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PROPOSAL FOR A PROGRAM IN APPROPRIATE TECHNOLOGY

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AGENCY FOR INTERNATIONAL DEVELOPMENT

PURSUANT TO SECTION 107 OF THE FOREIGN ASSISTANCE ACT

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FOREWORD

House of Representatives,
Committee on International Relations,
Washington, D.C., February 7, 1977.

In 1975 the House Committee on International Relations proposed a new section 107 of the Foreign Assistance Act of 1961 to authorize the Agency for International Development (AID) to support an expanded and coordinated private effort to promote the development and dissemination of technologies appropriate for developing countries. The new provision called on AID to prepare and transmit to this committee and the Senate Foreign Relations Committee a detailed proposal to carry out the section.

Accordingly, AID undertook a study of what could usefully be done to implement section 107. This study included both extensive discussions within the Agency and a series of workshops participated in by a wide range of knowledgeable individuals from private organizations and businesses, as well as Members of Congress and congressional staff. At the same time, the Agency commissioned a number of papers on various aspects of the subject.

On June 30, 1976, AID transmitted to Congress the proposal which resulted from this lengthy study. In order to make the study available to Members of Congress and other interested individuals and organizations, the committee published the Agency's proposal and several of the papers. Because of the widespread interest and requests for the document, the committee is issuing an updated version of the document. The only addition in this edition is Attachment H, "Intermediate Technology: An Informal Survey", written by Peter Askin for the Department of State's Senior Seminar in Foreign Policy, which was not completed in time to be included in the original transmittal.

Since the first edition of this document, a core Board of Directors for a private nonprofit corporation—A. T. International—has been named under the chairmanship of Fletcher L. Byrom, chairman of the Koppers Co.

The committee strongly believes that appropriate, or intermediate, technology, through its favorable impact on employment and self-reliance, can be an important means of implementing a development strategy which emphasizes participation and concentrates on improving the lives of the poor majority of people in the developing world. It is the committee's hope, therefore, that this new proposal will be a useful and constructive step in focusing development efforts more sharply on the needs of the poor.

Clement J. Zablocki, *Chairman.*

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1. "Appropriate Technology Study: Some Background Concepts, Issues, Examples and Recommendations," Louis J. Goodman and East-West Center.
2. "IT Organizations and the Indian Sub-Continent," Intermediate Technology Development Group.
3. "Appropriate Technology in Latin America," VITA.
4. Report on A.I.D.-Private Sector Meetings on Section 107.

LEGISLATIVE HISTORY

On December 20, 1975, the International Development and Food Assistance Act of 1975 was enacted into law as Public Law 94–161. That act introduced a new section 107 into the Foreign Assistance Act of 1961 that authorized the Agency for International Development to undertake a new effort in the field of intermediate technology. Section 107 reads:

> Of the funds made available to carry out this chapter for the fiscal years 1976, 1977, and 1978, a total of $20,000,000 may be used for activities in the field of intermediate technology, through grants in support of an expanded and coordinated private effort to promote the development and dissemination of technologies appropriate for developing countries. The Agency for International Development shall prepare a detailed proposal to carry out this section and shall keep the Senate Foreign Relations Committee and the House International Relations Committee fully and currently informed concerning the development of the proposal. The proposal shall be transmitted to these committees no later than March 31, 1976, and shall not be implemented until thirty days after its transmittal or until passage by each committee of a resolution in effect approving its implementation.

House Report 94–442 explained the various provisions of the International Development and Food Assistance Act of 1975 as voted by the House Committee on International Relations. Regarding intermediate technology, that report states:

> This new section of the Foreign Assistance Act of 1961 permits a total of up to $20 million of the funds made available under sections 103–106 over the 3-year period covering fiscal years 1976–78 to be used for grants to support an expanded and centralized private effort in the field of intermediate technology.
>
> The experience of more than a quarter century of development assistance programs overseas has clearly demonstrated that much of the technology used in the United States and other industrialized countries is not well suited to the economies of developing countries. It is too big, it is too expensive, and it does not create the jobs needed to absorb rapidly expanding labor forces in countries which already have an abundance of labor. It is not appropriate for use on the very

small farms and in the very small business enterprises that make up so much of the economic activity in the developing world.

If the poor are to participate in development, as envisioned by the reforms enacted in the Foreign Assistance Act of 1973 and by this bill, they must have access to tools and machines that are suited to labor-intensive production methods and fit their small farms, small businesses, and small incomes. They must have access to technology which is neither so primitive that it offers no escape from low production and low income nor so highly sophisticated that it is out of reach for poor people and ultimately uneconomic for poor countries—in short, *intermediate technology.*

Accordingly, the bill adds this new section 107 to the Foreign Assistance Act of 1961 in order to impel AID to study proposals for an institute of intermediate technology and to develop a plan for expansion and centralization of private efforts in this field. It is not meant to limit the amount of AID funds used for other activities involving intermediate technology, which should be expanded as rapidly as possible.

Among the objectives of such an increased effort in intermediate technology are the following:

(1) To promote the development and dissemination of technologies appropriate for developing countries, particularly in the areas of agriculture and rural development, small business enterprise, and energy;

(2) To identify, design, and adapt from existing designs, appropriately scaled, labor-intensive technology, and policies and institutions directly related to their use;

(3) To formulate policies and techniques to facilitate the organization of new small businesses;

(4) To engage in field testing of intermediate technology;

(5) To establish and maintain an information center for the collection and dissemination of information on intermediate technology; and

(6) To support expansion and coordination of developing country efforts in this field.

These objectives are based on the experience of the several institutes of intermediate technology that are functioning in both industrialized and developing countries.

The committee expects AID to begin immediately to develop its proposals for use of the funds authorized under this section, in conjunction with the private organizations now carrying out activities in intermediate technology and those which would be involved in a new effort, and to keep the committee fully informed during the planning process.

Senate Report 94–406, the report by the Senate Foreign Relations Committee on the same bill, outlines a similar purpose and intent concerning intermediate technology. That report reads as follows:

> The new section 107 of the Foreign Assistance Act of 1961 permits a total of up to $20 million of the funds made available under sections 103–106 over the 3-year period covering fiscal years 1976–78 to be used for grants to support an expanded and centralized private effort in the field of intermediate technology.
>
> The experience of more than a quarter century of development assistance programs overseas has demonstrated that much of the technology used in the United States and other industrialized countries is not well suited to the economies of developing countries. It is too big, too expensive, and does not create the jobs needed to absorb rapidly expanding labor forces in countries which already have an abundance of labor. It is not appropriate for use on the small farms and in the small business enterprises that make up so much of the economic activity in the developing world.
>
> The new section 107 is designed to encourage AID to place greater emphasis on coordinating and expanding private efforts to develop and disseminate technology which is appropriate for the developing countries. It does not authorize additional appropriations.

PROPOSAL BY THE AGENCY FOR INTERNATIONAL DEVELOPMENT FOR A PROGRAM IN APPROPRIATE TECHNOLOGY

Section 107 of the International Development and Food Assistance Act of 1975 establishes a new grant funded, private program to stimulate the development and dissemination of appropriate technology in developing countries.

The legislation states:

> "Of the funds made available to carry out this chapter for the fiscal years 1976, 1977, and 1978, a total of $20,000,000 may be used for activities in the field of intermediate technology, through grants in support of an expanded and coordinated private effort to promote the development and dissemination of technologies appropriate for developing countries. A.I.D. shall prepare a detailed proposal to carry out this section and shall keep the Senate Foreign Relations Committee and the House International Relations Committee fully and currently informed concerning the development of the proposal. The proposal shall be transmitted to the committees no later than March 31, 1976 and shall not be implemented until 30 days after its transmittal or until passage of each committee of a resolution in effect approving its implementation."

The deadline for submitting the proposal required by the legislation was extended to June 30, 1976. This paper is submitted to the Senate Committee on Foreign Relations and the House International

Relations Committee in compliance with Section 107. It contains three parts: 1) an introduction and background; 2) description of the proposed goals and activities of the Section 107 program; and 3) a statement of the organizational steps A.I.D. proposes to take in carrying out the program. This proposal has been prepared by a work group representing all major A.I.D. bureaus and offices.

I. INTRODUCTION AND BACKGROUND

The Private Sector Focus: Section 107 mandates an expanded and coordinated private effort to stimulate the development and dissemination of appropriate technologies in developing countries. The Congressional Committees interpret the term "private effort" widely. Section 107 is intended to complement on-going A.I.D. programs by stimulating a variety of non-A.I.D. entities to undertake innovative programs in appropriate technology. This includes U.S. private and voluntary agencies, private business, individual citizens, not for profit organizations, and universities whether privately or state supported. Under the legislation, grants can be made directly to LDC private groups or publicly supported groups such as LDC R&D institutions, universities, or others.

In reporting out the legislation, the HIRC suggested that we consult with U.S. private groups active or interested in appropriate technology. These consultations have been a major part of our preparations for this report.

Four day and a half workshops with representatives of U.S. private

and voluntary agencies, businesses, and academic institutions were held in April this year. A larger meeting of private sector representatives was held in May. More than 100 individuals and representatives from private groups attended the meetings.[1]

These meetings generated a large number of suggestions on the goals and activities of an appropriate technology program. The program described in this report is drawn largely from these recommendations. The meetings constituted the first step in an on-going dialogue between the private sector and A.I.D.

In addition to the meetings, A.I.D. commissioned a survey of eighty U.S. private and voluntary agencies to ascertain their current and prospective involvment in appropriate technology programs.[2] The survey notes numerous instances of successful development and use of appropriate technology by private and voluntary organizations. It contains a number of recommendations for enhancing U.S. private agency capacity in appropriate technology.

The overall impression from the meetings and the survey is that the Congressional decision to engage the talents of the U.S. private sector as a complement to A.I.D. programs in appropriate technology was well taken. We have been impressed with the diversity of

[1] The list of attendees is appended as attachment A.

[2] "Private and Voluntary Organizations and Appropriate Technology" - PASITAM - Bloomington, Indiana, May 1976. (Attachment B)

perspectives and ideas which we have encountered and the high degree of interest shown in the program.

Definition and Description of Appropriate Technology: The HIRC defines appropriate technology as "tools and machines that are suited to labor-intensive production and fit LDC small farms, small businesses, and small incomes." Morawetz defines appropriate technology as the set of techniques which make optimum use of available resources in a given environment.[3]

In both defintions, appropriateness is determined by the environment. For most developing countries, this is, of course, an environment of scarce capital and limited numbers of highly trained personnel. Unskilled and semi-skilled labor is abundant. The majority of productive enterprises are small. Four-fifths of the farms in developing countries are 12 acres or less; most of the businesses and industrial firms of the developing world are equally small. Family patterns, social structures, and cultures vary widely.

Despite this, much of the technology which has been utilized in LDCs was developed in Western countries which have quite different endowments of capital and labor, skilled workers, size of markets and enterprises, consumer incomes and tastes, and credit and distribution infrastructures.

Use of this capital intensive technology has been identified as

[3] David Morawetz, "Employment Implications of Industrialization in Developing Countries: A Survey", The Economic Journal, September, 1974

a contributor to unemployment in developing countries. Capital-labor ratios for new investment projects in LDCs are frequently $15,000 or more per worker while the capital available per worker is less than a tenth of this figure. The high capital cost of modern technology has also contributed to the development of dual economies — small, relatively well-off enclaves of high productivity and well-paid workers side by side with relative stagnation among the larger community.

In this context, a conviction has grown that developing countries need technologies which require little capital per worker (labor intensive), are efficient on a small scale, are easily serviced and maintained, do not require high levels of education or training to operate, and utilize locally available materials: In short, technologies which are appropriate to the environment of developing countries.

This prescription has not developed without controversy. Some assert that capital-intensive technologies are highly efficient and produce relatively higher returns per unit of investment. They state that in most sectors there are, in fact, few practical alternatives to modern technology. The so-called spectrum between traditional and modern technologies is really devoid of efficient techniques with alternative capital-labor ratios.

Quite a volume of literature has grown up around this controversy. In preparing this proposal, A.I.D. commissioned a survey of this

literature which indicates that, while the issues are complex and vary with circumstances, the view that LDCs are currently condemned to high capital-labor ratios because there are no efficient alternatives simply is not consistent with the evidence.[4]

The range of technologies available and in use throughout the world is much wider than has been thought. This is true for the majority of industrial products (particularly those with a technical life of more than 20 years), agriculture cultivation and harvesting techniques, excavation, earth moving, and some road building and construction techniques, means of transport, and a variety of service activities.[5]

For instance, the work by a group of economists at Strathclyde University (Scotland) on the sugar and shoe industries in India, Ghana, and Ethiopia demonstrates that over a wide range of technology, both individual profits and employment are higher if factor proportions reflect true factor costs. In these countries, production efficiency can be obtained through more intensive use of labor. Other studies show the possibility of expanding the effective use of appropriate technology in ancillary process, such as handling, packaging,

[4] Lawrence J. White, Appropriate Factor Proportions for Manufacturing in Less Developed Countries: A Survey of the Evidence, April, 1976, Attachment C

[5] ILO, Employment, Growth and Basic Needs. A One-World Problem, Geneva 1976, p. 144.

transporting and storage.[6]

This is not to say that capital-intensive technologies are invariably inappropriate in developing countries. In some circumstances, efficient, labor-intensive technologies may not exist (e.g. petro-chemical industries) or competitiveness in export markets may require precision machine-made products. Developing countries require a mix of technologies. The problem in many developing countries, however, is that the current mixture is felt to be over-rich in a capital-intensive direction to the detriment of both employment and output growth.

In terms of the competitiveness of the small-scale sector vis-a-vis large, capital-intensive enterprises in LDCs, White points out that comparisons of the relative efficiency of small and large firms are extremely difficult since product characteristics are usually different. In addition, larger firms often produce more of their own inputs or do some of their own distribution, both of which alters their capital-labor and capital-output ratios.

However, there is anecdotal and other evidence supporting the robustness of small scale industry. The ILO states, "small units

[6] Studies tend to show that the scope for use of alternative technologies is narrower if the characteristics of the product are fixed. If consumers demand drip dry, color fast, cotton/dacron shirts, the scope for substitution of technology in a labor intensive direction is more restricted than if consumers will accept cotton shirts. To this extent, the problem of appropriate technology is also one of consumer demand, which may in part be a function of income distribution.

generally compare favorably with large scale units on the efficiency indicators of particular relevance — capital-output ratios, capital surplus, yield per acre of land, and propensities to save and invest."[7] Pack states that "analysis typically reveals that small firms are at least as efficient as the larger ones in the sense that if both were to face the same socially relevant factor prices ..., the average cost of production in smaller firms would be competitive with that of larger firms, indeed often lower."[8]

Neither small nor large scale industries have intrinsic advantages across the board. Small scale industry typically employs 50% or more of the manufacturing work force in LDCs, is labor intensive, and hence is a prime user of appropriate technology.

In summary appropriate technology may be defined as follows:[9]

— In terms of available resources, appropriate technologies are intensive in the use of the abundant factor, labor, economical

7 ILO, op. cit., p. 147.

8 Howard Pack, "Policies to Encourage the Use of Appropriate Technology" Paper prepared for A.I.D., April, 1976, Attachment D

9 A more rigorous definition of appropriate technology is appended to this paper. Other terms which have been used to describe the same concept include optimal, progressive, intermediate, low-cost, middle level and light capital technology. The term "intermediate technology" was coined by E.F. Schumacher, the British economist who helped formulate the concept in the mid-1960's. Gradually, intermediate has given way to appropriate. Among LDCs, the word "intermediate" has come to connote second-best or second-hand. The term appropriate has wider currency and has been adopted by a resolution in 1972 of the UNESCO, and later by the ILO and other international agencies.

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in the use of scarce factors, capital and highly trained personnel, and intensive in the use of domestically-produced inputs.

— In terms of small production units, appropriate technologies are small scale but efficient, replicable in numerous units, readily operated, maintained and repaired, low-cost and accessible to low-income persons.

— In terms of the people who use or benefit from them, appropriate technologies seek to be compatible with local cultural and social environments.

Appropriate technology includes software as well as hardware. It includes health delivery systems, educational methods, credit systems and management methods which reduce the need for administrative overhead and highly skilled personnel. The concept of appropriate technology also includes products since shifts in the product mix or in quality standards can improve the utilization of a country's factor endowments.

Appropriate technologies, need not - indeed can not - maximize all the above criteria simultaneously. For instance, not all appropriate technologies are simple in their construction or in the degree of technical and engineering knowledge required to produce them. Solar energy equipment and concepts are highly sophisticated as are electric power and improved batteries which might be used to provide energy in remote areas.

Thus stated, the definition of appropriate technology is broad. For operational purposes the Section 107 program needs to concentrate on specific fields and problems within this broad area. The program described in Part II below suggests such a concentration.

Appropriate Technology in Developing Countries: A.I.D. commissioned preliminary surveys of existing appropriate technology activity in Asia, Africa, and Latin America. These surveys are appended to this report, as Attachments H, I, and J.

The picture in developing countries, as one would expect, is mixed. There is a substantial group of skeptics who see appropriate technology as "technological imperialism", a way in which Western nations are trying to keep poor countries in their place so that they can retain access to the energy and resources needed to maintain high consumption Western life styles. At a recent meeting on the employment problem in Latin America sponsored by the ILO, a number of Planning and Finance Ministers asserted that appropriate technology was a means of keeping developing countries dependent on the United States for imports of modern technology. While not rejecting the concept of labor-intensive technology entirely, they stated that Latin America would continue to produce the most modern technologies.[10]

Much of the economics and politics in developing countries favors capital-intensive technology. Public policy with respect to foreign exchange rates, licenses for imported materials and components, interest rates, wages, allocation of investment funds and others are often biased in favor of larger, capital-intensive methods. Regulations tend to favor large enterprises in metropolitan centers over small businesses and

[10] One indication that the penchant of government officials for the most modern equipment may not extend throughout society is this wall poster from India: PROTEST MEETING - Against Forcing Computer into South Eastern Railway under Armed Police Guard despite Mass Protest of Workers and Employees. Demonstration - Indian Association Hall - January 13.

entrepreneurs in small cities. Years of training in Western universities or in LDC universities with Western curriculums has yielded "engineering bias" toward Western technology among educated elites. Many of the policies above have political roots and are difficult to extirpate. Nonetheless, while no governments have adopted appropriate technology as a national policy, there are ministries and public agencies in many countries that are sponsoring appropriate technology organizations and appropriate technology work.

In Africa, five countries have appropriate technology organizations which are intended to become nation-wide focal points - Nigeria, Tanzania, Ethiopia, Ghana, and Kenya. A sixth such center is now being planned in Botswana. In addition, the survey commissioned by A.I.D. identified more than a hundred organizations involved in appropriate technology in 32 African countries. These organizations include community development groups, university engineering and agricultural faculties, research institutions and technical centers, and small industry extension units.

In the ten countries surveyed in East and South Asia, we identified 25 public agencies and universities involved in appropriate technology work plus dozens of smaller, mostly private organizations. Pakistan, India, and Bangladesh all have appropriate technology units in one of their central ministries.

In Latin America, government support of appropriate technology is just beginning. One of the first publically-sponsored organizations,

in Honduras, is being planned as this report is written as part of an A.I.D. rural development project. However, the survey of Latin America identified more than 300 organizations, nearly all private, involved in appropriate technology in Latin countries. Forty-six of these have a very high and direct involvement in appropriate technology.

The work being done by these public and private organizations covers a spectrum of appropriate technology. Research and design work includes farm mechanization, food storage, preservation and processing, brick-making and other building techniques, alternative energy, textiles, ceramics, foundries, coconut products, glue, salt, electro-plating, to name just a few. In some countries, such as Kenya, Sri Lanka, and Philippines, appropriate technology organizations are involved in industrial extension, financing of small business, market development, and information systems.

This array of organizations and activities confirms that there is a base for the Section 107 program to build on in developing and disseminating appropriate technology in LDCs.

Other Donor Activity: A.I.D. has not conducted a survey of other donor programs in appropriate technology. The following derives from informal contacts made while preparing this report.

The ILO is perhaps the leader among international agencies. The employment studies conducted by the ILO in Colombia, Kenya, Philippines and other nations have had a major influence on the development of the concept of appropriate technology. The ILO is

now doing an evaluation of small scale industry projects which may prove useful to the management of the Section 107 program.

