which improved technologies and more receptive environments could lead to a significant advance in the long-term economic and social welfare. Rather than working on a sugarcane processing technology, it might select the sugar and related commercial products sector. It would address sugarcane agriculture, searching for better sugar producing varieties for the prevailing soil and climatic conditions; better fertilizers, herbicides, and insecticides; tests for cane maturity; improved farming equipment; and better post-harvest technology and techniques. The systems-oriented second generation appropriate technology organization

would examine the possibilities for improved processing equipment, but having determined that the reason millers bought cane by weight was mistrust between millers and farmers, it would seek procedures acceptable and beneficial to both parties that would allow sugar content to determine the value of the cane. This might include the organization serving as an honest sugar content tester and broker between the miller and the farmer. However, its role would not cease here: it would examine the potential for new uses of sugar and the associated technologies; it would study the international market for new export possibilities; it would analyze the commodities market and point to approaches for protecting the country from "down-swings" in the international price of sugar; and it would examine legal and regulatory factors which affect the health of the sector and make appropriate recommendations to state and national policymakers.

In short, a systems-oriented organization would move its research program from a reactive and opportunistic mode to one which would be shaping the face of development.

Linkages: A Systems Consideration

Development assistance organizations assist small-scale and rural industries. Helping the poor, improving the distribution of income, and increasing employment are motivations. Because of the synergistic relationship which exists between large and small enterprises, a systems approach to benefiting the "little guy" may on occasion mean development assistance support for the larger firm.

In an analysis of four cases of technology acquisition, Black illustrated five such relationships.* They were:

- Firms with advanced technologies creating markets for less technologically sophisticated firms and vice versa.

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*Ronald P. Black, "Considerations in Selecting Appropriate Technology Projects," Warta: Pengelolaan Penelitian dan Pangembangan, Vol. 1, No. 5, 1980, pp. 18-23. Black based his analysis on the following four cases: Ronald P. Black, The IRRI Agricultural Equipment Program, (Denver: Denver Research Institute, 1976); Ronald P. Black and Chan Beng See, "Singapore: The Development of a Design Consulting Engineering Firm," Appropriate Technology for Development: A Discussion and Case Histories, edited by Donald D. Evans and Laurie Nogg Adler (Boulder: Westview Press, 1979); Ronald P. Black, Wanawan Peyayopanakul, and Sachee Piyapongse, Thailand: Cassava Pelletizing Technology (Washington: U.S. Agency for International Development, 1979); and Ronald P. Black and Sachee Piyapongse, Thailand: The Introduction of Mint Agriculture (Washington: U.S. Agency for International Development, 1979).

- Technologically advanced firms leading to improvement of the output of less advanced firms by encouraging greater standardization and quality control, and other product improvements.

- Technologically advanced firms generating investment income to create or expand less sophisticated firms.

- Firms with advanced technologies developing product markets which can later be exploited by smaller and less advanced firms.

- Firms with advanced technologies stimulating less sophisticated firms to move in new directions that are more profitable to the less sophisticated firms.

To illustrate how advanced technological industries could create new markets for lower level industries, Black pointed to a mint agriculture case from Thailand. In 1965 the Applied Scientific Research Corporation of Thailand (ASRCT)* initiated an essential oils program to identify and test available natural materials as potential sources of commercial perfume or flavor materials. One of the materials was mint. In 1971, the Thai Chemical Company, Ltd. (TCCL) was formed to produce menthol. This provided an outlet for mint oil produced in the country and a stimulus to farmers to grow mint and establish oil extraction plants. By the time TCCL was established, ASRCT had concluded that mint agriculture held significant potential as an income generator for Thai farmers and industrialists. ASRCT encouraged farmers to grow mint and entrepreneurs to set up oil extraction plants by providing both with technical assistance.

Partially as a result of the establishment of the Thai Chemical Company, Ltd. (a modestly advanced-level technology requiring $15,000 per job place), a market opened up for a mint oil extraction technology (costing $1,000 per job place) and mint farming (costing $70 per job place). The technology acquisition system included the mint farmers, mint oil extraction plants, a menthol production firm, a research institute, and the Thai government, which placed a 30 percent tariff on all imported menthol and mint oil.

Another example was provided by the agricultural equipment program of the International Rice Research Institute's (IRRI) Agricultural Engineering Department. As of 1976, IRRI had six successful implements: a tractor lug wheel, a hand tiller, an axial flow thresher, a rotary-powered hand weeder, a rice hull furnace, and a batch paddy dryer.

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*The name of ASRCT has subsequently been changed to the Thailand Institute of Scientific and Technological Research (TISTR).

By and large, the firms that produced IRRI equipment also marketed and popularized it. In terms of numbers sold, often a single large firm dominated the market. However, these relatively advanced enterprises also created a market and many small metalworking operations were able to produce similar machines and sell them. In the case of the axial flow thresher, one major firm bought sub-assemblies from small firms.

The IRRI program was also assisted by the Asian Development Bank (ADB), which made its funds accessible as loans to farmers for equipment purchase. This technology acquistion system included an international research institution, large equipment producers, small metalworking shops, and an international financial institution.

A third example of advanced technologies building new markets is illustrated by a Singapore design consulting engineering case. In 1968, Maunsell Consultants (MC), an international consulting engineering firm with its head office in the United Kingdom, opened Maunsell Consultants Asia (MCA) in Singapore. As the Singapore staff design engineering and management skills developed, the parent organization brought in a Singapore partner. In 1975 a Singaporean was made managing partner and the firm became known as Chan Chee Wah Maunsell and Partners, (CMP). By maintaining its linkage with the parent firm, CMP staff skills were strengthened and the linkage caused markets to open to CMP, first by MC's directly siphoning off work to CMP, and second by associating with MC in joint project tenders it could not have managed independently. The MC-CMP linkage, however, was not a "one-way street," it brought new business to MC through CMP's local contacts.

The Thai mint case also illustrates how technologically advanced firms can encourage the improvement of a lower level firm's technology. The Nanleaf Tobacco Company, Ltd. (NCTC), the first and largest Thai firm extracting mint oil from mint leaves, set standards for mint leaves. This encouraged farmers to use better farming, storage, and transport practices and consequently allowed the farmers to receive a higher price for their product. Similarly, the Krohn Company, Bangkok, Ltd., a cassava pelletizing company, had a standard against which it based its price for cassava chips,* this encouraged better practices on the part of both chipping plants and farmers, who subsequently reaped the benefit of higher prices for their products. Not only do such pressures allow lower level technological activities to better their income, they force the pace of development.

As a cassava sidelight, most Thai cassava is exported to Europe in the form of soft pellets. These pellets crumble easily during transport, with large quantities turning into meal dust, which led to pollution problems in the EEC compound feed industry. Pressure was exerted

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*Cassava chips are the primary input into the cassava pelletizing process.

on the Thai pelletizing industry to upgrade its pellet production technology. Thai pelletizing firms did this with the help of the Applied Scientific Research Corporation of Thailand and the Asian Institute of Technology.

To show how relatively technologically advanced firms can create investment income to establish new or expand lower level technological activities, an example can be taken from mint oil extraction, where NLTC made loans to farmers to produce mint.

An example of an advanced technological firm developing and marketing products that less sophisticated firms then copy and sell was demonstrated with the cassava pellet case. The Chonburi Casting and Metal Work Company, Ltd. (CCMW) copied the Krohn Company die and produced the first Thai-manufactured pelletizing mills. Similarly, while on a trip to Taiwan the general manager of NLTC sketched a mint oil extraction plant which later served as the design for his extraction plants. The Thai metalworking firm that produced these was then able to produce extraction plants for others. But perhaps the best and most illuminating example of how sophisticated industry models can serve as prototypes for less sophisticated industry was demonstrated in the IRRI case. IRRI stimulated large, sophisticated companies to produce IRRI designs. The sophisticated firms using their nationwide marketing networks in the Philippines created demands for essentially new products. As demand developed, cottage-level metalworking firms copied the models and captured a significant share of the market. Without the marketing activities of the major firms, it is doubtful if any of the IRRI designs would have provided a basis for significant production by small-scale metalworking firms.