The World Bank is paying increasing attention to the appropriateness of the technology included in Bank projects. In Egypt, for example, a loan to modernize cotton ginning incorporated labor-intensive rather than capital-intensive machinery. Water projects in Bombay, India and several cities in Colombia are based on a capital-saving technology for water filtration. A recent loan to Yugoslavia is aimed at small-scale agro-industries. Loans for slaughter houses based on labor-intensive techniques have been approved for Honduras and Cameroon. The Bank has done extensive work on labor-capital substitution in road construction.

The Peace Corps has considerable experience in village-level appropriate technology and is preparing training materials based on its work. These materials will be made generally available. The principal subjects on which the Peace Corps is now working are small farm grain storage, health education, construction of buildings and roads, forestry and conservation in arid lands, freshwater fisheries, and well construction. Peace Corps volunteers are also developing a program of bio-gas plants in Nepal.

In terms of other agencies, IDRC in Canada is funding Technonet/Asia, an experimental small scale industry extension service operating in a half dozen Asian countries. UNIDO is developing plans for a Clearing House on Industrial Information which may complement the

Section 107 program.

Overall, the state of the art among other donors and agencies seems roughly parallel to that in developing countries and A.I.D. itself. There is some official interest in the subject and pockets of activity in all agencies. There is need for greater communication and coordination among agencies working on appropriate technology and this will be one of the aims of the Section 107 program.

Current A.I.D. Programs in Appropriate Technology: A.I.D. has a diversified portfolio of projects directed toward development and use of low-cost, labor-intensive technology. This includes the small-scale agricultural equipment project begun at the International Rice Research Institute in the Philippines and currently being extended to Thailand and Pakistan. It includes the small industry program run by the Georgia Institute of Technology. It also includes projects in low-cost housing, low-cost roofing, conversion of saw dust and other agricultural wastes to energy, construction of simple grain storage facilities, solar kilns for drying timber, village level food processing, non-formal education, and a major program in low-cost health delivery systems. There are about 40 current projects which directly bear on development and dissemination of appropriate technologies.

In addition, there are many projects in which appropriate technology plays a role. For instance, A.I.D. is currently helping develop agricultural research capabilities in more than two dozen countries. All of these are concerned with turning out technology which meets

the conditions of small farmers. Much of A.I.D.'s economic research on questions of employment and development strategy bears on the question of choice of technology.

The Congress has indicated that it expects A.I.D. to continue activities in appropriate technology in addition to the monies allocated for Section 107 grants. The House Appropriation Committee states that it expects such activities "to account for a steadily increasing share of A.I.D.'s development budget... beyond the modest allocation under Section 107."[11]

There are two main areas for expansion. One is to expand funding for projects such as those listed above which are directly concerned with assisting LDC's develop and utilize appropriate technologies. Such projects would derive from sector or other analysis of country needs and would be part of the on-going development assistance program for the country. A second area for expansion is to insure that questions of choice of technique are carefully attended to in all A.I.D. projects, whether they are titled appropriate technology projects or not. Peter Timmer's analysis of the choice of rice milling technology in Indonesia indicates that A.I.D. financed engineers recommended capital-intensive technologies even though their own economic analysis showed that more labor intensive techniques would generate both higher returns and

[11] Foreign Assistance and Related Programs Appropriation Bill, 1977, Report of June 3, 1976, p. 14.

more jobs.[12] The need for rigorous consideration of choice of technique runs throughout A.I.D.'s program.

Expansion of A.I.D. projects to develop and disseminate appropriate technology in LDCs implies a need to develop criteria to distinguish between technical assistance activities which A.I.D. might fund directly and those which might be funded through Section 107 grants. We have not attempted to spell out these criteria in this paper. This should be done as the goals and activities of the Section 107 program are clarified, and as the new Section 107 organization develops demonstrated competence in given areas.

[12] C. Peter Timmer et al, Choice of Technology in Developing Countries: (Some Cautionary Tales), Harvard University, 1975, pp. 16-26.

II. OUTLINE FOR THE SECTION 107 PROGRAM

A. INTRODUCTION:

The program outlined in this section reflects the priorities and recommendations for action expressed in A.I.D.'s April and May meetings. It is an initial configuration. It has been drawn from recommendations of U.S. private groups and tailored by A.I.D.'s internal judgment as to priorities for action. Several steps are needed to sharpen it further.

First, consultations with developing countries are required. One of the first steps taken by the management of the Section 107 program should be to hold participatory planning meetings with LDC groups active or interested in appropriate technology. These meetings should help clarify priorities and determine opportunities for action.

Second, more detailed A.I.D. - private sector planning is needed for each section of the program. The meetings produced a preliminary overall design with five main areas of activity. Further joint planning will be needed in each area and this may rebound to alter the overall design.

The outline below describes a comprehensive program with funding of approximately $10 million dollars per year. This program will not spring to life full-blown at some date in the future, but will necessarily start small. Hence, this program can be considered a guide for future development. The ultimate

shape of the program will be determined by both planning and action--pursuing promising activities and winnowing out less successful ones.

B. Goals and Policies for Section 107

Goals: The over-all goal for the program expressed at the April-May meetings is to assist developing countries strengthen their own capacities to develop, adapt and utilize appropriate technology. Development of indigenous capacities for appropriate technology involves policies and institutions as well as hardware. It ir ludes management, tax structures, marketing infrastructure, education, financial institutions, and other concerns.[13]

This goal is ambitious for a $10 million per year venture. Yet - as was mentioned in all our consultations - development and dissemination of appropriate technology in and by LDC's is a nascent endeavor. There are no clearly lit or conventional paths to accomplishing the job. A great deal of experimentation, learning from experience, and innovations in approaches to the problem as well as specific innovations in technology are required. It is here that the primary contribution of the Section 107 program to the larger problem of appropriate technology should be found.

The program is intended to serve, not just as a funder of

13 There was a clear consensus that while development of new technologies or transfer of technology from developed to less developed countries or among developing countries may be a part of the program, this is not the goal of the program in the first instance.

privately run projects, but as a source of experimentation, evaluation and ideas in appropriate technology which can be picked up by LDC governments and aid donors or be spread by private enterprise. This is a basic reason for using A.I.D. funds under Section 107 to engage and stimulate the talents of a wide-range of private U.S. and LDC groups. The Section 107 program is seen as a forum for innovation — a provider of yeast to leaven the larger efforts of aid donors and LDC governments.[14]

In this context, the operational goal of the program can be stated as:

—carry out innovative projects in appropriate technology in LDC's which enhance the on-going capacities of developing countries to develop and utilize appropriate technology; advance the state of practical knowledge about the problems of appropriate technology and develop through trial and

[14] As an illustration, we have an application from a U.S. small industry development group which is linked with a group in the Philippines. They propose a pilot project to provide village or household potable water systems using a ceramic filter recently developed under a Swiss government research contract for their army. The filters are reportedly extremely effective and inexpensive; they use locally available materials and could be the basis for a local industry. The pilot project estimated at $100,000 would be to see if the filters can be fitted into a system which meets local needs. If successful, dissemination might be by the Philippine government and/or by private industry.

The significance of this illustration lies in the fact that it picks up a little known technology, combines a private U.S. group and a Philippines group with local knowledge, and seeks a quick acting, flexible source of funding for a pilot effort.

evaluation, surer means for assisting developing countries develop, adapt and utilize appropriate technologies.

It is important to stress that pursuit of this goal in a particular country or project should begin - not with consideration of technology - but with identification of real needs of people in their local environment. Countries do not face appropriate technology problems in isolation. They face development problems of which technology is one part. Appropriate technology is part of a multi-disciplinary approach to development problems and it is the problems which constitute the analytical foundation for appropriate technology programs.

For purposes of program management the goal stated above will need to be refined into specific project goals whose accomplishment can be evaluated. It also needs to be linked to a higher order of goals which derives from the aid legislation itself and forms the backdrop for all Section 107 activities. As expressed at our April-May meetings, this is to: (1) help contribute to broad based growth of jobs and output in LDCs through more effective use of resources; (2) assist the poor participate in development by raising their productivity and standards of living; and (3) help foster, through technical and economic growth, national independence and self-reliance. This umbrella of principles animates all Section 107 activities.

Program Policies: As a matter of policy, the program will focus on the small scale sector in LDC's — small farms and small and medium scale enterprises. It will focus on appropriate technology to provide low cost services and consumption goods for the poor. The concentration on the small scale sector is not intended to be exclusive. In terms of jobs and improving income distribution, the program is also concerned with appropriate technical choice in larger enterprises and government public works as well as with exploiting subcontracting and other complementarities between the large and small scale sectors. In addition, the focus on the small scale sector should not be calcified as exclusive attention to the smallest farms or enterprises. These may not be productive users of appropriate technology. The point is that, while focusing on the small scale sector is basic to the program, the interpretation of this policy will need to be flexible. Fidelity to the concept cannot be ensured by definitions, but will be the responsibility of program management.

The program is expected to be oriented largely though not exclusively toward rural areas. Included are villages, market towns, and those small cities which are centers of rural regions. Although this policy was not endorsed by all participants in A.I.D.'s meetings with private groups, we believe it is operationally sound. The primary focus of the present U.S. assistance legislation and many

(not all) of the private U.S. agencies concerned with appropriate technology is toward rural development. Again, this emphasis on rural areas is considered a predominant program direction, not an exclusive focus. For instance, there is some feeling that the export oriented, traditional goods sector may be a natural entry point for appropriate technology programs in some countries and while this industry may not be rural, it may be a base from which a more rural orientation can be developed.

As a matter of policy, specific attention will be given to the role of women throughout the program.

In work overseas, emphasis will given to working with existing, qualified developing country institutions concerned with appropriate technology rather than creating new ones. This policy was strongly recommended by the private groups consulted during our April workshops. As described in Section I, there are many institutions in developing countries already working on or around appropriate technology.

As a matter of policy we believe grants under Section 107 should be given to private or publicly-supported institutions in developing countries regardless of whether A.I.D. has a Mission and a bilateral program in the country. However, by law A.I.D. can not provide direct assistance to more than 40 countries. There is a fairly complex set of considerations which apply in determining what constitutes direct assistance and we recognize that a blanket application of this policy is not possible. It depends

on legal judgments which will be made on specific proposed grant activities when the program gets underway.

As a matter of policy, we believe grants under Section 107 should require prior notification but not prior approval of Missions and Embassies in developing countries.

Emphasis will be given to maintaining close links with U.S. groups concerned with appropriate technology for the United States. Efforts will be made to encourage a return flow of information and experience from LDC efforts into the United States.

C. Program Areas Under Section 107:

As stated above, five areas for activity under the program emerged from the April-May meetings. These are:

1. Communication and coordination: Programs to gather and evaluate past and present experience with appropriate technology; to improve communication among practitioners of appropriate technology; and provide both information about selected specific low-cost technologies, and models to be tested and adapted.

2. National policies for appropriate technology: Efforts to encourage LDCs to adopt economic and other policies which facilitate choice of appropriate technology by private entrepreneurs.

3. Appropriate technology projects in LDCs: Grant projects in fields such as assisting LDC small businesses, assisting local R&D units, farm machinery and food processing, health, and energy. This is the main business of the program; the program will be organized around

six or so types of projects or functional areas, e.g. agricultural machinery, small business enterprise, health, energy.

4. Education: Projects to assist LDCs develop innovations in education systems which increase the relevance of their education investments for appropriate technology.

5. U.S. business: Programs to find means to involve U.S. businesses, on a case-by-case basis, in appropriate technology programs in developing countries.

Further explanation of these program areas follows.

1-Communication and Coordination-

This is a key function for a program which seeks to expand knowledge about alternative technologies and the do's and dont's of mounting programs to develop and disseminate appropriate technology. The private groups consulted during A.I.D.'s April and May meetings recommended strongly that the starting point for an expanded program should be to develop existing sources of information about appropriate technology, to encourage more communication among groups active in appropriate technology, and to link them to potential LDC users. Nearly one-third of the action recommendations we received during our April and May meetings concerned the need for better information. The immediate aim will be to identify and organize existing sources of information rather than create new data banks or facilities. For instance, the PASITAM survey of private agencies indicates that many of them have unique experiences with appropriate

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technology, but they lack the resources to communicate this experience to others.

Improving communications among organizations and groups active in appropriate technology is one aim of this part of the program. Another is to improve understanding and acceptability of appropriate technology among a wider audience of LDC and DC opinion leaders and policy makers. One of the barriers to expanding activities in appropriate technology in LDCs is widespread lack of understanding or negative attitudes toward the concept. Stated simply, some selling of appropriate technology is necessary. This requires - not crude proselytizing - but marshalling and presenting better information about appropriate technology in a variety of formats for different audiences.

A third aim of this aspect of the program is to develop better coordination and division of labor among groups and institutions active in appropriate technology. We received many recommendations concerning the need for an international federation of appropriate technology organizations. We understand that ITDG in London and the ILO are interested in this concept. A long-range goal in this connection would be to strengthen developing country abilities to collaborate among themselves in appropriate technology endeavors.

Some of the activities suggested during our April workshops for carrying out this segment of the program are listed below:

(1) Surveys and case studies of existing or completed projects (successful or unsuccessful) to develop and disseminate appropriate technology.

(2) Video tapes or other visual media to capture the on-going experience of practicing appropriate technology groups. Using existing groups to teach other appropriate technology groups.

(3) Travel grants - Funds for cross-fertilization of ideas through travel of practitioners, government officials, or individual entrepreneurs.

(4) Workshops and seminars for government and private persons in both DCs and LDCs.

(5) Grants to U.S. and developing country organizations involved with appropriate technology to expand their capacities to communicate their experience to others.

(6) Exchange of proven and prototype equipment.

2-National policies for appropriate technology-

Government polices have a critical impact on widespread adoption of appropriate technology by private entrepreneurs. These include policies which affect the prices faced by entrepreneurs for labor and capital, policies on credit and finance, and regulatory policies affecting small businesses. The types of policy actions which are open to government to encourage adoption of more socially useful, appropriate technology are extremely sensitive politically and include:

(1) Undertaking programs to increase the supply of wage goods (e.g. food) in order to reduce their price.

(2) Limiting the growth of wages paid by the government. These often serve as a guidepost for private sector wages.

(3) Removal of the minimum wage, particularly for new

employees, or reducing it to the levels prevailing in the craft sector.

(4) Limiting fringe benefits such as social security.

(5) Maintaining the official exchange rate at its equilibrium value, i.e., that at which the supply and demand for foreign currency will be equal, without imposition of tariffs, administrative limits on imports and so on. Alternatively, and less desirably, tariffs on imported capital goods could be introduced to raise their cost in domestic currency.

(6) Removal of interest rate ceilings.

(7) Elimination of tax incentives which reduce the cost of utilizing capital in production.

(8) Elimination of the licensing of imported raw materials, a practice which has often been shown to discriminate against small, labor intensive enterprises.

Two comments can be made on these policies: First, it would be difficult to construct a more politically contentious set of policies. Second, with the exception of individual economists at our meetings, few of the U.S. private groups we talked to see themselves as working on this sort of macro-policy issue.

This presents a problem for the program. Although it is possible to fund micro projects to develop and disseminate appropriate technology in LDCs, such efforts are probably unsustainable over time unless the environment for use of appropriate technology is favorable. This requires competition in product markets and reduction of distortions in relative factor prices.

In this context, we believe one of the goals of the program should be to find better means to encourage planners and policy makers to

design economic and institutional policies which facilitate use of appropriate technology by private entrepreneurs.

As an example of techniques which might prove useful in this regard, Pack recommends using Section 107 funds to systematically catalog alternative economically efficient techniques for various industries.[15] For example, Pack shows the aggregate employment and capital effects of four weaving techniques as follows:

Type of Loom	Requirements per 100 million square yards per annum (1) Manyears	(2) Investment	Capital/Labor Ratio (2) (1) (3)	Investment Funds Saved Using Lancashire (4)	Additional Indirect Employment (5)	Percentage Increase Output (6)
Lancashire	2,180	$ 3,582,000	$ 1,645			
Battery	1,110	7,163,500	6,454	$ 3,581,500	2,177	100
Airjet	820	7,877,700	9,665	4,295,700	2,611	120
Sulzer	510	15,006,300	29,715	11,424,300	6,944	319

Columns 1 and 2 indicate the inputs required to produce an additional 100 million square yards of material. Column 3 indicates the capital-labor ratio associated with each type of process. Column 4 shows the amount of investible funds saved by adopting the Lancashire loom, the least capital intensive one, rather than each of the others. Column 5 indicates the additional employment which could be generated by investing the funds thus saved in an activity whose capital-labor

[15] Pack, op. cit., (Attachment D)

ratio was no greater than that of the Lancashire loom. These must be added to the differences shown in Column 1 to derive the total difference in employment. Finally, Column 6 presents the percentage increase in output which could be generated by investing the saved funds in additional weaving capacity.

The table shows that using the Lancashire loom and investing the capital saved from not using the Sulzer loom, would produce about 7,1 00 more jobs and 319% more output than if the Sulzer loom was used.

Pack states that such comparisons in other industries are likely to yield equally large benefits and that these calculations may be helpful in stimulating LDC governments to consider the policy changes needed to realize these benefits.

Other activities suggested at our meetings to facilitate policy changes in LDCs include:

—Grants through private U.S. entities or direct grants to LDC institutions such as universities, science policy councils, and ministries of planning, industry or agriculture to help develop their capabilities for analyzing and choosing alternative technologies and for considering effect of alternative technologies on national economic and social development.[16]

[16] A recent study in India financed by the Ford Foundation (Tata Economic Consultancy Services, "Industry in the Second India", Orient House, Bombay, 1975.) projects industrial growth through the year 2000 assuming alternative growth strategies. Were the product mix and the technologies employed selected to increase the output to capital ratio, it should be possible to virtually eliminate underemployment and increase the GNP by 80% in the year 2000 over a projection of the currently employed strategy of relatively low output to capital industry. (Information supplied by Joseph Stepanek.)

--Travel and consultation grants to facilitate interchange of planners and policy makers among developing countries. For instance, visits to countries which have active appropriate technology policies by officials of countries which are considering such policies and programs.

--Identification of gaps in knowledge about appropriate technology and alternative policy choices and preparation of research agendas for possible funding by other agencies. (Funds from this program would not be used for research, but could be used to stimulate needed research financed by others.)

3-Selected innovative projects to develop and disseminate appropriate technology in developing countries-

This is the key activity under Section 107 in terms of the goal of the program -- developing innovations in appropriate technology, testing innovative approaches to appropriate technology, and enhancing the on-going capacities of developing country governments, institutions, and private sector to develop, adapt, and disseminate appropriate technology.

Although there is virtue in diversity, the program will need to concentrate on certain categories of problems and activities. Areas for concentration suggested so far include:

--Agricultural machinery and rural based food processing industries.

--Projects to assist small and medium scale enterprises, particularly in rural areas; facilitate utilization of appropriate technology for small and medium scale enterprises by channeling appropriate assistance to them in management, credit, marketing, as well as in technology.

--Energy for rural areas; cooking fuels.

--Health, sanitation.

--Low-cost housing

--Projects to strengthen capabilities of LDC institutions for identifying local problems and developing and disseminating appropriate technology in response to those needs. For instance, assistance to LDC research institutes or industrial extension services.[17]

Some of these areas are broad and need further sharpening. Other areas suggest themselves: rural works, construction. One of the prime tasks of the program management will be to define the portfolio of projects as a result of consultations with developing countries and A.I.D. missions, and further planning with the private sector.

[17] For a perceptive analysis of the problem of strengthening LDC institutional capacities in appropriate technology, see the paper by Bruce Koppel and Gary Hansen: Appropriate Institutions for Appropriate Technology, April, 1976, Attachment E.

An important point here is that at the project level, the multi-disciplinary aspects of appropriate technology come to the fore. As stated earlier, technology is only an ingredient in the solution of a particular development problem. The relative role of technology in a project depends on the nature of the problem and the context of the target group. This merely reiterates the truism that any specific project in an LDC must start with identification of local needs, consider the many ingredients necessary to solve the problem, and place the technology involved in its proper role.

4-Education and training-

The goal is to assist developing countries develop educational innovations which increase the relevance of their educational investments for appropriate technology.