An example of a sophisticated firm directing or encouraging a less sophisticated firm into more profitable activities was demonstrated in the cassava case when in 1967 two European companies produced cassava pellets in Thailand. They virtually cornered the cassava market by paying farmers more for their product than could the indigenous starch manufacturers, which at that time were the only other processors of cassava for export. When CCMW produced a pelletizing machine the Thai cassava starch processors could afford, the cassava processors' income increased by 60 percent by changing from starch to cassava pellets.

A recent look at the role of linkages in the LDC technology acquisition system was taken by Susumu Watanabe.

> Preoccupation with the more equal distribution of income and economic power has induced some governments to restrain growth of larger firms allegedly to give greater opportunities to small firms. But this approach frequently defeats its purpose in

industries where business opportunities of small enterprises (such as subcontractors) increase with the growth of large firms: the small industrial sector alone cannot develop easily.*

*Susumu Watanabe, editor, Technology, Marketing and Industrialization: Linkage Between Large and Small Enterprises (New Delhi: Macmillan, forthcoming), as reported in ILO Information, Vol. 10, No. 4, October 1982, p. 6.

RECOMMENDATIONS

Hypothesis 1

Countries having catalytic policies will be more successful in (1) bringing about industrial and economic development, (2) acquiring technologies more appropriate to the nation's factor endowment, (3) achieving an equitable income distribution, and (4) developing a "world class" group of enterpreneurs.

Recommendation 1

Client countries should be encouraged to adopt policies which allow their natural factor advantages to come to the fore. They may accomplish this by restricting their manipulation of foreign exchange rates, by providing equal credit access to all segments of their economies, by using realistic annual depreciation rates for equipment, and by refraining from artificially escalating the costs of labor.

Client countries may also be encouraged to increase their foreign exchange earnings by stimulating the development of their entrepreneurial capabilities through opening their economies to the world market and taking advantage of their natural factor advantages. This means that artificially high tariffs and other barriers to imports should be gradually diminished. It also suggests that regulatory activities in international technology acquisition be minimized.

Hypothesis 2

In international transfers of technology, the ability of the parties to establish good interpersonal relations is as important as their technical expertise.

Recommendation 2

In evaluating proposals that include the transfer of technology, AID may find it useful to use "demonstrated ability to establish effective interpersonal relations" as one evaluation criterion.

Hypothesis 3

Technology acquisitions involve uncertainties and often have significant barriers to overcome before they reach fruition. To shepherd a venture through this process often requires someone with a strong belief in the venture's ultimate success--a "technology champion" willing to push ahead in the face of resistance.

Recommendation 3

AID, intermediary organizations, and local technology institutions should be consciously aware of the potential role of the technology champion and be sensitive to his or her needs and requirements. Further research on this subject with wide dissemination of the results would help.

One of AID's most important mechanisms for transferring technology and for strengthening the technology acquisition capability in developing countries is the Participant Training Program. AID may want to consider developing a technology champion indicator profile to test as one of the devices for assisting in the selection of participant trainees. The indicator profile would be less a screening device than a means to identify potential technology champions.

Hypothesis 4

In the public sector, interest groups assume an important role in supporting and in resisting acquisitions of technology.

Recommendation 4

AID officers are aware of the significance of interest groups in public sector technology acquisitions, yet there is still need explicitly to assess the likely reactions of interest groups and to judge their impact on the probability of project success. While an appropriate stage for such an assessment is during project planning, the need continues through the life of the project.