There was a strong feeling at all the meetings that the manner in which LDC education systems are planned, curricula designed, and educational pedagogies and technology chosen is a critical part of fostering more appropriate technological development. There is evidence that curriculums in developing countries in fields such as engineering are oriented to Western standards, overly academic, or discipline oriented. Also, the formal education system reaches only a fraction of the populace giving rise to needs for grassroots training methods and programs.

While there was consensus on the problem - sufficient to warrant

its inclusion as one wing of the program - there were relatively few concrete ideas on penetrating the problem presented at the April-May meetings or in the papers we commissioned. Funds would be spent on pilot or innovative efforts which would complement or feed into larger programs. Some action ideas suggested at the meetings were:

—Grants to assist LDC institutions develop model appropriate technology design and lab courses in engineering and technology education.

—Grants to develop multi-disciplinary programs in "development technology" at developing country universities. Basic technological and engineering skills would be one aspect of such programs, but it would also include micro and macro economics, industrial and rural sociology, regional development, and R&D and extension management.

—Development of pilot programs for management training and on-the-job technical training.

5-Involve U.S. Business in Appropriate Technology Programs in LDCs-

The goal is to involve U.S. businesses in development and dissemination of appropriate technology in developing countries either by facilitating direct investments or through organized transfer of relevant business management experience and technology.

There was a consensus among the participants at the meeting that U.S. businesses should play a role in the appropriate technology effort. It was noted that many U.S. small businesses employ technology

and managerial practices which are relevant to kindred businesses in developing countries. However, there was little agreement at our April-May meetings on how U.S. companies could be best involved, particularly if the aim is a long-term, unsubsidized involvement which profits the companies.

To gain a better picture of possible U.S. business involvement in appropriate technology programs, A.I.D. commissioned an analysis of U.S. investments in developing countries, particularly evidence regarding the propensity of U.S. firms to make changes in product design or manufacturing processes in response to LDC conditions.[18]

The survey indicates that most products manufactured in developing countries by U.S. firms are generally mature and well-established. Examples might be non-leak proof batteries or or inexpensive motor scooters. The design and technology for these products has been well-worked out and the market for them in the U.S. and Europe is declining. Firms are generally loath to invest funds and engineering time in changing these product designs for developing country conditions. This tendency is reinforced by the strong preference for "Western" goods which often prevails in LDCs. Locally manufactured goods with Western brand names can often

[18] "The Inducement Of U.S. Firms To Adapt Products And Processes To Meet Conditions In Less Developed Countries", Robert B. Stobaugh, Harvard Business School, with Management Analysis Center, Inc., Cambridge, June, 1976.

command premium prices which further reduces the incentive for product adaptation.

The survey concludes that development or adaptation of simplified, but modern, products for low income markets by large multinational enterprises has not occurred often in the past and does not seem likely to expand significantly in the future. These firms are more interested in developing new products for high-income markets. The report notes, however, that development of such products might prove fruitful for small engineering firms.

The evidence on the willingness of U.S. firms to utilize labor-intensive manufacturing processes in LDCs is mixed. White reports that a number of surveys of multi-national corporations by Reuber (1973), Hughes and Seng (1969), Baranson (1971), Yeoman (1968), and Gregory and Reynolds (1965) have concluded that only a modest amount of technological adaptation has taken place, and that has been mostly in response to lower volumes, not local factor costs.[19]

But there is an interesting paragraph in Boon (1975, p. 270) that is worth recounting at some length. He describes an interview at an engine plant owned by a multi-national corporation in Mexico. At the beginning of the interview, the management assures Boon that the Mexican plant uses exactly the same technology as that used in

[19] Lawrence White, op. cit., pp. 31-33, (Attachment C).

the parent plant in the developed country. But as Boon tours the factory, it becomes clear that the factor proportions are different. The main machinery process are automated, but second-hand equipment is used. And all of the auxiliary processes, like packaging, handling, transporting and storing, are done much more labor intensively.

White feels that any researcher who looks around a multi-national corporation in an LDC is likely to find substantial adaptations of capital-labor ratios, particularly in auxiliary processes. This is the case for Boon (1975), Pack (1972, 1976), Barenson (1967, pp 59-62); Strassmann (1968, chs 5 and 6), Mason (1970), ILO (1972b, pp. 446-450), Wells (1973), and Armas (1973). Ranis (1971, 1973, 1974, 1975), Helleiner (1973a; 1973b), and Baerresen (1971) find multi-national corporations adapting to labor-intensive processes for export products.

Both locally controlled firms and multi-national corporations can and do adapt their factor proportions. Is either group more likely to adopt more labor-intensive methods? On this question, Strassmann, Pack, and the ILO mission to Kenya all find the multi-national corporations to be more labor-intensive; they explain this on the grounds that adopting labor-intensive technology requires good management and multi-national corporations have this in abundance. Mason (1970;1973) finds that for a group of matched pairs of firms, U.S. controlled firms tend to be somewhat

more capital-intensive than locally owned Philippino or Colombian firms; he explains this on the grounds that the U.S. firms pay higher wages and have access to cheaper capital. Radhu (1973a) also finds foreign firms to be more capital intensive than locally owned Pakistani firms. But Cohen (1973; 1975) finds no significant differences between foreign and Korean firms producing for export markets. The evidence is clearly mixed.

White concludes that although the multi-national corporations may not be the heroes of appropriate technology, they appear to be far from the villains that many make them out to be. They have the management expertise, and they are frequently willing to use it to adapt to labor intensive processes.

These surveys are general. But they clearly indicate that U.S. firms investing in LDCs are not a monolith. As our meetings with the private sector clearly confirmed, there are companies and people within companies who are clearly concerned with the problems in developing countries and are seized with the idea of appropriate technology. Ford and General Motors are both producing and marketing low-cost vehicles in developing countries.

What this indicates is that opportunities for involving U.S. firms in appropriate technology doubtless exist on a case by case basis, and the strategy for the Section 107 program -- initially at least -- is to search out such opportunities and seek to capitalize on them. There was a clear consensus at all our meetings that more investigation of

such opportunities should be undertaken and modest experimental programs launched.

Some initial ideas for activities which emerged at the meetings include:

(1) Establish a system (possibly through banks) to seek out medium-sized U.S. companies for matching identified needs in developing countries.

(2) Conduct surveys and in-depth analysis to determine what it takes to get U.S. small business to participate in the process of technology transfer.

(3) Fund a two-way exchange program for managers of U.S. and LDC small business to facilitate transfer and know-how and technology.

(4) Assist emerging small scale industry projects to develop by encouraging the direct involvement of similar U.S. small businesses.

(5) Organize a number of firms in a specific U.S. small scale industry to help them transfer technology and management practices to similar firms abroad. For instance, the Denver Research Institute is considering organizing about 30 small metal working firms in Colorado as a resource for technical and managerial advice for similar working firms in Mexico.

(6) Training or orientation programs in the choice and evaluation of appropriate technologies for U.S. equipment suppliers, U.S. manufacturing companies, and U.S. consulting firms. Such courses could be given on an industry basis and include entrepreneurs from LDCs.

In addition, monetary incentives might be used to encourage U.S. firms to consider alternative technology, although we believe the Section 107 program should be very cautious about using grant funds as incentives. Some suggested ideas are:

a) Ask U.S. investors about to invest in a less-developed country to develop a new design of plants that would employ more labor and use less capital than their customary plant designs. If the investor, after having developed a new design decided not to use it, Section 107 grants would pay for the extra expenses incurred in making the design (a limit on the expenses provided would be set in each case) and would obtain the rights to the design so that it could be made available to other firms. If on the other hand, the new design were to be adopted by the firm that developed it, no reimbursement would be due.

b) Give grants to U.S. equipment manufacturers to encourage the development of appropriate technologies for less-developed countries. The reward system might be similar

to that discussed above under (a); i.e. the firm is paid for the design if it does not use it, but not paid if it does.

CODA - Window on the West

All the activities and goals described for the program above are directed toward developing countries. Yet part of the audience for the Section 107 program lies in the United States. This is true in several senses.

First, as already stated, the program is to serve as a source of expertise, knowledge, and influence on A.I.D. and other donors.

Second, there are actions - large and small - which can be taken in the United States to facilitate the development and dissemination of appropriate technology in developing countries. For instance, U.S. universities can be encouraged to introduce appropriate technology into engineering courses for foreign students. There are both national and international policies (for example, international patent policies) which can hamper LDC efforts to develop their own appropriate technologies. A program of the size of Section 107 cannot do much to deflect these forces. But it can maintain a watch on them and - at the least - not proceed on the narrow assumption that the problem of appropriate technology for LDCs lies solely overseas.

Third, there is a signficant movement in this country toward lower cost, small scale, decentralized technology. The National

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Center for Appropriate Technology is being established in Montana under federal funding. There are numerous private groups at work. The appropriate technology program needs to build links to these groups both to help overcome the notion that appropriate technology is suited only for underdeveloped countries and to encourage two-way flows of information between domestic and overseas groups.

III. Organization

A. INTRODUCTION: When the House International Relations Committee wrote Section 107, they felt that a small, independent, non-profit entity should be established outside A.I.D. to make grants and coordinate Section 107 activities. According to the staff of the Committee the reasons were:

—a feeling that a small unit would be more flexible, could act quickly, and better fulfill the innovative spirit of Section 107 than an A.I.D. office.

—a feeling that an independent private entity with a governing board from the private community would more readily garner private sector support and stimulate private efforts.

The HIRC realized that an outside organization might drift away from A.I.D. They felt this could be overcome by appropriate linking mechanisms.

The committee originally planned to require an independent institute as part of the new legislation. At our request, they deleted this provision and requested that A.I.D. "study proposals for an institute of intermediate technology." This has been a major part of the A.I.D. work group's task.

A.I.D. identified three organizational options for the program. These are: (1) a new, independent, private, non-profit organization to make grants and contracts to carry out Section 107 activities; (2) a new, independent government corporation outside A.I.D. (on the model

of the Overseas Private Investment Corporation or the Inter-American Foundation); or (3) an Office of Appropriate Technology inside A.I.D. responsible for the full range of Section 107 activities.

After careful consideration, A.I.D. has decided on an independent, private, non-profit organization to carry out Section 107 activities. We have chosen this option because we believe that it can best fulfill the innovative, private aspects of the program.

An independent, non-profit organization will be an organization of and by the private sector. It will have a board consisting of representatives of business, private and voluntary agencies, universities, and others. The orientation of both the board and staff will be toward the private sector. As such, we believe the program will readily garner private sector support.

In addition, experience with similar organizations has shown that they generally have a great deal of flexibility and can make grants rapidly in response to perceived opportunities. There is less procedural red tape and more rapid decision-making. Such organizations have a great deal of flexibility in hiring and managing staff — a condition which does not pertain in A.I.D.

We believe these attributes have an important bearing on the innovativeness of the program. Certainly no organizational format can ensure innovativeness, but the flexibility, links with the private sector, and ability to act rapidly which are characteristic of a small, independent organization are to some extent preconditions for innovation

and thus we have endorsed this alternative.

At the same time, A.I.D. is concerned that the Section 107 program serve as an energizer and resource for A.I.D.'s development program.

As stated in Section I, A.I.D. already has a diversified portfolio of activities in appropriate technology. Congress expects - and A.I.D. intends - that we increase our concern with appropriate technology both in terms of specific appropriate technology projects and as an integral part of our development activities.

Hence, it is vitally important that ideas generated in Section 107 experimental programs reach the programmers of other A.I.D. funds. It is important that A.I.D. be a strong customer for real, useful, innovative, replicable, and adaptable appropriate technology emanating from the Section 107 program.

A.I.D. is concerned that appropriate linkage mechanisms be established and a strong degree of complementarity be maintained between activities carried out under Section 107 and the overall A.I.D. program. We expect that there will be close consultation between A.I.D. and the management of the new Section 107 entity in developing policy, program goals, and strategy. This collaboration would be a continuation of the A.I.D. - private sector dialogue begun during our April and May meetings.

Complementarity between A.I.D. and the new Section 107 program does not mean a one to one correspondence of policy and program. If

the new organization is to fulfill its innovative mandate, it needs freedom to move into areas and activities in which A.I.D. is not currently active. In this sense, ensuring complementarity becomes something of a balancing act: maintaining broad congruity with A.I.D.'s priorities while preserving enough freedom to embark on new initiatives. Keeping these in balance will require close communication and collaboration between A.I.D. and the management of the new entity.

In terms of specific activities, there are a number of on-going and prospective A.I.D. projects which might be referred to the new 107 entity for possible funding as grant projects. We believe over time a division of labor will evolve under which certain types of actions will be funded by Section 107 and others through normal A.I.D. channels. However, such a division of labor should evolve only as the new organization demonstrates its competence in given areas. The criteria for deciding which types of projects might be referred to the new organization and which types should be funded by A.I.D. directly should evolve as the Section 107 program develops and be based on development of demonstrated competence by the new entity.

The basic point is that A.I.D. expects to continue to be a creative actor in appropriate technology; the existence of the Section 107 program does not absolve the agency from this responsibility. A.I.D. bureaus and offices will continue to develop appropriate technology projects and activities. As the new organization develops, it is expected to become a growing resource for A.I.D. efforts, but it

is not intended to substitute for A.I.D. efforts nor will it be the only resource available.

B. Organizational Framework: The decision to establish a new, independent, private entity for Section 107 is one aspect of the proposed organizational framework for appropriate technology. Beyond this, there need to be appropriate mechanisms for linking the Section 107 and A.I.D. program. Hence, the organizational format we propose has several parts.

The first is the new, non-profit Appropriate Technology Fund. This organization will receive an annual grant from A.I.D. for Section 107 programs and will, in turn, make sub-grants to contract with private or publically supported groups in developed and less developed countries.

The second is establishment of a small office within A.I.D. to act as liason with the new Fund, and service appropriate technology activities carried out by A.I.D.'s bureaus and missions. This office will have the prime responsibility for ensuring complementarity between A.I.D. and the Section 107 program. It will oversee the annual grant to the to the new entity. It will provide information and help locate technical help for bureaus and Missions which are working on appropriate technology problems.

Linking these two organizational elements will be a series of policies and procedures which will govern - in effect - the quality and effectiveness of the relationship between them. These include among other things: provisions for A.I.D. participation at the board level of the new organization; provisions for A.I.D. participation in

technical panels or conferences called by the Fund; and provisions in the grant agreement designed to insure consultations on policy and program, and flexibility in day to day operations.

We outline each of these three elements below. Much detailed planning remains to be done. This will be carried out following approval of this report by the Congress.

C. The Appropriate Technology Fund: The Fund will be an independent, non-profit corporation located in the Washington area.

The Fund will not be an operational entity in the sense that it will run appropriate technology programs overseas. It will be a facilitator of actions in apppropriate technology taken by others. It will make grants to or contracts with private groups; serve as a resource for A.I.D. programs; serve as a communications channel; and help organize and coordinate the activities of various U.S. and LDC groups active in appropriate technology.

More specifically, the functions of the Fund will be to:

1. Develop overall policy and programs for Section 107.
2. Encourage innovations in appropriate technology and projects to develop and disseminate appropriate technology in LDCs; receive, review, and approve projects and grants.
3. Evaluate appropriate technology projects and programs; seek widespread utilization of appropriate technology innovations, or adoption of appropriate technology programs,

by LDC governments, private enterprises, or A.I.D. donors.

4. Promote awareness of appropriate technology; serve as a communication point; help transfer selected information about appropriate technology.
5. Encourage networks of organizations interested in appropriate technology in the United States and LDCs; help coordinate activities of organizations interested in appropriate technology.
6. Serve as a source of, and link to, appropriate technology resources for A.I.D. projects and programs.
7. Receive and disburse funds from A.I.D. and other organizations; hire staff and consultants.

The Appropriate Technology Fund will be empowered to receive funds from sources other than A.I.D. for programs in appropriate technology. This could include contributions from U.S. foundations or corporations. It could include support or contracts for specific projects. While A.I.D. welcomes such contributions, we are assuming that A.I.D. will provide most if not all of the funding for the Fund. A.I.D.'s decision to establish the Fund is not based on the expectation that it will become self-supporting or receive major outside contributions in the foreseeable future.

The Section 107 authorization extends to 1978, but the proposal for a new, independent fund assumes implicitly that the Congress will continue the authorization beyond this date assuming adequate performance. We believe - if the Congressional Committees accept this proposal -

that they should provide explicit assurance that they understand the funding basis for the new Fund and that they will not condition future funding on criteria other than performance.

We believe the Board of Directors for the Fund should include representatives from business, private and voluntary agencies, academic institutions and alternative technology groups in the United States. We believe at least two A.I.D. officers should participate regularly in Board meetings as non-voting observers and as advisers on A.I.D. policies.

In terms of organization and staffing, we have drawn up organization charts, staffing patterns, and cost figures for two illustrative versions of the Appropriate Technology Fund. These are attached to this report. They are intended to indicate the approximate maximum magnitude of the outside office and serve as a guide for planning.

In drawing up these organizational proposals, we consulted with two organizations which are analogs for the proposed Appropriate Technology Fund: the Inter-American Foundation, and the Pathfinder Fund in Boston.

The Pathfinder Fund is an independent, non-profit fund which receives $4-5 million per year from the A.I.D. Population Office. It, in turn, makes small sub-grants to LDC and (some) U.S. organizations for family planning projects. It has a staff of 27 persons at its Boston headquarters and 35 employees (all foreign nationals) in 6 field offices overseas. Its administrative and staff costs amount to about $1.0 million out of a $4.5 million budget. ($600,000 for the Boston staff; and $400,000 for the

regional offices.) It receives 90% of its budget from A.I.D. Pathfinder makes about 180 small grants a year ranging between $2,000 and $20,000.

The Inter-American Foundation is larger. It is an independent government corporation which makes grants to LDC private groups for social and community development projects. Its budget is about $20 million a year; its grants average about $120,000 each — the smallest being $400 and the largest $1.8 million. It has a staff of 64, all in Rosslyn, Virginia. Total costs for salaries and administration are about $1.8 million per year.

We estimate that the proposed Appropriate Technology Fund established for Section 107 would be somewhat larger than Pathfinder's 27 man Boston headquarters and smaller than IAF. We follow the IAF pattern of having no overseas offices. We have estimated average grants of $100,000, and a maximum annual budget of $10.0 million per year.

Appropriate Technology Fund - Alternative A: The first version of the Fund would be at maximum a 30 man office consisting of 12 program professionals, 8 administrative staff, and 10 clerical/secretarial staff. The professionals include a director and deputy, eight specialists in fields such as small business enterprise, and agriculture machinery and food processing, and a two man communications/information/evaluation staff. Total annual staff and overhead costs are $1,004,820.

Appropriate Technology Fund - Alternative B: This is based on consultations with the Pathfinder Fund. The estimated maximum total staff under this alternative is 34 and administrative and overhead costs would be $1,021,738.

The principle difference between this and Alternative A is that it: (1) reduces the administrative staff; and (2) strengthens the professional staff. On the professional side, there are two specialists in each functional area and, except for an editorial associate, there is no separate communications staff. Communications and information would be part of the job of the functional specialists and thus better integrated into the ongoing program. The smaller administrative staff is based on Pathfinder's experience. It assumes that auditing and legal services would be purchased from commerical firms.

The organization charts for these alternatives are attached. We emphasize that these charts are illustrative and intended to indicate the approximate eventual size of a mature organization. The organization will start small and evolve as its program grows.

D. Appropriate Technology Liason Office: This will be a small office located in the Technical Assistance Bureau in A.I.D. We currently estimate a staff of two professionals for the office. However, we are planning to conduct a more detailed review of the functions and staff requirements for this office. This will include the expected workload for the office, current and prospective Agency involvement in appropriate

technology programs, analysis of the number of staff in A.I.D. regional and central bureaus who either now carry or potencially could carry responsibilities in appropriate technology and the desireability of utilizing or augmenting this staff rather than further building up a central office.

The functions of the liason office would be to:

- Manage the annual grant to the Appropriate Technology Fund.
- Maintain liason with Fund including attending board meetings.
- Consult on A.I.D. projects involving appropriate technology.
- Provide information about appropriate technology for A.I.D. bureaus and missions.
- Locate technical and other expertise to assist Missions. (From both the Appropriate Technology Fund and other sources.)
- Represent A.I.D. in international meetings on appropriate technology.

The office is intended to serve as a source of information and technical resources to meet Mission needs. Missions, of course, do not normally face appropriate technology problems in isolation. They face development problems of which appropriate technology may be an ingredient. Hence, the office must relate in a multi disciplinary fashion to other staff offices in A.I.D. which are concerned with serving Missions.

The basic role for the internal office is to respond to Mission

and bureau needs for assistance in appropriate technology. It should function as a link in a bottom-up chain which starts with appropriate technology related problems emanating from Missions. It is only by reflecting the real concerns of Missions and bureaus that it can best represent the concerns of the Agency in dealing with the outside office.[20]

For these reasons, we believe the internal office should be quite small. It should develop and maintain strong links with staff in the missions and the regional and central bureaus who are concerned with appropriate technology. We believe the current A.I.D. Appropriate Technology Work Group might be continued as a means for funneling the concerns of regional and other bureaus into the internal office and hence on to the new Appropriate Technology Fund.

E. Policy and Procedures: The policy and procedures adopted by the Board of Appropriate Technology Fund and by A.I.D. in its grant agreement with the Fund will be critical in maintaining the proper balance between operational independence and flexibility for the new organization and close communication and complementarity with A.I.D. Tension between these two operational principles is inherent in the Section 107 legislation.

[20] We do not mean that the internal office will not be an active promoter of appropriate technology concepts within the Agency. We do believe that the office can best be an active promoter of appropriate technology by relating to real problems of Missions not by selling activities conceived in Washington.

On the substantive level, Section 107 creates a tension between the innovative, private aspects of the program -- with its concommitant need for independence from A.I.D. — and the requirement that the program serve as a resource for A.I.D., with its concommitant need to stay close to A.I.D.

On the administrative level, there is a tension between the need for procedural flexibility, rapid action, and minimal red tape, and A.I.D.'s ongoing need to ensure accountability and proper expenditure of funds.

These tensions will persist. Maintaining the proper balance between them will require close communication and careful consideration of policy and procedures governing mutual relations between A.I.D. and the new entity.

These procedures fall in three areas:

(1) Procedures in over-all program and policy: Here we believe the operating principle should be to encourage the closest possible coordination and consultation between A.I.D. and the Appropriate Technology Fund. We believe the new organization should develop open, participatory processes for policy and program development which engage A.I.D. staff as well as U.S. and LDC private sector groups. The workshops held in April this year constitued a first step in this direction and we believe similar methods should be used in the future.

We recommend that two A.I.D. persons participate ex officio

on the board of the Fund, and that A.I.D. join in technical panels, advisory boards or planning conferences sponsored by the Fund. The basic principle to be followed between A.I.D. and the new Fund is close coordination in development of over-all policy and programs and maximum freedom in day to day operations.

(2) Procedures Governing Specific Sub-Grant and Contract Activities: Here the operating principle should be to provide flexibility for the outside entity to approve specific sub-grants and contracts without prior approval from A.I.D. This will require development of criteria and guidelines for the Fund's financial/accounting system, procurement system and programming and grant approval process. Once these guidelines have been mutually agreed upon, the Fund should have latitude to approve individual projects without prior A.I.D. approval.

(3) Operational Procedures: Again we believe that the operating principle should be to provide maximum flexibility to the new agency and to its grantees. As stated in Section I, we recommend that the Fund have authority to approve grants for activities in non-A.I.D. countries subject to the existing statutory limitations on direct A.I.D. assistance. We recommend that grants and travel by the Fund staff require prior notification but not prior approval of Missions and Embassies.

We also recommend that a mutually agreed upon ceiling on operating expenses be established in the grant agreement so as to maintain an appropriate balance between operating and program expenses.

In addition, the A.I.D. grant handbook contains 15 pages of optional provisions which stem from A.I.D. policy and may be waived by A.I.D. These include provisions such as Buy America, Fly America, and Ship America. Some of these policies are generally sound. Others, such as the Buy America provision, need reconsideration.

The grant agreement will be the instrument for considering these policies and we will seek to follow a policy of minimum restrictions.

Next Steps: Assuming approval of this report by the House International Relations Committee and the Senate Committee on Foreign Relations, A.I.D. will move immediately to implement the actions recommended in this paper. The next steps to be taken include:

—Creation of the internal A.I.D. appropriate technology office including designation of its staff members.

—Planning for the Appropriate Technology Fund including identification of incorporators and inviting the incorporators take the necessary steps to draw up articles of incorporation for the Fund.

—Planning for consultations with LDC governments and private groups about programs and priorities in Section 107.

—Joint A.I.D. - private sector planning regarding the organization, staffing, and initial budgets for FY 1977 and FY 1978 for the Fund; development of a draft grant agreement and policies.

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--Review of current A.I.D. efforts in appropriate technology and consideration of means to better integrate appropriate technology into A.I.D.'s program. This review will include reconsideration of staffing and location of the internal appropriate technology office as well as other bureau staff.

Estimated Annual Costs for a
Proposed Organization Within A.I.D. for Appropriate Technology
(Alternative A)

I. Salaries and Benefits — $662,765

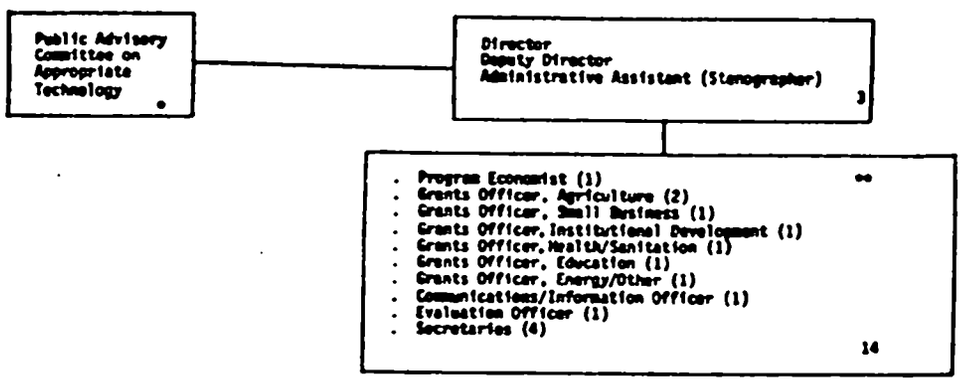
A. Central AT Entity*	Salaries	Benefits
1. Director (GS-17)	37,800	3,553
2. Deputy Director (GS-16)	37,800	3,553
3. Administrative Assistant (GS-10)	16,306	1,533
4. Program Economist (GS-15)	34,441	3,237
5. Communications/Information Officer (GS-14)	29,546	2,777
6. Grants Officer, Agriculture (GS-15)	34,441	3,237
7. Grants Officer, Agriculture (GS-15)	34,441	3,237
8. Grants Officer, Health (GS-15)	34,441	3,237
9. Grants Officer, Education (GS-15)	34,441	3,237
10. Grants Officer, Small Business (GS-15)	34,441	3,237
11. Grants Officer, Institutional Development (GS-15)	34,441	3,237
12. Grants Officer, Energy/Other (GS-15)	34,441	3,237
13. Evaluation Officer (GS-14)	29,546	2,777
14. Secretary/Stenographer (GS-7)	12,150	1,142
15. Secretary/Stenographer (GS-7)	12,150	1,142
16. Secretary/Stenographer (GS-7)	12,150	1,142
17. Secretary/Stenographer (GS-7)	12,150	1,142
B. Staff Augmentations in other AID entities, Supportive of the AT Program		
1. Grant Administration Officer (GS-13)	25,198	2,369
2. Grant Administration Officer (GS-13)	25,198	2,369
3. Secretary/Stenographer (GS-7)	12,150	1,142
4. Program Analyst (GS-13)	25,198	2,369
5. Other (2)	43,035	3,902
Total	605,957	56,808

II. Overhead Factor (calculated as 25% of salaries and benefits to cover travel, consultants, overtime, space, telephone, administrative procurement, etc.) — 165,691

Total — $828,456

*There are now two positions established in the Bureau for Technical Assistance; thus, the net additional would be 21 positions.

ALTERNATIVE A: PROPOSED ORGANIZATION WITHIN A.I.D. FOR APPROPRIATE TECHNOLOGY



* The assumption is made that sub-committees may be established for specific functional areas, e.g., Health, Small Business, etc.

** Any one of the program specialists could act as chief of the unit assuming he/she is a broad-gauged individual with executive capacity.

NOTE: The total staff of the proposed new AID Office is 17. Grants would be processed by SER/Contract Management. SER/CM estimates 3 additional positions would be required. The program will also use services of GC, Audit, PPC, Public Affairs, etc. Estimated additional workyears are 3.

ALTERNATIVE A: PROPOSED ORGANIZATION WITHIN A.I.D. FOR APPROPRIATE TECHNOLOGY

Public Advisory Committee on Appropriate Technology

- Participates in the formulation of policy for the AT program.
- Advises, through sub-panels, on the substance and content of project proposals

Office of the Director

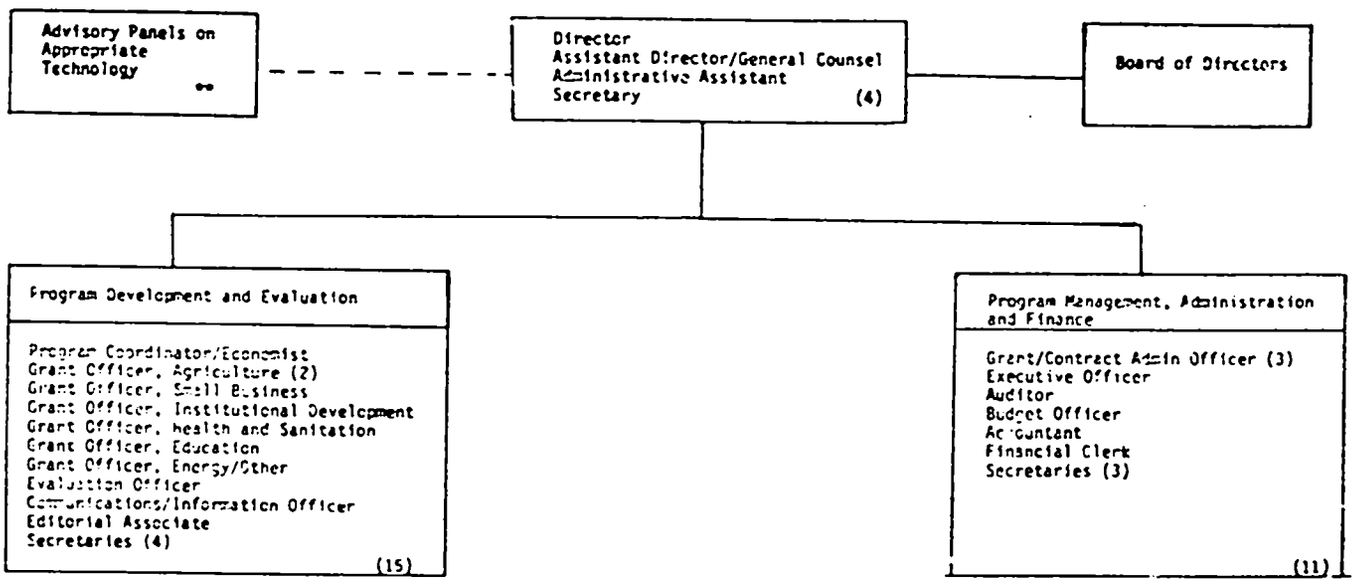
- Reviews/approves Section 107 grants within delegated authority.
- Acts as the focal point for liaison with the public advisory committee on AT.

- Recommends areas for grant and/or AID activity;
- Reviews and recommends decisions on Section 107 grants; reviews the AT element of AID projects;
- Encourages networks of AT organizations; helps organize substantive AID-Private Sector panels;
- Consults on AID and private sector projects or identifies/recommends consultants for same;
- Develops and oversees evaluation system for projects;
- Conducts seminars and informational meetings on AT; acts as liaison link with U.S. and LDC AT organizations;
- Compiles reports, blueprints,etc. on AT; provides same upon request.

ESTIMATED COSTS FOR A
PROPOSED PRIVATE NON-PROFIT ORGANIZATION FOR APPROPRIATE TECHNOLOGY
(ALTERNATIVE B)

		Salaries	Benefits	
I.	Salaries and Benefits			847,985
1.	Director	55,000	5,170	
2.	Assistant Director/General Counsel	50,000	4,700	
3.	Administrative Assistant	16,306	1,533	
4.	Secretary	12,150	1,142	
5.	Program Coordinator/Economist	34,441	3,237	
6.	Grant Officer, Agriculture (2)	68,882	6,474	
7.	Grant Officer, Small Business Development	34,441	3,237	
8.	Grant Officer, Institutional Development	34,441	3,237	
9.	Grant Officer, Health and Sanitation	34,441	3,237	
10.	Grant Officer, Education	34,441	3,237	
11.	Grant Officer, Energy/Other	34,441	3,237	
12.	Evaluation Officer	29,546	2,777	
13.	Communications Officer	29,546	2,777	
14.	Editorial Associate	16,306	1,533	
15.	Secretaries (4)	48,600	4,568	
16.	Executive Officer (Personnel, GSO)	29,546	2,777	
17.	Auditor	34,441	3,237	
18.	Budget and Fiscal Officer	25,198	2,369	
19.	Accountant	29,546	2,777	
20.	Financial Clerk	16,306	1,533	
21.	Secretaries (3)	36,450	3,426	
22.	Contract/Grant Administrators (3)	75,594	7,107	
	Total	780,063	67,922	
II.	Overtime (500 hours @ $9.40)			4,700
III.	Consultants (350 days @ $100)			35,000
IV.	Travel			50,000
V.	Administrative Procurement/External Auditing Services			12,000
VI	Rent, Equipment, Supplies, etc.			55,135
		Total		$1,004,820

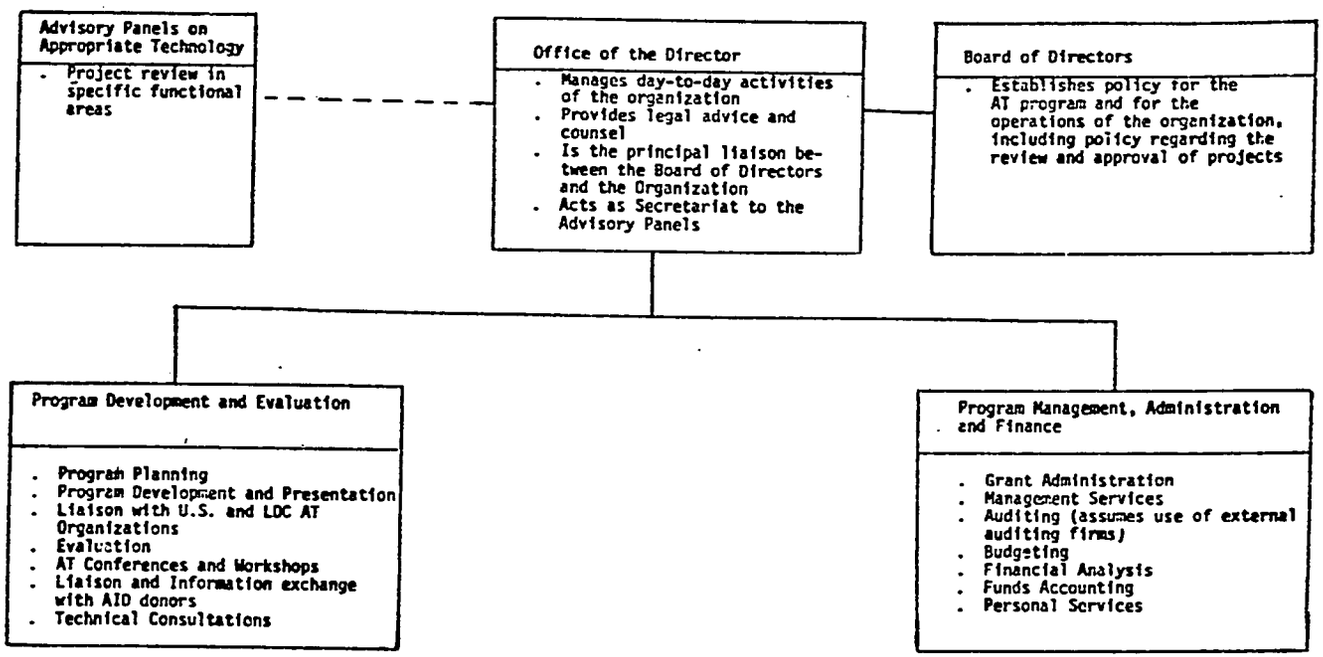
ALTERNATIVE B: PROPOSED ORGANIZATIONAL ARRANGEMENT FOR A PRIVATE, NON-PROFIT ORGANIZATION FOR APPROPRIATE TECHNOLOGY*



* Proposal developed by AID/SER/MP in consultation with AID Work Group on Appropriate Technology.

** The assumption is made that project review panels may be established for specific functional areas; e.g. Health, Small Business, etc.

ALTERNATIVE B: PROPOSED ORGANIZATIONAL ARRANGEMENT FOR A PRIVATE, NON-PROFIT ORGANIZATION FOR APPROPRIATE TECHNOLOGY*



* Proposal developed by AID/SER/MP in consultation with AID Work Group on Appropriate Technology.

ALTERNATIVE B & C: SMALL, INTERNAL OFFICE IN A.I.D.

Appropriate Technology Liaison Office
- Chief - Development Officer - Secretary
Functions: -- Manages annual grant to outside Appropriate Technology Fund. -- Maintains liaison with Fund including attending board meetings. -- Reviews and consults on AID projects involving appropriate technology, liaison to U.S. sources. -- Represents AID in international meetings on AT.