Hypothesis 5

Developing country entrepreneurs seldom make a thorough search for the optimum technology from the perspective of a technology's maximum profitability based on the country's factor endowments because of (1) the complexity of and uncertainties associated with the process of commercial technology acquisition in LDCs, (2) technological optimization being only one of many ways to increase a venture's profitability, (3) the lack of technological choice if a venture is to proceed at all, (4) the pressures resulting from shortages of time and funds, (5) the costs associated with international searches for technology as well as a lack of knowledge as to how to conduct such a search, and (6) the desire to move swiftly to counter perceived threats from competitors and to existing arrangements.

Recommendation 5

There are two approaches that AID could take to assist LDC acquirers in obtaining more appropriate commercial technology. One would be to improve the acquirer's skills in obtaining access to and in assessing information on the world's available technology. The other approach would be to improve access to information and consulting assistance needed by the acquirers.

With respect to the first approach, it could be useful to test a training program for technology champions, a component of such training would be aimed at improving the champion's skills in obtaining and assessing industrial "know-how" information.

As to the second approach, there is need for investment in institution building. An interesting project of this nature is currently in the planning phase at AID. The goal is to help business enterprises in selected LDCs to increase productivity and employment by improving their access to new technologies and marketing expertise from U.S. firms. AID's proposed mechanism is an intermediary organization that can market its capabilities to establish the firm to firm ventures needed to achieve the goal. It is assumed that the benefited firms would pay for the services of the intermediary organization. AID will provide seed money to the intermediary organization for an initial period. This is the type of experimental program that could reap huge benefits for AID and developing countries.

Hypothesis 6

Many developing country technology acquisitions founder as a result of a lack of management skills.

Recommendation 6

For projects which will involve indigenous technology acquisitions, AID, sellers, intermediary organizations, and recipients should explicitly assess the need for strengthened management capabilities and, where needed, include a provision for such in the transfer plan.

Hypothesis 7

Developing country R&D institutions have a potential for effective assistance to local industry, entrepreneurs, and government agencies in acquiring technology. The building and strengthening of local R&D institutions create indigenous capability to acquire and adapt technology on a commercially self-sustaining basis. This capability will continue to serve the country long after AID programs have ceased.

Recommendation 7

AID should explore the utility of increasing its assistance to nonagricultural R&D institutions until it is on a par with the support provided agricultural research institutions.

Hypothesis 8

AID may be able to find synergistic ways to work with multinational firms in transfers of technology which could lead to the local acquisition of supporting technologies, thus providing a development multiplier effect.

Recommendation 8

AID should consider conducting a study to determine which are the most probable development activities, fitting within AID's mandate, that AID could stimulate MNCs to undertake.

Hypothesis 9

Only part, and sometimes a small part, of the technology acquisition process is concerned with technological questions. Other factors that may require attention are: inputs from infrastructure support mechanisms such as research institutes, financial institutions, communication and transportation systems, legal requirements and potential legal and policy shifts, behavioral patterns and customs, incentives and disincentives, organizational considerations, the market, and myriad similar system components. If attention is paid to all system components, the probability of a successful acquisition will be increased. While sometimes called common sense, this has also been called a "systems approach."

Recommendation 9

Perhaps the clearest perception resulting from this research is that the international transfer and acquisition of technology is a systems process. There is little evidence that this is widely understood, however, and little of the research on the process has been directed toward the AID-mandated areas of primary health care, nutrition, fertility limitation, literacy and numeracy, and vocational and technical training. Development is largely a process of transferring and acquiring technology and thus is a subject that all concerned with the process, including the supplier, the acquirer, AID, and other intermediary organizations, should know a great amount about. As this is not now the case, and because of the importance of technology transfer and acquisition to AID's mandate, we believe AID should take the lead in gaining and disseminating information on the subject. To effectively accomplish such a

mission, AID management should make a clear assignment of the responsibility and resources for conducting and surveying technology transfer and acquisition research and disseminating the resultant lessons learned.

Finally, to encourage use of a systems approach in technology acquisitions, in its programs AID should focus on goals rather than procedures. Flexibility, resilience, noninterventionist assessment of process and goal achievement, and timely response can greatly enhance the acquisition environment.