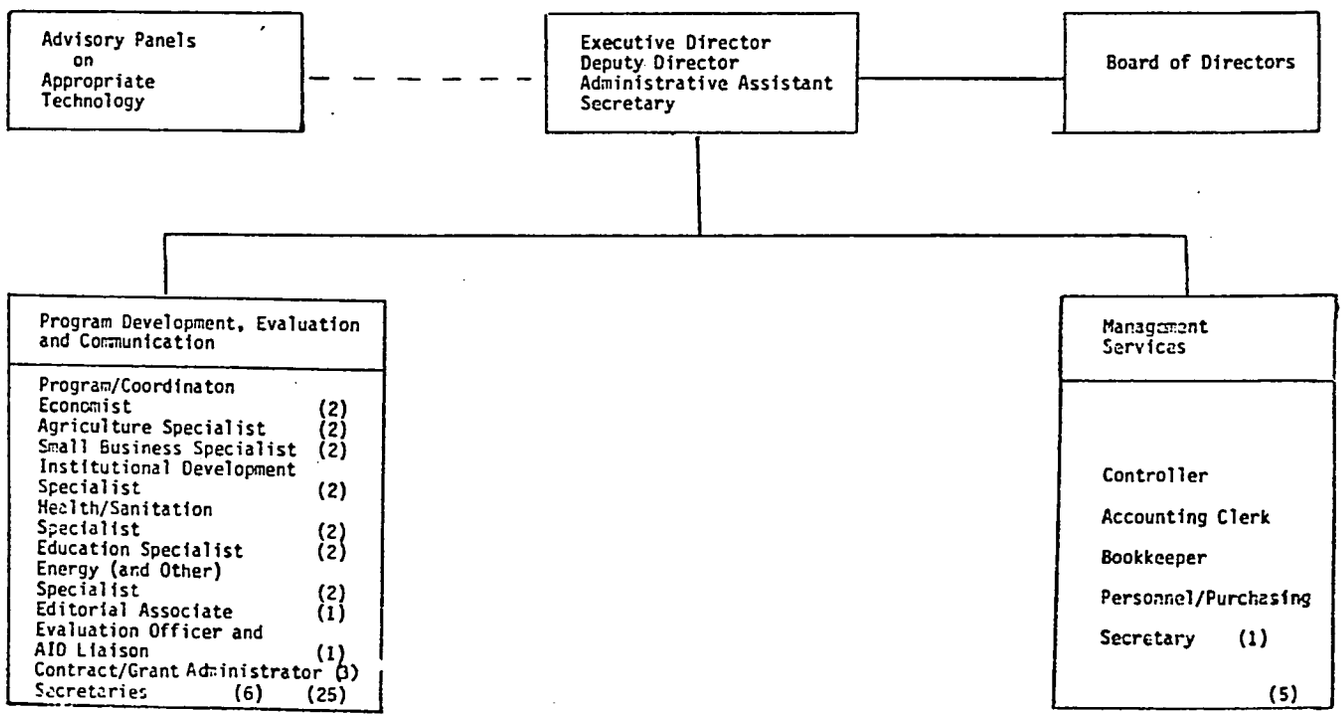
ESTIMATED COSTS

FOR A PRIVATE, NON-PROFIT ORGANIZATION FOR APPROPRIATE TECHNOLOGY
(Suggested by Gaines B. Turner, Director of Operations, Pathfinder Fund)

(Alternative C)

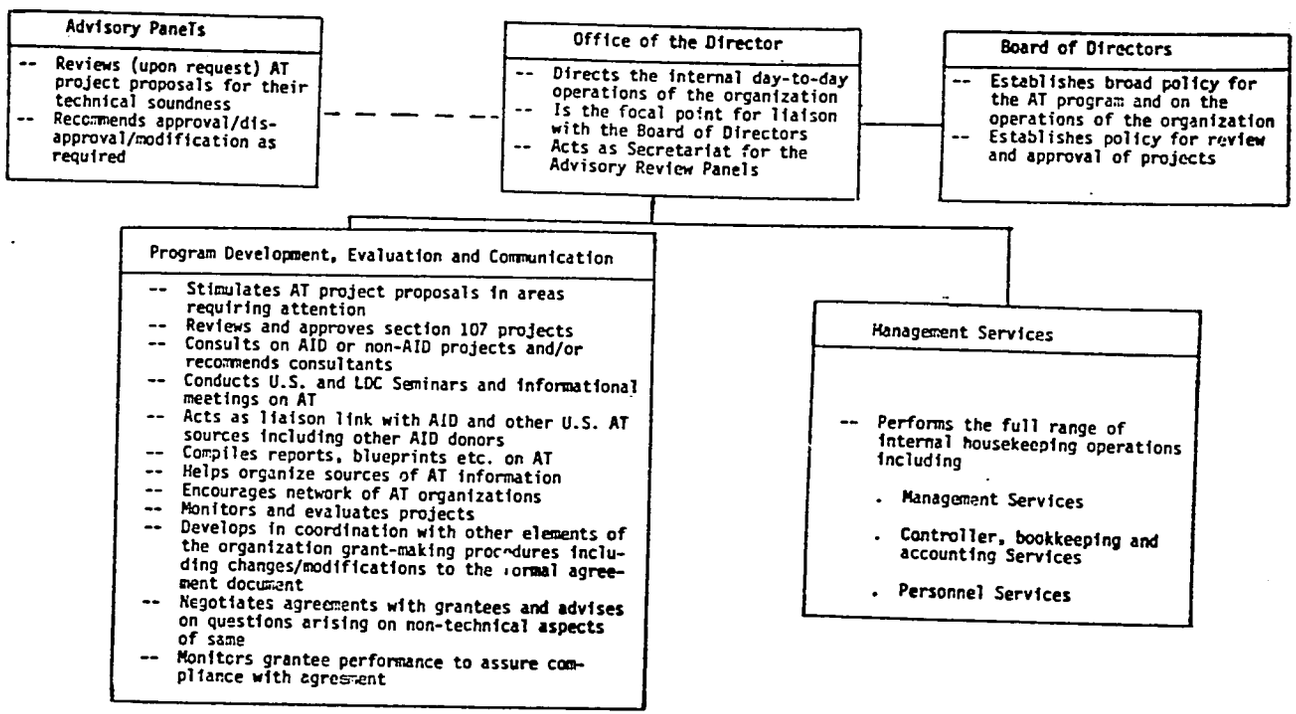
Salaries and Benefits			$856,903
	Salaries	Benefits	
1. Executive Director	$ 55,000	$ 5,170	
2. Deputy Director	50,000	4,700	
3. Administrative Assistant	16,306	1,533	
4. Secretary	12,150	1.142	
5. Program Coordinator/Economist	34,441	3,237	
6. Program Coordinator/Economist	16,306	1.533	
7. Agriculture Specialist	34,441	3,237	
8. Agriculture Specialist	16,306	1,533	
9. Small Business Specialist	34,441	3,237	
10. Small Business Specialist	16,306	1,533	
11. Institutional Development Specialist	34,441	3,237	
12. Institutional Development Specialist	16,306	1,533	
13. Health Sanitation Specialist	34,441	3,237	
14. Health Sanitation Specialist	16,306	1,533	
15. Education Specialist	34,441	3,237	
16. Education Specialist	16,306	1,533	
17. Energy/Other Specialist	34,441	3,237	
18. Energy/Other Specialist	16,306	1,533	
19. Editorial Associate	16,306	1,533	
20. Evaluation Officer	29,546	2,777	
21. Contract/Grant Administrators (3)	75,594	7,107	
22. Secretaries (7)	85,050	7,994	
23. Controller	34,441	3,237	
24. Accounting Clerk	12,150	1,142	
25. Bookkeeper	16,306	1,533	
26. Personnel/Purchasing	25,190	2,369	
Total	$783,276	$73,627	
II. Overtime			4,700
III. Consultants			35,000
IV. Travel			50,000
V. Administrative Procurement (e.g., audit services, etc.)			20,000
VI. Equipment and Supplies			55,135
Total			$1,021,738

ALTERNATIVE C: PROPOSED ORGANIZATIONAL ARRANGEMENT FOR A PRIVATE NON-PROFIT ORGANIZATION FOR APPROPRIATE TECHNOLOGY



* Proposal suggested by Gaines B. Turner, Director of Operations, Pathfinder Fund.

ALTERNATIVE C: PROPOSED ORGANIZATIONAL ARRANGEMENT FOR A PRIVATE NON-PROFIT ORGANIZATION FOR APPROPRIATE TECHNOLOGY



ALTERNATIVE B & C: SMALL, INTERNAL OFFICE IN A.I.D.

Appropriate Technology Liaison Office
- Chief - Development Officer - Secretary
Functions: -- Manages annual grant to outside Appropriate Technology Fund. -- Maintains liaison with Fund including attending board meetings. -- Reviews and consults on AID projects involving appropriate technology, liaison to U.S. sources. -- Represents AID in international meetings on AT.

IV. APPROPRIATE TECHNOLOGY - DEFINITION

Appropriate technology is technology which enables developing countries to provide goods and services for their people in a manner which is compatible with their economic and social conditions.

Appropriate technologies relate both to economic and non-economic goals. They are applicable to employment, output, and equity objectives, as well as goals in population, health, nutrition and education.

Given typical LDC conditions of scarcities of capital and skilled labor with an abundance of unskilled and semi-skilled labor, and taking as objectives of development assistance:

-- growth of employment and output through more effective use of resources,

-- while decreasing inequalities in income distribution,

-- emphasis on the basic needs of the poor, both economic and non-economic, and

-- increased participation of the poor in all aspects of the development process.

It is expected that technologies appropriate in production will generally have the following characteristics:

1) They will be intensive in the use of the abundant factor, unskilled labor, and economical in the use of scarce factors, capital and highly trained personnel.

   In the provision of services, appropriate technology relies to the extent possible on less highly-skilled labor - economizing on human capital. Appropriate technologies do not demand sophisticated skills of their users.

2) Appropriate technologies are primarily based on locally and domestically-produced inputs, or on the use of national (not expatriate) personnel.

3) Appropriate technologies in physical production are economically efficient in small and medium-scale enterprises, replicable by local entrepreneurs, and often produce primarily for a local or regional market.

It is expected that goods appropriate to LDCs in consumption will emphasize the needs of the poor: they will generally be

— low cost,

— accessible to low-income people,

— individually or locally maintainable without extensive support requirements,

-- compatible with local cultural patterns.

Appropriate service technologies are those designed to produce manpower and medical care relevant to the requirements of the poor. They, similarly, will be low-cost, accessible, and compatible with local cultural patterns.

None of these characteristics are binding. That is, satisfaction of these criteria does not certify a technology as appropriate. They are merely a set of attributes set out in order to give substance to the definition set out in the first paragraph: technology which enables developing countries to provide goods and services in a manner compatible with their conditions.

What is appropriate in each country's development situation will be different in every case. For example, in a small country with a

limited internal market, production for export may be important, for which a different product may be appropriate than for domestic consumption.

While appropriate technology emphasizes small-scale production, in a number of circumstances, such as economies of scale, large-scale production may be appropriate.

Appropriate technologies are expected to contribute to employment, output, and equity objectives, meeting the needs of the poor, and increasing participation by the poor in a number of ways. Emphasizing labor-intensity and employment of relatively unskilled labor will cause additional broadly-based employment of those at the bottom of society. Broad expansion of low but adequate income employment improves income distribution, contributing to a major social objective: equity. Encouraging the use of locally or domestically-produced inputs emphasizes the backward linkages of an appropriate technology: its downstream effect on domestic employment and output.

Small-scale production allows regional dispersal of enterprises, especially over rural areas, each satisfying a limited market. Some governments consider this an objective, as well as the regional self-sufficiency promoted by local industries using local inputs. Low-cost goods and services and compatibility with local culture emphasize that appropriate technologies are aimed toward the poor.

ATTACHMENT A

List of Attendees at Appropriate Technology Meetings, April 4–5, 12–13, 19–20, 26–27, and May 10, 1976

Ross M. Clemenger, Institute for International Development, 8150 Leesburg Pike, Suite 504, Vienna, Virginia 22180.

Melvin B. Myers, Church World Service, 475 Riverside Drive, New York, New York 10027.

Ross Hammond, Economic Development Laboratory, Georgia Institute of Technology, Atlanta, Georgia 30332.

Martha Stuart, 66 Bank Street, New York, New York 10014.

Thomas Fox, Executive Director, Volunteers In Technical Assistance, Inc., 3706 Rhode Island Avenue, Mt. Rainier, Maryland 20822.

William G. Hunter, Engineering Experiment Station, University of Wisconsin, 1500 Johnson Drive, Madison, Wisconsin 53706.

John Hammock, Executive Director, AITEC, 10-C Mt. Auburn Street, Cambridge, Massachusetts 02138.

Roy E. Harrington, Deere and Company, John Deere Road, Moline, Illinois 61625.

William McCrea, Entrepreneurship Institute, Suite 1190, IBM Building, Town and 4th Streets, Columbus, Ohio 43215.

Kristin Shannon, Center for Policy Process, 1755 Massachusetts Avenue, N.W., Washington, D.C. 20036.

Frank Tan, Agribusiness Council, 20 East 46th Street, New York, New York 10017.

George Goss, 7 Orchard Lane, Woodstock, New York 12498.

Eugene Eccli, Consultant to National Center on Appropriate Technology, MERDI, Box 3809, Butte, Montana 59701.

Donald R. Redden, Multinational Agribusiness Systems, Inc., 1725 K Street, N.W., Washington, D.C. 20006.

Dr. Norman Brown, ERDA, Office of International R&D Programs, 20 Massachusetts Avenue, N.W., Washington, D.C. 20545.

B. E. Ritzinger, Administration Centre, Deere and Company, Moline, Illinois 61625.

Grafton Trout, PASITAM, University of Indiana, 1005 East 10th Street, Bloomington, Indiana 47401.

Jack Sullivan, House International Relations Committee Staff, 2170 Rayburn Office Building, Washington, D.C. 20515.

Robert P. Morgan, Engineering Department, Box 1106, Washington University, St. Louis, Missouri 63130.

Theodore W. Schlie, Denver Research Institute, University of Denver, Denver, Colorado 80210.

Peter J. Davies, International Planned Parenthood Federation, 711 Ladd Road, Bronx, New York 10471.

Brenda Gates, MSP/IO, Room 700, 806 Connecticut Avenue, N.W., Washington, D.C. 20006.

Mary Ann McKenzie, Office of Policy Development and Review, Community Services Administration, 1200 19th Street, N.W., Room B219E, Washington, D.C. 20036.

Clarence J. Mann, Assistant General Counsel, Sears, Roebuck and Company, Sears Tower, 45–49, Chicago, Illinois 60084.

Wallace W. Elton, Vice President, International Executive Service Corporation, 622 Third Avenue, New York, New York 10017.

Robert M. Pierson, Chemical Research Division, Goodyear Tire and Rubber Company, Akron, Ohio 44316.

Peter N. Gillingham, Intermediate Technology, USA, 556 Santa Cruz Avenue, Menlo Park, California 94025.

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Richard Raymond, Portolo Institute, 541 Santa Cruz Avenue, Menlo Park, California 94025.

Scott Rutherford, EDA, Department of Commerce, Room 7842, Washington, D.C. 20230.

Frank J. Ahimaz, School of Engineering, Cornell University, Ithaca, New York 14850.

H. E. Hoelscher, School of Engineering, Benedum Hall, University of Pittsburgh, 4200 5th Avenue, Pittsburgh, Pennsylvania 15261.

Michaela Walsh, Rockefeller Brothers Fund, 30 Rockefeller Plaza, New York, New York 10020.

David Eynon, The Koppers Company, Koppers Building, Pittsburgh, Pennsylvania 15219.

Mark Sterner, Executive Director, Meals for Millions Foundation, 1800 Olympic Boulevard, Santa Monica, California 90404.

David H. Scull, Partnership for Productivity, P.O. Box 170, Annandale, Virginia 22003.

Shafeek Nader, National Commission on Cooperative Arrangements, Suite 1010, 1875 Connecticut Avenue, N.W., Washington, D.C. 20009.

Francis Method, Education Development Center, 55 Chapel Street, Newton, Massachusetts 02160.

Dean Phillips, Goodwill Industries of America, Inc., 92 Wisconsin Avenue, Washington, D.C. 20014.

Surjit Mansinyh, Institute for International Policy, 122 Maryland Avenue, N.E., Washington, D.C. 20002.

Per Christiansen, Program Designs for Educators, 314 Faneuil Street, Boston, Massachusetts 02135.

Edward Bullard, Technoserve, Inc., 36 Old Kings Highway South, Darien, Connecticut 06820.

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ATTACHMENT B

PRIVATE VOLUNTARY ORGANIZATIONS AND APPROPRIATE TECHNOLOGY

(A Report for the Agency for International Development)

PREFACE

This report has been prepared by PASITAM -- the Program of Advanced Studies in Institution-Building and Technical Assistance Methodology. PASITAM is a component of MUCIA -- the Midwest Universities Consortium for International Activities.

PASITAM was created with significant financial assistance from the U.S. Agency for International Development, to help link academic experts and practical planners and managers in identifying, and analyzing certain key problems of developmental assistance -- essentially the problems of designing effective systems of practical action in such fields as agriculture, rural development, health, and others.

A generic concern of PASITAM is the effective use of organization and management in developmental efforts. Private voluntary organizations represent one broad and certainly diverse category of organizations. A number of them play interesting roles in development. "Appropriate technology" is the current catchphrase for a set of important and interesting concerns, which require sound analysis and effective organization, if these concerns are to be transformed into practical realities. This limited study identifies basic opportunities for enhancing the exploitation of appropriate technology by PVOs. It also identifies certain questions which lie outside the scope of this report, but which are germane to the broad issue at hand.

Wm. J. Siffin
Director

SUMMARY

This study examines the role which Private Voluntary Agencies (PVOs) play in the development of appropriate technology (AT). More than 30 PVOs involved in AT-related activities have contributed to this study.

The study is not comprehensive nor can it be considered definitive. It does, however, provide a set of informed answers to a set of questions posed as the basis for this report.

(1) What are the PVO experiences and contributions to generating and disseminating AT?

'Appropriate technology' in essence means 'good' technology -- technology which both works and serves desirable social and economic aims. PVOs are usually action oriented groups concentrating in extensive field programs. This field experience presents them with unique opportunities to identify and respond to local needs, including needs for AT.

Each PVO works differently in identifying project needs and opportunities. Some develop extensive, long term programs which require considerable external technical assistance. Most PVOs, however, rely heavily on project-by-project approaches using local voluntary technical expertise and their own staff.

After identifying a need PVOs may respond in one of three ways: They may improvise in the field, conduct in-house research and development efforts to find or devise a promising solution, or conduct local and international searches for solutions involving the application of technology.

Considerable technological adaptation and innovation occurs through improvisation, especially in small-scale resource-short projects. Relatively few PVOs have the technical resources to conduct in-house R & D PVOs generally obtain technological information through local and international searches. International agricultural institutes are commonly used; other institutes are used infrequently.

Few PVOs can undertake projects primarily for testing. Most lack resources to establish specialized evaluation units. Most PVOs disseminate limited project information in newsletters or similar brief reports. There is little dissemination into more formal channels.

(2) What weaknesses or limitations can be isolated from PVO experiences in AT?

PVOs often lack the necessary financial and human resources to properly assess technical components in either project design or implementation. Only a few technology centers currently offer adequate technical consultancy services. PVOs need better backstopping and stronger linkages to sources of R & D.

PVOs are also weak in testing, assessment, and dissemination of their AT experience. Few PVO-AT projects are extensively documented, and even fewer have been systematically analyzed. The operational modes of these agencies are generally action oriented, with minimum emphasis upon studies and analysis.

(3) What kinds of support and assistance would best promote effective PVO involvement in generating and disseminating AT?

If PVOs are to play a larger role in AT activities, stronger linkages

are required between technology sources and opportunities for PVO technology applications.

- Technology institutes and clearinghouses could provide on-site technical consultancy services in needs identification, engineering, and impact assessment.
- Catalogs of simple technical ideas like VITA's Village Technology Handbook could be more widely distributed to field-based PVOs.

Most PVOs do not have the resources to extract and disseminate lessons from their practical experience. To facilitate such dissemination:

- AT testing and monitoring could be underwritten, in arrangements involving those employing and using the technology.
- Backstopping capability might be further developed in such organizations as World Education, World Neighbors, the Education Development Center, and similar PVOs to assist field based PVOs in monitoring, testing, evaluating, and disseminating AT.
- AT institutes and clearinghouses could produce and disseminate manuals on PVO-developed "hard" and "soft" technology projects.

AT field delivery could also be improved. Local indigenous extension services which provide "soft" technologies and identify potential technology manufacturers might be a promising delivery system in certain circumstances.

Indigenous capacity building, through technical and management training and creating linkages with outside resources, is essential for AT to have

a lasting development impact.

(4) What specific types of assistance should AID undertake to best improve PVO use of AT?

As a group, PVOs are weakest in back-up assistance in identifying and shaping appropriate technological responses to field-situation needs, and in documenting and disseminating the results of their own experience. USAID could provide assistance in these areas.

The Agency for International Development might enhance the effectiveness of PVOs in identifying, assessing, adapting, applying and assessing AT in several ways: by funding the establishment or expansion of technical consultancy services available for field assistance to PVOs (and possibly not limited to them); by underwriting one or more arrangements for enhancing the documentation and analysis function as it applies to PVO field experience with appropriate technology; and by undertaking or underwriting the dissemination selected and tested materials on appropriate technology among PVOs likely to find it of use. Means might range from field-oriented conferences and seminars to a publications program.

PURPOSE AND DESIGN OF THE STUDY

This study examines the role which Appropriate Technology (AT) plays in the development activities of Private Voluntary Organizations (PVOs). The first section of the study defines the term 'appropriate technology' and discusses the general implications of AT activities for PVOs. The second section describes the field operating characteristics of PVOs and cites cases illustrating how they design, adapt, assess and disseminate AT. The third section analyzes the problems currently facing PVOs and identifies potentially rich areas for the expansion and strengthening of AT activities. The fourth section offers recommendations on what kinds of support and assistance would best promote effective PVO involvement in generating and disseminating AT.

There are two basic assumptions underlying the design of this study: (a) that there are actually and potentially practical ways to identify, develop, test, apply, and disseminate forms of technology which are distinctively appropriate to development aims and (b) that PVOs are in several ways important parties to these activities. By learning from PVO experience, we may be able to expand the development and use of appropriate technologies and to enhance the contributions of PVOs.

With these assumptions in mind, eighty-three organizations involved in substantial AT-related activities were selected for study. A questionnaire was sent to these organizations. Twenty-seven responded with letters and materials, and several telephoned their responses. In

addition, interviews ranging from one to six hours were held with the staffs of twenty organizations (see Appendix).

It should be apparent that this study cannot be considered comprehensive or in any way definitive. The PVOs examined in this study do reflect a wide range of AT activities. Any comprehensive study would require a much larger survey of organizations and a greater number of in-depth interviews.*

*The Technical Assistance Information Clearing House provides brief descriptions of 418 voluntary agencies, missions, and foundations in U.S. Non-Profit Organizations in Development Assistance Abroad (1971).

I DEFINITION AND GENERAL IMPLICATIONS

'Appropriate technology' is the shorthand label for efforts to develop, apply, evaluate, and disseminate knowledge about technologies which are distinctively useful to the conditions of poor countries and to the needs of poor people within those countries. Implicit in the use of the term is the assumption that there are some technologies which are inappropriate to a particular development situation. The appropriateness of a certain technology is determined by two criteria.

First, the potential technology must be applicable to the particular environment. Among the factors important in determining applicability are relative sophistication and availability of human resources necessary to apply the technology, suitability of the technology to the situation, and compatibility with the customs and social institutions of the local environment.

The introduction of inappropriate technology can, all too often, occur, and the inappropriateness need not be great to have a disastrous effect on a project. Recently a well designed, two-handed oxendrawn plow was introduced into an area where a one-handed plow had been the custom. The one-handed plow allowed the driver to use the other hand to guide the oxen. The introduction of a two-handed plow would require the use of an extra person to guide the oxen or a retraining of the oxen. After a short trial period many of the farmers abandoned their new plows and returned to the old one-handed plow.

The second criterion for determining the appropriateness of a technology is the relevance of the social goals which will be served by the

technology to the aims of the promotors. Readily transferable technology may be inappropriate to development needs in the target society. For instance, a particular project may have as its goal the lowering of labor costs in a certain native industry through the introduction of labor-saving technology. Such a project would be appropriate in an area deficient in labor resources, but in an overpopulated area, a labor intensive technology might be more appropriate.

It should also be noted that the term 'technology' refers not merely to 'hard' machinery and technical skills. It also encompasses training programs, organizations, management and other 'soft' technology. Technology is not and cannot be abstracted from the situation in which it is to be used; it is the direct link connecting needs to organized and rationalized means of satisfying those needs. Appropriate Technology considers the local, natural, and human resources and encourages indigenous initiation and innovation.

There remains considerable disagreement about the import of the idea of AT, but it is generally agreed that the basic determination of appropriateness must come from the field. Moreover, the potential technology must be tested in the field, in its intended use area. Finally, it is acknowledged that PVOs play important roles in developing, testing, applying and disseminating technologies.

PVOs are of distinctive importance because of their heavy involvement in field programs. PVOs are usually action oriented groups concentrating upon field operations. Their orientation and their experience give them

unique opportunities to develop, test, apply, and disseminate applications of technology. By examining the PVO experience with AT activities much can be learned about the nature of AT and about how best to expand the PVO's role in AT activities.

II GENERAL PVO OPERATING CHARACTERISTICS

PVOs may be roughly categorized into three groups.

1) A small number of PVOs operate field projects and have internal technical backup personnel (e.g., project analysis, engineering, organizational training). Representative agencies include Catholic Relief Services, CARE, the American Friends Service Committee, and Technoserve.

2) The largest number of PVOs are field action-oriented and have thin internal backup capability. Representative agencies include Foster Parents Plan, the Paul Carlson Foundation, Community Development Foundation, Partnership for Productivity, and the Mennonite Central Committee.

3) A small number of PVOs usually do not operate direct field projects but do provide specialized assistance (e.g., information services, personnel) to other organizations. Representative agencies include Volunteers in Technical Assistance (VITA), World Education, World Neighbors, Heifer Project International, and Credit Unions of North America (CUNA).

Identifying Needs

Crucial to the proper function of all three types of PVOs is the identification and specification of the technological needs and opportunities of the local environment. Beside the accurate assessment of technical needs, good project identification requires a careful assessment of the

social criteria which an appropriate technology must meet.

Each PVO works differently in identifying project opportunities. CARE, one of the largest PVOs, establishes five-year country plans in cooperation with counterparts, government agencies, communities, and indigenous PVOs. These plans include project goals which may require external technical assistance and material. Technology needs are integral to project design, and CARE uses outside technical consultants and its own staff to specify the required technologies. Other organizations rely heavily on project-by-project programming, using local voluntary technical expertise and their own staff.

PVO Responses to AT Needs

PVOs can pursue three modes of action when they identify technical needs and specifications:

1) They may improvise in the field;

2) They may conduct in-house research and development; or

3) They may conduct local or international searches.

Field Improvisation

Considerable technology adaptation and innovation occurs through improvisation in the field. One respondent stated, "We live on the edge of virtual non-survival most of the time. Maybe that is one reason why we improvise and come up with answers; we just have to survive." While managing a small hospital and an associated agricultural program, his organization identified fourteen examples of local innovation and

adaptation ranging from rebuilding a dental X-Ray for chest and pelvic examinations to designing and constructing a bicycle ambulance.

One PVO made a placental extract for an anabolic in a local hospital, adapted an autoclave for charcoal, and built a waterwheel from local materials.

To build local tools or introduce new processes, field workers often proceed from a drawing or newsletter description. There are numerous catalogs of simple ideas similar to VITA's Village Technology Handbook available to draw information from. Many of these catalogs present simple, provocative technical ideas.

It is not surprising that small-scale resource-short projects produce technological innovations that are consistent with local materials, skill levels and customs. The innovators are familiar with the social setting and this combined with ingenuity and local materials produces many useful implements.

In-house R & D

Several PVOs have developed and adapted relatively sophisticated technologies. ACCION Internacional Tecnica, and Meals for Millions are developing high protein soybean food for production and consumption in Central America. CARE, assisted by outside experts and an AID grant, has developed and is testing plastic-treated jute to provide typhoon-resistant material in Bangladesh.

The Community Development Foundation uses local volunteer consultants in agriculture, credit, health, and nutrition to provide technical

assistance and AT development. Church World Services is cooperating with John Deere in Africa to develop a locally adapted plow.

World Neighbors, International Planned Parenthood, and the Community Development Foundation have developed innovative techniques in family planning, rabbit breeding, community organization, construction, sanitation, and cooperative organization. These technologies have been developed through cooperation among field representatives, local organizations, and national and international experts. World Neighbors, for example, assisted in the production of a multi-lingual filmstrip on rabbit farming with SEDA (Service de Developpement Agricole) in Zaire.

Information Searches

Information on most technologies is obtained through local and international searches. Many PVO searches begin in an informal network at the field level. Failing there, a PVO search often extends to more distant technology centers via the PVO headquarters, VITA or other clearinghouses.

Searches begin with a specific need and a rough idea similar to the "product development" stage of a manufacturing process. Searches may occur during project design or during project implementation.

Field Level Searches. A typical informal search begins locally and, depending upon individual contacts and the nature and scale of the problem, may end quickly and successfully. ACCION uses indigenous talent and financial resources in its small commercial and industrial promotion projects in Central and South America. It draws heavily on the private

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sector and regional organizations like IICA for technical advice. Other smaller PVOs also use this approach.

Localized searches permit personal interchange in which needs and proposed technologies can be specified over a short time period. Yet project managers often miss locally available resources because of a lack of information. For example, one respondent was looking for high-lysine corn suitable for his project. At a large U.S. agricultural school, he learned that a locally adapted high-lysine corn was being tested 80 miles from his project site.

The Christian Relief and Development Association (CRDA) in Addis Ababa, Ethiopia provides search services to any Ethiopian organization needing technical assistance. There are similar units in other LDCs. This more formal approach appears to plug gaps in the informal networks.

PVOs have their closest field working relationships with AT centers when planning and implementing projects. These relationships are not often maintained on an on-going basis because PVOs collaborate on the basis of needs related to projects, not simply to maintain contacts for their own sake.

Many PVOs stress their reliance on local technology and expertise sources. Most report that field personnel or counterpart organizations make every effort to resolve technical problems in the field before calling for external assistance. PVOs recommend that local technical assistance sources like corporations, universities, applied research centers, local clearinghouses, and government research and extension services be strengthened as prospective AT sources.

When AT-associated projects are beyond local technical and information resources, a wider search is conducted for technical assistance. These searches are usually initiated in the field but are conducted by an intermediary who channels the requests to AT sources.

Field-based international searches reach technology sources directly. Their success depends on a knowledge of sources and the requestor's ability to specify appropriate criteria. A technology search is difficult even for those familiar with worlwide sources. Dr. W.H. Boshoff of Makere University had many such problems while designing the Mak V tractor.

> In the U.K.[Boshoff] had a direct connection with an agricultural college which is cooperating on the project but even then he experienced difficulties in finding out who the potential suppliers were. In the ... United States, he initially only had catalogues which listed perhaps 20-30 suppliers for a particular part, with no detailed specifications or other information.... This necessitated a laborious and time-consuming correspondence with all suppliers in order to determine which two or three of them might actually be able to supply what he needed. Finally, the Rockefeller Foundation sent him to the U.S. so he could be there to choose parts suppliers, ... Dr. Boshoff would be in favor of some kind of clearinghouse for technological information transfer to developing countries.*

Headquarters-based international searches are done by organizations with highly technical needs. To be successful searches must match field technical specification of need skills with headquarter knowledge of technology sources.

Technologies must sometimes be sought in unlikely places. Technoserve

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*Theodore W. Schlie, "Appropriate Technology: Some Concepts, Some Ideas, and Some Recent Experiences in Africa, (Mimeographed Program of Research on the Management of Research and Development, Department of Industrial Engineering and Management Sciences, Northwestern University), p. 21.

and local groups working on the re-development of the Corozo nut industry in La Caba lacked a high-pressure cracker for the exceptionally hard nut. A headquarters-based search led from VITA to the California walnut industry to ITDG in London. Commercial nut-growers gave them more detailed specifications of what machinery would be needed. Simultaneously, ITDG learned that Unilever had absorbed two companies that had been part of the earlier Corozo-nut industry at the turn of the century. Technoserve found that the corporations and their technologies had literally vanished in corporate mergers. However, the required machinery specifications were clear enough to suggest a search of coal crushing technology. The search began anew in Thompson's Registry of Industrial Suppliers and ended with a small firm in Ohio which manufactured coal crushing machinery.

While this seems to be an idiosyncratic case, many other technology searches are as complex. The difficulties of this search process include:

1) International searches require considerable skilled manpower.
2) They often require long lead times which can disrupt project schedules.
3) Linkages between AT sources and PVOs are often poor. PVOs are hesitant to approach them for a variety of reasons including simply not knowing whom to approach. Linkages are primarily initiated through intermediaries.
4) PVO field and headquarters linkages are occassionally insufficient to adequately identify technical specifications.

Headquarters-based searches often ignore LDC technology sources. Some PVO-AT projects require access to American or western technologies, but

technologies do exist in various fields.

LDC technology development research is increasing as a result of lopment efforts, and their technical capacities are increasing.* In- ıatior on LDC technology sources are being disseminated through units WAITRO. Yet, LDC advances in information dissemination and R & D city will lack some of their potential impact if PVOs do not exploit ı.**

Information Clearinghouses assist PVOs and other organizations by ıting technologies or providing technical consultants. VITA, ITDG, and a growing number of other organizations also conduct R & D and ıish manuals on widely applicable technologies like solar cookers and lmills. These organizations are multi-sectoral. Other organizations :entrate on specific technology areas.

The number of clearinghouses and AT centers has expanded to include:

- Intermediate Technology Development Group Ltd. (London);
- Brace Research Institute (Ste Anne de Bellevue, Canada);
- Appropriate Technology Cell (New Delhi);
- Planning Research and Action Division (Lucknow, India);
- Appropriate Technology Development Unit (Varanasi, India);
- Industrial Development Division, Engineering Experiment Station (Atlanta, United States);
- Volunteers in Technical Assistance (Mt. Rainier, United States);
- Division of Microprojects (Eindhoven, Netherlands);
- Appropriate Technology Centre (Islamabad, Pakistan);
- Technology Consultancy Centre, University of Science and Technology (Kumasi, Ghana);
- Agricultural Engineering Department, the International Rice Research Institute (Manila, Philippines);
- Earth Resources Development Research Institute (Washington, D.C.);
- Technonet Asia (Singapore);

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*AID's Office of Science and Technology has fostered the growth of industrial earch institutes. The Industrial Research Institute of Central America AITI) in Guatemala and others have begun active programs. UNIDO, through the ld Association of Industrial and Technological Research Organizations (WAITRO), plied members assistance in applied research capacities. In 1970 the OAS be- technical assistance programs in technology development areas.

**James Utterback, "The Role of Applied Research Institutes in the Transfer of hnology to Latin America." Discussion paper (Bloomington: Indiana University ool of Business and PASITAM, 1974).

- Small Industries Development Network (Georgia, U.S.A.);
- East West Technology and Development Institute (Hawaii, U.S.A.);
- TOOL (Holland);
- Intermediate Technology (Menlo Park, Calif., U.S.A.).

Many PVOs are aware of VITA and use its services. A significant number use ITDG. Only a few use the other clearinghouses or centers.

Technonet Asia, a consortium of Asian engineering groups, responds to small industry and private agency problems. Anti-Poverty, Ltd. (UK) uses LDC and PVO's problems for student work in vocational education classes.

Some technology institutes disseminate soft technology training materials. ITDG, Cooperative League of the USA, and the University of Wisconsin's Cooperative Center have developed training packages, which might be more widely disseminated.

Not all PVOs need to use and be in close touch with technology centers. Information network organizations like ITDG, Technonet Asia (supported by IDRC-Canada) and the Small Industry Development Network at the Georgia Institute of Technology provide descriptive information on existing agricultural and applied-industrial institutes.

Yet, several PVOs, including some with multi-purpose objectives like the Community Development Foundation, Catholic Relief Services, and the Near East Foundation, are closely linked with applied research organizations. These centers provide significant resources for field adaptation of seed varieties and farm implements in conjunction with the FAO and such international crop-specific networks as International Rice Research Institute (IRRI), International Maize and Wheat Improvement Center (CIMMYT).

and CIAT (International Center of Tropical Agriculture).*

The Near East Foundation, collaborating with CIMMYT, supports an adaptation field station in Morocco. In Bangladesh, the MCC uses seed provided by the IRRI (Philippines) and furnishes them with the results of field testing. Only a few PVOs use the services and material of agricultural institutes.

There are several applied-industrial institutes, such as the Philippines Institute for Small-Scale Industries and the Technology Consultancy Center in Kumasi, Ghana. Our data indicate little cooperation between these groups and PVOs in the adaptation of small industry technologies.

Testing, Assessing, Disseminating

Once a technology is located, it must be field tested, monitored, assessed, and the results disseminated. Beyond a basic agreement that these steps are necessary, PVOs have varied views on how to do them.

PVOs face several barriers to testing technologies. Many cannot provide adequate funding for feasibility exploration and pilot testing of alternative technologies. They are reluctant to divert funding from operational projects to experimental or even pilot projects having significant research costs.** They rarely have adequate staffing to monitor experimental programs.

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*These and nine other organizations provide training and are responsible for genetic research and field adaptation through an extensive network of experiment stations.

**Several PVOs do conduct detailed evaluations, e.g., AFSCs Barpali (India) after ten years and FPP's Socio-Economic Study of Foster Parents Plan of Bolivia. Others can be expected to do so with Development Program Grant monies.

Few PVOs could or would use their projects primarily for testing if the testing was not clearly consistent with local needs and desires. However, a significant number of cases reveal a convergence of technology and receptive local conditions for testing. For example, MCC's development of sun-protective nets for covering vegetables in Botswana and CARE's impregnated jute roofing in Bangladesh involve on-site testing. CARE is also currently testing nutrition techniques in three countries. The experimental design is carefully controlled and should enhance the knowledge of alternative methodologies. The Mennonite Central Committee (MCC) maintains experimental plots and field tests new seed varieties with international research organizations like CIAT.

Francis Method of the Education Development Center describes the testing process followed in that organization: "Though most project initiative now rests in the countries themselves, EDC often identifies potential projects through interactions with academic specialists and R & D groups outside EDC. EDC provides a means of testing the applicability of innovative suggestions with specialists in other countries and international agencies who may be interested. Where there is interest, EDC can complement the specialized expertise with its capacities for situational knowledge, program design, implementation and administration."

The quality of PVO project assessment varies greatly. PVOs generally agree however, that they do not want to establish specialized evaluation units; PVOs would prefer to obtain evaluation assistance from other specialized PVOs like World Education, World Neighbors, and the Educational Development Center.

World Education, among its many services, provides evaluation assistance. Its approach views technology as a component of larger efforts and overall program effects. World Education and VITA have recently proposed a joint project to evaluate the suitability and usefulness of AT manuals to the small farmers and rural villagers.

Most PVOs disseminate limited project information through newsletters or similar formats. There is very little dissemination into more formal documentation channels.

One organization reports the progress of its projects in quarterly reports. However, no program effectiveness evaluations are carried out. A staff member says, "We have a vehicle for spreading the word within the family. That is, each field director writes a Quarterly Report which is duplicated and a complete set goes to each program country. That Quarterly Report contains a program statistical section which enables us to trace program progress, but it will not tell us a thing about program effectiveness and this is precisely where we want help and know that we must devise an evaluation mechanism. We also have means of spreading the word to our constituents, but we have no time for professional writing for publication."

This statement summarizes difficulties faced by most PVOs.

III PROBLEMS AND OPPORTUNITIES

PVOs in general are action-oriented organizations. Most PVOs have only limited technical backstopping capability. This is reflected in PVO project planning procedures.

For AT needs and opportunities to be adequately assessed, a detailed feasibility study and design process is often necessary. Otherwise, examination of the project environment is apt to be shallow, and only standard technologies are likely to be considered. One PVO respondent believes each project should have a pre-investment impact statement. The statement should assess:

1. The technology itself;
2. The influence of the project's structure, scale, and operating style on possible technical choices; and,
3. The project's interaction with other sectors and projects.

Catholic Relief Services (CRS) provides a technical assessment fund of $10,000-15,000 per project to conduct counterpart project feasibility studies. CRS uses in-country and regional consultants to provide technical assistance at the project initiation stage.

AT needs may emerge during project implementation when there is little time for a technology search to determine specifications. These needs, not easily pre-specified during the project design stage, must be resolved quickly or a project may fail.

Thus, staff members or consultants with a technical background are necessary to properly assess a project's technical soundness. Those PVOs with

technical staffs in agriculture, health or small industry can best identify a locality's characteristics affecting the specifications of technical issues. For example, the Mennonite Central Committee and the Farmer's Brigade needed a detailed assessment of soil conditions, rainfall and manufacture costs to design a multi-purpose agricultural tool in Botswana.

However, as noted above, most PVOs do not have the necessary financial or manpower resources to properly assess the technical components in either project design or implementation stages. They are interested in "doing" projects, not developing prototypes. This is partially a result of limited financial resources, but primarily because of organizational philosophy.

VITA has responded to this problem by developing a "mail order" approach to technical information requests. This approach works poorly. VITA receives over one hundred technical requests per month. Many are general inquiries containing inadequate technical and contextual data. VITA encourages the requestors to better specify the problem context. However, PVO technical capability limits the degree to which the problem context can be specified.

When the problem context is not adequately specified, problems occur. Windmill pumps failed in Guinea Bissau because seasonal and daily wind velocity was not measured and maintenance requirements were not thoroughly explored. Supplemental pump systems caused additional problems and expense.

In addition, some technology problems are so complex that they can only be personally communicated to or directly perceived by a technical expert.

This severely limits the utility of sending problems to R & D centers and clearinghouses for a mail response.

Thus, the linkages between field-based PVOs and sources of information and R & D are weak in many cases. The field-based PVOs operate in complicated environments. They are confronted by a wide array of applied technology centers which specialize in various fields of technology. For them to effectively assist PVOs adequate technical specifications are necessary.

Only a few technology centers offer technical consultancy services. Yet PVOs often need flexible consulting assistance in technical matters, including marketing problems and adaptation of technologies to local human and natural resource requirements. This requires capabilities beyond the abilities of local PVO staff, i.e., local personnel training in the use of a particular technology.

Thus, a major PVO weakness is in technology need identification and searches. There appears to be a need for better backstopping and a strengthening of network linkages.

A second PVO-AT process weakness is in the testing, assessment, and dissemination of AT experience. Few PVO-AT projects have been extensively documented, and even fewer have been systematically monitored or analyzed. Yet it is necessary for technology centers and clearinghouses to have access to proper documentation of PVO-AT experiences, if information is to be built from experience and disseminated effectively.

PVOs in general should not be expected to extensively test, evaluate, and disseminate technologies. Their resources are limited and their operational modes are action oriented.

Several PVOs stated that a significant bottleneck in technology center utilization is that the centers often treat only the "hard" technologies. They do not treat the small farmer's or businessman's problems as systems requiring comprehensive approaches. Organization-building, economics, cultural considerations and management are inseparable from the "hard" technologies of machines and equipment. Indeed, an overall development weakness is that the "softer" technologies are often ignored or dealt with inadequately in project design and implementation. The "soft" technologies need to be better monitored, assessed, documented and disseminated. This requires exapnsion of the scope of backstopping and information network linkages.

While PVOs have their weaknesses they also exhibit certain strengths which other development entities lack. For example, PVOs have far more flexibility than do government and bureaucratic entities. They can experiment more easily with new projects, without excessive bureaucratic justification and political and foreign policy implications. They demonstrate a history of working in rural areas with the poorest majority and have built up a good reservoir of experience. In fostering efforts to develop and use AT, it would certainly be worthwhile to tap that reservoir of knowledge. Better backstopping linkages and dissemination would serve this aim.

IV CONCLUSIONS

A. General

Examining the relationships of "appropriate technology" and "private voluntary organizations" is a bit like considering the possible association between "good recipes" and "people who live in houses."

Appropriate technology in essence means "good" technology -- technology which both works and serves desirable social and economic aims. It thus covers a vast and varied terrain. Private voluntary organizations are indeed a heterogenous group of entities. They are of several different types when classified by aims, forms, and methods. They do different kinds of things. They work in different places. Many of them are concerned more with humanitarian assistance than with the development, identification, assessment, application, and dissemination of technology.

Yet there is an important (though not exclusive) nexus of these two things -- appropriate technology and PVOs as vehicles for promoting and applying it. In this report we try to examine aspects of that nexus.

PVO experience shows once more that technology is always instrumental. The word is the label for a certain kind of response to a need or problem -- a response whose most distinctive quality is determinateness.

By definition, a technology is a recipe whose ingredients and processes are well-specified, and whose effects can be predicted with

assurance. Thus the crucial issue of appropriate technology is to find or devise and to apply the right kind of technology, when the factors which determine rightness are not completely contained within the technological recipe.

PVOs are distinctively interesting as vehicles of appropriate technology because they include many organizations with earthy and intimate field experience involving the compelling objects of current development concerns, the poorest of the poor. Thus these organizations offer special promise of good judgment in defining concrete problems, in helping assess the potentials of technology as a source of auspicious response to those problems, and in helping deliver such technology.

Appropriate technology is not the exclusive province of PVOs, nor are PVOs exclusively concerned with this subject. But they do play a part in harnessing and promoting appropriate technology, and there are ways in which that general role might be enhanced. The aims of this report have been to sketch the nature of the involvement of these organizations in what we have labelled "the process of appropriate technology," and on that basis to outline some needs and opportunities.

Our most general conclusion is quite simple: "Appropriate technology" is certainly not the panacea envisioned by some experts. The term itself is an invitation to debate. Yet it does contain, or can be given, worthy substance. And there is a fruitful relationship between the ideas associated with "appropriate technology" and capabilities and potentials within the domain of the private voluntary organizations.

B. Some Specific Findings and Suggestions

The major findings of this survey identify needs for buttressing the supporting resources available to PVOs, and for extracting and disseminating lessons from their experience with the development and use of appropriate technology.

A few additional findings and conclusions are worth noting here: One set concerns possible needs for additional information:

1. Are certain promising fields or topics of appropriate technology being neglected? Does the field experience of PVOs offer guidance identifying such fields or topics?

From this limited study we are unable to answer this question. The matter could, however, be addressed as one aspect of the dissemination function discussed earlier in this report.

2. It would be useful to further examine the potentials of AT sources within LDCs. A number of PVOs have expressed the opinion that LDC sources of technological expertise should be nurtured and used as much as possible, for three reasons.

   a) LDC institutions presumably have a greater knowledge of their environments than outside organizations. Therefore they are likely to provide relevant and workable technological inputs.

   b) Reliance upon LDC sources of AT can help build indigenous developmental capacity, which is certainly a desirable objective.

c) LDC sources of AT are less costly than the alternatives.

The first of these assumptions is, at this point in our studies, problematic. It would be useful to have more information on PVO experience with LDC sources of technology, and additional insights into the possibilities for selectively building and using LDC sources of AT. Inasmuch as appropriate technology is not the label for a clearly bounded set of artifacts or recipes, it would be necessary to determine, through practical inquiry, what concrete AT needs and opportunities might be best served through LDC sources, and how this might be done in ways involving PVOs.

As part of our conclusions we would stress another point: technology is not just a synonym for engineering. Appropriate technology encompasses the idea of "soft" technologies, such as ways of organizing and operating processes, as well as the more conventional "hard" technologies. Appropriate technologies may also be rooted in customs and traditions. Certainly, as noted earlier in this report, the vital conventions of particular societies and communities can have large effects upon the appropriateness of a technology -- e.g., the two-handed plow-- which may appear to be superior to the existing state of the art, but which may be at a given time quite inappropriate for non-technological reasons. In general, there is a large potential role for applied social science in the broad effort to promote appropriate technology as a means of development. This role is not limited to assessing the suitability of technical artifacts; it includes contributions to the design of appropriate ways

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and means for enacting and disseminating various kinds of technology.

Finally, we turn once more to the topic of indigenous capacity-building. There are many ways of serving this aim. "That is not to suggest for a moment that institution building in developing countries is easily achieved. Nevertheless, we have always been of the conviction that unless we can transfer to a given developing country a capability which will eventually belong to and be controlled by local people, in the long term we have accomplished very little."

Organizations working in enterprise development offer interesting insights into capacity building. Three were interviewed in depth. They included ACCION, Partnership for Productivity (PFP) and Technoserve. Each works with indigenous organizations. ACCION primarily provides technical assistance in planning, organizational development, and training. PFP is training small business extension agents in Kenya. Technoserve's Alenfam cane-sugar processing project, initiated by a Ghanaian, identified not only the need for adapted technology but also for training local unskilled labor and introducing marketing research and development skills for Alenfam managers.

All three groups believe "appropriate management" is necessary to complement "hard" technologies. "The key question is not how to develop a particular process or piece of equipment. It is to find ways whereby Africans on their own can and will adopt and adapt such developments in the interest of their own society. Furthermore, this means that these developments should be capable of becoming economically useful and viable

when they are no longer the subject of being introduced by Western technicians... "

The importance of indigenous capacity building, and the significance of social, organizational, and economic issues, demonstrate once more that the crux of a concern with appropriate technology is not, and cannot wisely be, upon engineering. In practice concerns with appropriate technology must be molded and blended into concerns with astute problem analysis, practical project design, and effective implementation and assessment.

APPENDIX ORGANIZATION SURVEYED

ORGANIZATION	RESPONSE TO MAILED QUESTIONNAIRE	VISITED FOR IN-DEPTH INTERVIEWS
Accion International		X
The African-American Institute		
Africare		X
Agricultural Coop Dev Intl		
Agricultural Dev Council, Inc	X	
Agricultural Missions, Inc		
American Dentists for Foreign Service	X	
American Foundation for Overseas Blind, Inc.		
American Friends Service Comm	X	X
The American Lutheran Church		
American Ort Federation, Inc.	X	
The Asia Foundation		
Board of Intl Ministries		
CARE, Inc		X
Catholic Relief Services		X
Christian Children's Fund, Inc		
Christian Church		
Christian Reformed World		
Church World Service		X
Codel, Inc	X	X
Columban Fathers		
Community Development Fund, Inc		X
Coop League of the USA	X	X
Direct Relief Foundation	X	

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ORGANIZATION	RESPONSE TO MAILED QUESTIONNAIRE	VISITED FOR IN-DEPTH INTERVIEWS
Education Development Center	X	
Episcopal Church of the US		
Family Planning International	X	
FCH Services Inc		
Foster Parents Plan		X
General Conference Mennonite Church		
Goodwill Industry of America	X	
Heifer Project International	X	
IDEAS, Inc		X
Institute of International Education		
Interchurch Medical Assistance		
International Association for the Exchange of Students for Technical Experience/US	X	
International Developement Fund, Inc		
International Educational Developement, Inc		
International Institute of Rural Reconstruction		
International Road Fund	X	
International Voluntary Services, Inc		X
IRI Research Institute, Inc		
WK Kellogg Foundation		
Laubach Literacy, Inc		
Lutheran Church of America		
Lutheran World Fund		
Maryknoll Fathers		
Maryknoll Sisters Center		
Meals for Million Fund		

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ORGANIZATION	RESPONSE TO MAILED QUESTIONNAIRE	VISITED FOR IN-DEPTH INTERVIEWS
Medical Assistance Programs, Inc	X	
Medical and Surgical Relief Commission	X	
Mennonite Board o Missions & Charities		
Mennonite Central Committee	X	X
Mennonite Economic Development Association, Inc		X
National Association of the Partners of the Alliance, Inc	X	
National 4-H Club Foundation of America, Inc		
National Rural Electric Coop Association		
Near East Foundation	X	
New Eyes for the Needy	X	
Operation Crossroads Africa		
Oxfam-America		X
Pan American Development Foundation		X
Partnership for Productivity Foundation USA, Inc	X	X
The Pathfinder Fund		
The Paul Carlson Medical Program, Inc	X	
The Peope-to-People Health Foundation, Inc.-Project Hope		
Planned Parenthood Foundation of America, International Division of Family Planning	X	
Private Agencies Collaborating Together, Inc	X	
Project Concern, Inc		
Project Endeavor		
Research Corporation		
Sudan Interior Mission		
Technoserve, Inc	X	X

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ORGANIZATION	RESPONSE TO MAILED QUESTIONNAIRE	VISITED FOR IN-DEPTH INTERVIEWS
Unitarian Universalist Service Committee		
United Church Board for World Ministries		
The United Presbyterian Church in the USA		
Volunteers in Technical Assistance		X
World Education, Inc	X	X
World Neighbors, Inc		
World Rehabilitation Fund, Inc	X	
World Relief Committee, Inc of the National Association of Evangelicals		
World Vision Relief Organization	X	
Young Men's Christian Association-US		

APPENDIX C

APPROPRIATE FACTOR PROPORTIONS FOR MANUFACTURING IN LESS DEVELOPED COUNTRIES: A SURVEY OF THE EVIDENCE

(By Lawrence J. White,* Princeton University)

I. Introduction

The question of appropriate factor proportions in LDCs has emerged as one of the most important development problems of the 1970s. High and rising rates of unemployment in urban areas pose major political and economic problems for LDCs. Simultaneously, employment in manufacturing is frequently growing far more slowly than the growth of manufacturing output. The high capital intensity of LDC manufacturing is frequently cited as the cause of these phenomena. Capital-labor ratios for new or proposed industrial projects in LDCs are frequently $15,000 or more per worker, and facilities in the petrochemical industry can run as high as $200,000 per worker (Morawetz, 1974). We shall argue below that the connection between urban unemployment, slow growth of manufacturing employment, and high capital-labor ratios is not as simple as may appear at first glance. But the high and clearly inappropriate capital-labor ratios frequently found in LDCs are nevertheless a genuine and important economic problem.

A critical set of questions can and must be asked about these high capital-labor ratios in LDC manufacturing: Are they necessary? Or are there efficient alternatives for LDCs which are more labor intensive and hence more appropriate for LDCs? What evidence is available on this point? If alternatives are available, why have they not been utilized? If alternatives are not currently available, what are the prospects for

creating them? What are the best ways of creating them? What do we know about the processes and institutions concerned with creating new technology, especially in LDCs?

This paper will provide a non-technical review of the available evidence that can shed light on these questions. Other surveys or summaries that deal explicitly with or touch upon the problem of appropriate technology for LDCs have appeared in recent years by Turnham (1971), Ridker (1971), Jackson (1972), Morawetz (1974), Acharya (1974), Edwards (1974a), Bruton (1973), Westphal (1974), Brown and Usei (1974), OECD (1975), Cline (1975), and Bhalla (1975a, 1975b). But the emphasis of each is somewhat different, and none has focused primarily on the evidence concerning factor proportions and appropriate technologies in manufacturing. That will be the major task of this paper.

The remainder of this paper will be organized as follows: Section II will provide some background by sketching briefly the patterns that many economists would expect to characterize a well-functioning, healthy, growing LDC economy. Against this background, the phenomena of high urban unemployment, lagging manufacturing employment, and high capital-labor ratios can be put into proper perspective.

Section III will briefly summarize the a priori arguments concerning the absence of choice in efficient factor proportions and then will offer a survey of the available evidence. The evidence will be organized around three headings: econometric evidence on the elasticity of substitution of capital for labor; engineering or process analyses of the elasticity of substitution and the availability of choice; and anecdotal evidence. In addition, separate attention will be given to comparison of

large and small firms within LDCs, since many observers feel that these comparisons shed valuable light on the question of choice: to the opportunities for the use of used machinery, as a means of efficiently lowering capital-labor ratios for LDCs: and to the evidence concerning multinational corporations and whether they do or do not alter their factor proportions in LDCs. This section will also explore the evidence on relative saving rates in LDCs, since this is sometimes used as a justification for capital intensive methods. And it will examine the possibility of gaining more appropriate factor proportions by encouraging more appropriate product choice in LDCs. In this author's opinion, the evidence indicates substantial possibilities for labor-capital substitution, both among processes and among products, particularly when the possibilities for international trade are acknowledged. More appropriate factor proportions are currently feasible.

Section IV then briefly examines the evidence concerning the reasons why currently feasible appropriate factor proportions are not chosen. Inappropriate factor prices and the absence of competitive markets (which allows the non-optimal instincts of the engineer to prevail) are important causes.

Section V explores the possibilities of developing new products and processes in LDCs, to widen the range of technological choice and to increase the productivity of all resources over time. This usually falls into the category of research and development. Even in developed countries, the systematic evidence concerning R&D is quite limited, and the LDC evidence is considerably more restricted. The available evidence will be discussed and analyzed. Attention will also be given to the role of research institutes, multinational corporations, and patent systems in creating new

knowledge and transferring existing knowledge from the developed countries to the LDCs.

Section VI will offer some conclusions from this survey.

Before proceeding further, we should offer a few definitions that may clarify the discussions in the following sections. By a "technology," we will mean all of the known efficient ways of producing a product or process.[1] Thus, in a favorable case there may be many efficient capital-labor combinations encompassed within a known technology, and better factor utilization for LDCs would only require moving to the lower capital-labor ratios within the known technology; this is the evidence on which Section III largely focuses. In an unfavorable case, there may be only one currently known feasible factor ratio (usually capital intensive), and more appropriate factor combinations for LDCs will have to be newly discovered. This would be considered to be new technology (so would, of course, the discovery of new production processes that were more efficient in using less of all factors to product a unit of output); this is the subject of Section V. The quest for appropriate factor proportions for LDCs, then, includes both efficient changes within known technologies and the discovery of new technologies.

Finally, by "appropriate," we mean factor proportions that are roughly in line with the overall factor availabilities in an economy. The poorer the LDC, the less capital (physical and human) relative to labor we expect to find, and, hence, the more labor intensive the "appropriate" factor proportions would be.[2]

II. The Well-Functioning LDC and the Inappropriate Factor Proportions Problem

Let us imagine an LDC which starts, for whatever reason, with low levels of physical capital and human capital per capita and, consequently, low capabilities of assimilating modern technology. Per capita income will be low. Nevertheless, product and factor markets could still be operating competitively and allocating the (very limited) amount of resources in an efficient fashion.[3] Since unskilled labor is in relative abundance, its wage would be relatively low. With trained skills in relatively short supply, the premium for skilled labor of various kinds would be relatively high. Similarly, relatively scarce capital would earn a high return. Competition and mobility among sectors would ensure that the returns to labor, skills, and physical capital were the same in all sectors of the economy. The relative proportions of labor, skills and physical capital would not be identical in all sectors of the economy, since different sectors have different technologies. Thus, some sectors would be more capital intensive than others, but as long as there were reasonable opportunities for factor substitution, there would be no problem in manufacturing full employment of all factors.

The high returns to skills and to physical capital would induce saving and investment. The increased physical capital would be used to equip new additions to the labor force (reflecting population growth) at prevailing capital-per-worker levels and also to raise those levels generally. The rising levels of capital per capita would gradually raise per capita incomes. Wages for unskilled labor would rise compared to the returns to the now relatively more abundant skills and physical capital. Again, competition and mobility would tend to keep wages and returns equal across all sectors. Rising skill levels would increase the assimilation

of advanced technology, raising incomes yet further. And the additions to human and physical capital would tend to be spread uniformly across sectors, although differences in technologies and in human abilities and proclivities would rule our complete uniformity. Again, competition would ensure this relative uniformity of the additions.

The pattern of expansion of various sectors of the economy (e.g., manufacturing, agriculture, services, etc.) would depend on the pattern of tastes with rising incomes, on technologies, and on the possibilities for international trade. We would expect to see manufacturing grow faster than the overall economy until high income levels were reached.

Let us now focus more closely on the manufacturing sector. Wages in manufacturing (corrected for the cost of living) would tend to be more or less equal with wages in other sectors of the economy. Increases in the amount of capital per worker -- capital deepening -- would take place relatively gradu lly, at a pace basically consistent with the capital deepening taking place in the rest of the economy. If serious unemployment were somehow to appear, two effects would follow: There would be downward pressure on wages, and the process of capital deepening would temporarily halt until the unemployment had disappeared. It would be less profitable to add more capital to existing workers (because of diminishing returns to capital) than to equip new workers (from the ranks of the unemployed) at existing capital-per-worker levels.

Finally, as manufacturing output rose, we would expect manufacturing employment to rise less rapidly, even in this well functioning economy, for three reasons: the gradual physical capital deepening, gradual human capital deepening, and technological change.[4] All three would

raise the output per worker and hence cause employment growth to lag behind output growth. A rough estimate of this increased productivity factor would be 3%.[5] Thus, if overall manufacturing output were growing at a rate of 8%, we would expect employment to rise by only 5%. Only if there were unemployment (so that capital deepening did ot occur), no increases in skill levels, and no technological change (or only labor-augmenting technological change) would we expect employment to rise as rapidly as output.

With this as background, we can now see the connection between urban unemployment, slow employment growth rates, and capital-intensive manufacturing establishments. As we have just argued, the lag of employment growth behind output by itself is not cause for concern. It is the existence of a differential in growth rates in the presence of substantial urban unemployment and (even when open unemployment is low) the existence of differentials in excess of roughly 3% that are causes for concern. New manufacturing projects requiring $15,000 per worker in investment, when the current average capital per worker is less than one-tenth of that, again indicates that the economy is not functioning in the smooth manner of the model.

Finally, the relationship of urban unemployment to these problems needs to be clarified. Many economists have come to believe that the large real wage differentials between the urban modern sector and rural areas can explain much of the urban unemployment. Workers from the countryside are willing to migrate to the cities and sustain periods of unemployment, in order to get the chance to get a high wage job.[6] The high urban wages are non-competitive, in the sense that the unemployment pool would otherwise drive them down, but a combination

of legal minimum wages, union pressures, government required fringe benefits, and other government pressures keep the wages high. If this view of the urban unemployment problem is correct,[7] then the high capital-labor ratios in manufacturing, while not helping greatly in solving the problem, are not directly responsible for it. (To the extent that the high wages discourage the use of labor intensive processes, the high capital-labor ratios are another consequence, along with unemployment, of these high wage policies. See Section IV.) Even if lower capital-labor ratios prevailed[8] and employment grew faster, the unemployment would persist as long as the urban-rural real income differential persisted. Only if manufacturing employment grew fast enough, so that enough people were pulled out of the countryside so that incomes in rural areas rose close to urban levels, would the unemployment problem disappear. Thus, the high capital-labor ratios for new manufacturing in the face of high urban unemployment can be seen as an indication that the system is not functioning properly, but the former cannot really be seen as a cause for the latter.

Finally, it may be instructive to see the direct effect of high capital-labor ratios for new manufacturing projects.[9] Let us suppose that an LDC has a per capita income of $500. The country has a current population of 1,000 (for easy computation), growing at 3% per year. Current GNP is $500,000. If the country is investing 18% of GNP,[10] perhaps 12% would be available for net new investment (the remainder covering the replacement of older, worn-out capital). Thus, $60,000 would be currently available for net new investment. With a population of 1,000, the labor force will be around 400. Average capital per worker in the entire economy might be $1,000. If the labor force is also growing at 3%, 12

workers will be added to the labor force.

Now suppose that new manufacturing projects require a relatively high capital-labor ratio -- say, $15,000 per worker.[11] The available investment funds would only stretch as far as equipping four new workers; i.e., only one-third of the new workers would be equipped; the remainder would have no capital with which they could work and presumably would be unemployed or underemployed. Of, if we could equip all of the new workers at the prevailing $1,000 capital per worker level, we would have funds remaining to provide only three and one-half workers with the capital intensive manufacturing jobs. Thus, if unduly capital-intensive manufacturing processes are chosen, not only will capital deepening fail to take place among the existing labor force but at best only a quarter or a third of new entrants into the labor force can be provided with the high productivity capital intensive jobs. With only a small fraction of the overall labor force benefiting from the new investment, a small industrial labor elite may well develop.[12] And, if there are efficient low capital-labor alternatives so that the new investment could be more or less spread over the entire labor force, overall output and income would be higher in this latter case, because of the diminishing marginal productivity of capital when it is all concentrated on a few workers. Thus, though the high productivity from high capital-labor ratios is the eventual goal of economic development, the efficient path to this goal is gradual capital deepening for all rather than sharp capital deepening for a few.

High capital-labor ratios, then, clearly pose serious economic (and social) problems for LDCs. But are there efficient alternatives, or are the high ratios a problem that LDCs must live with until alternative technologies are devised? It is to that evidence that we now turn.

III. Alternative Factor Proportions: The Evidence

The belief that capital intensive manufacturing processes
ilar to those found in developed countries are the correct ones for
Cs appears to have been very strong in the 1950s and 1960s, especially
engineers and even by some economists. The major argument in favor of
em was that they were simply more efficient than any more labor intensive
ternatives: the latter, it was claimed, would always use more labor
d more capital per unit of output than would the process with the high
pital-labor ratio. Thus, though alternatives might exist in a technical
nse, they would always be found to be inferior. Statements to this
fect can be found in the comments of Nicholas Kaldor (as reported by
binson [1965, pp. 28-29]), Amin (1969), Barber (1969), Ady (1971), and
ECLA (1970). This could also be characterized as a belief in fixed
roportions (as opposed to factor substitutability), since the efficient
ctor combination is fixed at the proportions found in developed countries.

The identification of efficiency with "productivity" (i.e.,
bor productivity) by many international study groups and productivity
issions in the 1950s and 1960s helped contribute to this view.[12] Though
w labor productivity could be due to pure inefficiency (e.g., bad
anagerial supervision, bad organization of work tasks, etc.), it cou'd
lso be due to the efficient combination of labor with low levels of capital
n poor countries. The confusion of labor productivity with efficiency
eant that high capital-labor ratios would be associated with efficiency.

Another strand of argument has claimed that efficient alternatives
ight exist for some processes but that the alternatives are limited and
ence in practical terms most LDCs are faced with little or no alternatives

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to high capital-labor ratios for most manufacturing processes (Stewart, 1972; 1974). Others, like Baranson (1969b, chs 2,3; 1972) and Strassmann (1968, pp. 93-102, 155-157) have argued that high levels of mechanization are necessary to ensure high levels of quality (e.g., in machined products) or can substitute for managerial skills in organizing and supervising workers, skills which are even in shorter supply in most LDCs than is capital (Hirschman, 1958, ch. 8).

A completely different line of argument favoring capital intensive technologies has rested on alleged saving and reinvestment rates by different economic groups. As argued by Galenson and Leibenstein (1955), capital intensive technologies would mean high returns to capital, and capital owners have higher saving and re-investment rates than workers. Hence, even though there might be efficient labor intensive methods available, capital intensive methods should be chosen because reinvestment would be greater and the pace of industrialization would proceed faster. This argument clearly hinges on empirical evidence concerning savings rates by different groups, a topic to which we shall return later in this section.

We now turn to the evidence. In one sense, it is easy to provide evidence that developed country capital-labor ratios are not the only alternatives available. A glance at any LDC industrial census which contains capital data will reveal capital-labor ratios that are usually a third of those in the U.S.;[14] and this is in spite of the fact that LDC rates of capacity utilization are usually below that found in the U.S., thus raising the LDC capital-labor ratios above what they would be with better capacity utilization (and hence more labor employed).[15] But a

believer in the superior efficiency of capital intensive methods would probably not be convinced by this kind of evidence. He or she might well argue that the LDC methods are inefficient (old, antiquated, improperly conceived) and/or that the over-manning of otherwise efficient capital equipment is occurring because of employment pressures in LDCs; protectionist policies in LDCs buffer these inefficient production units from more efficient competition from internal or external sources. Or, they might argue that the LDC methods are efficient only for the small size of the LDC markets and that larger volumes could be produced more efficiently with more capital intensive methods. This scale argument is one that we shall return to below. Accordingly, a more systematic investigation than just a casual perusal of LDC industrial censuses is needed. We shall discuss six kinds of evidence: (1) econometric investigations of the elasticity of substitution between labor and capital, (2) engineering or process analysis of substitution possibilities, (3) anecdotal evidence on substitution, (4) evidence concerning big firms versus small firms, (5) evidence on the use of used machinery; and (6) evidence concerning multinational corporations. Evidence on saving rates and hence the desirability of captial intensive methods, even if they are not efficient, will be reviewed. And the question of substituting more labor-intensive products in consumption will also be discussed.

(1) <u>Econometric investigations of factor substitution</u>

There have now been a large number of efforts to use LDC data, usually from industrial censuses, to try to measure the degree of substitutability between capital and labor. All of the efforts involve trying to measure the elasticity of substitution (i.e., the percentage

change in the capital-labor ratio in response to a change in the factor-price ratio) in a constant-elasticity-of-substitution production function involving capital and labor.[16] Since the CES production function is non-linear and cannot be estimated through ordinary least-squares estimation techniques and since data on capital is frequently not available or not considered reliable, an indirect method is used. If the logarithm of output per worker is regressed against the logarithm of the wage, the coefficient on the letter variable is an estimate of the elasticity of substitution.[17] Most studies use this form. (Some of the studies use a direct demand for labor formulation, in which labor is regressed against the wage, output, and other variables.) A few regress the ratio of output-capital ratio against the return to capital (both in logarithms) of the capital-labor ratio against the wage alone or the ratio of the wage to the return to capital (again in logarithms) to provide alternative estimates. These estimates have been made for the whole of manufacturing in single countries and for individual sectors within manufacturing, for both time series and cross-sections, and for cross-sections for sectors across different countries. Table 1 lists the countries, the empirical studies, and their dates of publication. As can be seen, a wide variety of countries have been covered by these studies.

It is difficult to characterize the results of these studies. The estimates of the elasticity of substitution are, with only a few exceptions, positive, indicating (if one accepts the methodology as valid) that efficient factor substitutability is possible and that the fixed proportions view of the world is incorrect. The estimates tend to clump between 0.5 and 1.2, but some studies find values appreciably above and

Table 1: Econometric Studies of the Elasticity of Substitution of Labor for Capital in LDCs

International cross-section

Boon (1969)
Bruton (1972a; 1972b)
Courtney and Leipziger (1974)
Daniels (1969)
Diaz-Alejandro (1973)

Argentina

Bruton (1972b)
Eriksson (1969)
Katz (1969)

Brazil

Bruton (1972b)
Eriksson (1969)
Tyler (1974)

Chile

Behrman (1972)
Bruton (1972b)

Colombia

Bruton (1972b)
Eriksson (1969)

Costa Rica

Eriksson (1969)

Dominican Republic

Bruton (1972b)

Egypt

Abed (1975)

Ghana

Leith (1974)
Roemer (1975)

Greece

Bruton (1972b)

India

Bruton (1972b)
Diwan and Damodar (1968)
Sethurman (1971)

Table 1 (continued)

Iran

Bruton (1972b)

Isreal

Bruton (1972b)

Jamaica

Tidrick (1970)
Williams (1974)

Kenya

Harris and Todaro (1969)
House (1973)
King (1972)
Maitha (1973)
Senga (1973)
Weeks (1974)

Korea

Bruton (1972b)

Malaysia

Bruton (1972b)

Mexico

Bruton (1972a)
Eriksson (1969)
Ibister (1971)
Witte (1973)

Nigeria

Oyelabi (1971)

Pakistan

Ahmed (1975)
Husain (1974)

Panama

Peru

Bruton (1972b)
Clague (1969)
Witte (1971)

Philippines

Bruton (1972b)
Sicat (1970)

Table 3 (continued)

Williamson (1971a)
Williamson (1971b)

Puerto Rico

Reynolds (1965)

Southern Rhodesia

Bruton (1972b)

Turkey

Demirigil (1971)

below these values. Cross-section studies tend to find higher elasticities than do time series studies. An elasticity above 1.0 implies that not only will a fall in wages induce an increase in employment (as labor is substituted for capital) but also that labor's share of output will increase. There will also be an extra effect from the added demand for the final product due to the fall in price induced by the decrease in wages, so that the total wage bill can increase even if the elasticity of substitution is below 1.0.

The problems -- in concepts, data, and econometric technique -- have been reviewed by Nelson (1968), O'Herlihy (1972), Morawetz (1974), Acharya (1974), Gaude (1975), and Morawetz (1976). The data are bad, the CES form may not be the correct one, the time series studies may not include lags properly, the profit maximization assumption may not be a good one, the assumption of competitive markets is surely not true, all firms may not be using the same technology, the cross-country studies may not use the correct exchange rates, the cross-section observations (especially across countries) may not be using comparable industries, the level of capacity utilization is usually not held constant, all labor and all capital are assumed to be uniform and to be the only factors of production, to name a few of the problems.[19] It is easy to be sceptical of the results. Pack (1972), for example, has argued that the time series regressions may well just be showing that value added per worker increases as capacity utilization increases and simple technological improvements occur over time and that wages increase as workers succeed in capturing some of that increase in productivity. Thus, rather than showing a causality between substitution away from labor and wages, the regressions may be showing a reverse causality between wages and increasing productivity.[20] Cross-section regressions

may be capturing a similar effect, as could the regressions using capital-labor ratios. And Moravetz (1976) has shown that there is little consistency among the cross-section studies in their rankings of common industries by estimated elasticity of substitution.

Leaving aside, then, the data and econometric problems which are always present to a greater or lesser degree in any empirical work, one's evaluation of the worth of these regressions does hinge crucially on how one views the causality between wages and capital-labor ratios. If one already believes that capital-labor ratios are efficiently flexible and that entrepreneurs do respond to factor price incentives, then the results of the regression do provide support for this view: making labor more expensive and capital cheaper tends to cause factor substitution towards greater capital intensity. On the other hand, if one believes that efficient factor proportions are more or less fixed (and that observed differences are largely due to random elements or to pressures to increase employment) and/or that wages respond to higher levels of productivity, then the regressions may not support the claim of substitutability. In this author's view, both effects are probably occurring, and the econometric evidence probably does give some support for the position that efficient labor-intensive alternatives for manufacturing exists. But this is probably more an act of faith than a hard conclusion from incontrovertible evidence. The believers in fixed proportions are unlikely to be convinced.

(2) Engineering or process analysis studies. In these kinds of studies, researchers investigate individual manufacturing processes or individual products. The investigators usually use engineering or other technical information to determine the inputs necessary to produce a given

volume of products (or to process a given volume of manufactured items). A principal part of the investigation is to see if there are alternative means of producing that same volume: i.e., if more workers and fewer machines (or, more usually, simpler and cheaper machines) can produce the same volume as fewer workers and more machines. This is, of course, the heart of the substitutability question.[21]

Table 2 lists the products and processes for which these studies have been done.[22] The list is not long, but an important result does emerge from these studies: Factor substitutability does seem to be quite possible, and the differences in factor ratios can be quite substantial. Timmer's (1975) study of rice milling and marketing systems found four efficient alternatives, of which the most capital intensive required $65,000 investment per worker and the most labor intensive required $700 per worker. The ECLA study of cotton textiles reported by UNIDO (1969, p. 44) showed a choice of efficient techniques ranging from $6,600 investment per worker to $21,500 investment per worker; Pack's (1974) study argues that the lower limit is closer to $1,100 per worker. Further, Pack (1974) was abla to relate the efficient factor combinations observed in operation to the wage rates and returns on capital also present and thus to calculate elasticities of substitution. Of six industries observed, all had positive elasticities of substitution, and five were above 1.0.

Of course, not all technically efficient factor combinations, even labor intensive ones, would be economically efficient for LDCs. Just as a factor combination could be too capital intensive, it could also be too labor intensive. For example, suppose that a given volume of output can be produced with one worker and a $10,000 machine or by 100 workers

Table 2: Engineering and Process Analysis Studies Relevant to LDCs

Textiles

Bhalla (1964)
Hewavitharna (1970)
Pack (1974)
Pack (1975)
Sen (1972, Appendix C and D)
UNIDO (1969, p. 44)

Grain Milling

Bhalla (1965)
Pack (1974)
Timmer (1975)

Bicycles

Pack (1974)

Paints

Pack (1974)

Tires

Pack (1974)

Sugar Manufacturing

Baron (1975)
Hewavitharna (1970)
Pickett et. al. (1974)

Jute Processing

Coopar and Kaplinsky (1975)

Can Manufacture

Cooper, et. al. (1975)

Cement Blocks

Stewart (1975)

Table 2 (continued)

Coir

Hewavitharna (1970)

Metal Working Processes

Boon (1964; 1975)
Morse and Staley (1965, pp. 213-219)

Wood Working Processes

Boon (1964)

and a $9,900 machine. The latter combination is technically efficient, since it does involve a trade-off of labor and capital. But only if one was sure that the opportunity cost of labor was zero would the latter option make economic sense. In fact, however, in virtually all cases, at realistic opportunity cost wage and interest rates for LDCs, labor intensive or intermediate alternatives are economically sensible. LDCs do not appear to be limited to current developed country capital intensive methods.

There are some limits to these studies and some unanswered questions, however. First, the question of economies of scale and whether optimal factor proportions change with scale is examined only by Boon (1964-1975) and by Stewart (1975). They find that there are appreciable economies of scale in many metal machining processes and in cement block making and that capital intensive methods are necessary to capture these economies. Thus, at low volumes, there are efficient alternatives, and relative wage and interest costs should determine the proper technique. As volumes increases, input levels grow more slowly, so that unit costs fall (for any wage and interest rate), but this happens to a greater degree for capital intensive processes. At very high volumes, the capital intensive processes dominate so that at any wage or interest rate it makes economic sense to choose the capital intensive processes. The lower the wage, however, the higher the volume at which it makes sense to switch from the labor intensive to the capital intensive processes.

Why economies of scale should favor capital intensive processes is unclear: it just seems to be a fact of technological nature for the particular processes investigated. To what extent can it be generalized?

Most of the investigators of product technology do not mention it, and it seems likely that this is a phenomenon restricted in significance to only some of the processes that go into manufacturing a product, like metal finishing, and flow processes involving liquids, pipes, and containers like petroleum refining and chemical production. The importance of setting-up costs for a production run or of the surface area and volume relationship of containers[23] dominate here. For other manufacturing processes, scale effects seem likely to be much less important. (This appears especially true of the peripheral activities mentioned in the next section.) Clearly, though, much more needs to be known about the relationship between scale and factor substitutability.

For a product that does embody significant scale effects, LDCs face a dilemma.[24] The small market LDC can achieve appropriate factor proportions but has high unit costs (but, it must be emphasized, the LDC would have yet higher unit costs if it switched to the capital intensive method); the large market LDC has lower unit costs but high capital intensity.[25] Only research leading to new technologies that would decrease the importance of scale effects or have them apply equally to labor intensive methods offers a way out of this dilemma.

A second open question in these studies is the problem of quality. Are capital intensive processes necessary to ensure high quality? Stewart (1975) argues that this is the case for cement blocks. The other studies though, either claim that quality need not be affected by technique or neglect to mention the problem. As noted above, other observers, like Baranson (1967; 1969b, chs. 2 and 3, 1972) and Strassmann (1968, pp. 93-102, 155-157) argue that, particularly in metal finishing processes, machines

can substitute for skilled labor and foreman supervision in ensuring a high, uniform quality standard. Again, we need to know more in this area.

Finally, on this last point, there are other inputs into the production process, and the process studies do not tell us enough about them. Baron (1975) and Pack (1974) do account for the differential efficiency in the utilization of raw materials of different techniques. Unfortunately, it is difficult to tell if this is a serious problem generally. Further, is the argument that mechanization is an efficient substitute for management supervision skills valid? Unfortunately, there is only one piece of quantitative evidence on this point. Clague's (1970) study showed that the overall efficiency of Peruvian industries relative to that of comparable U.S. industries increased as capital intensity increased; machine paced processes seem to offer less latitude for labor inefficiency.[26] The engineering and process studies have not thus far been able to quantify this, and so it must remain, with the exception of Clague's study, largely an open question. Pack (1972; 1976) argues that good management is also needed in order to recognize the possibilities for labor-capital substitution and to do the necessary innovations to adapt equipment rather than just accept completely the sales pitch of the traveling capital goods salesman from the U.S., Europe, or Japan. But Pack (1975) reminds us that high levels of mechanization will require the repair skills necessary to repair the complex modern machinery, and these are usually as scarce in LDCs as the management skills that the machines are supposed to replace. The repair skills to handle simpler machinery, however, usuallyare in greater supply.

In all, the engineering and process analysis studies do provide powerful demonstrations of the feasibility of labor intensive methods and are probably more convincing than the econometric studies of the previous section, but there are still the difficult questions of scale, quality, and skill substitution.

(3) Anecdotal evidence. Under this category we group studies that report examples of labor-capital substitution but do not offer precisely quantified estimates of the frontier of efficient combination in the way that the engineering studies do. These reports can nevertheless offer useful insights in the production processes.

Fei and Ranis (1972; 1975) and Ranis (1957; 1971; 1973; 1974; 1975) have documented a number of ways in which labor could be efficiently substituted for capital. During Japan's early industrialization, when wages were comparatively low, machinery in textiles and other industries were run faster and more intensively (extra shifts); this meant more frequent halts for repair, but repair was a labor intensive activity. The overall effect was greater labor intensity and greater efficiency in the use of all resources. Thus, even in processes in which mechanization was necessary for quality reasons, double and triple shifts greatly decreased the overall capital-labor ratio. Greater use was made of older, used equipment from the West. Raw material inputs were modified so that more labor intensive processes could be used. Ranis reports that similar capital-stretching, labor intensive techniques are currently being used in Korea and Taiwan in textiles, electronics, woodworking, and other industries. He further points out that even for products in which there may be technical rigidity in some main production processes, there are always

peripheral processes like materials handling and packaging, which can be done efficiently with labor intensive methods, so that the overall production of the product still has scope for labor-capital substitution.

Similarly, Pack (1972;1976) reports examples of labor-capital substitution in consumer goods manufacturing in Kenya. He too notes the possibility of factor substitution in peripheral activities, but also notes quality problems: human handling of fruit inputs into food manufacturing may lead to higher rates of spoilage or breakage. He also notes a scale sensitive process: container filling. At high rates of volume, some container filling processes would be worth automating regardless of wage levels.

Other reports of LDC production processes that are more labor intensive than those of developed countries include Strassman (1967; 1968, ch. 6), Baerresen (1971), Sharpston (1973), ILO (1972b, pp. 141, 446-450), Wells (1973), Boon (1975), Baranson (1967, pp. 59-62; 1969, pp. 4-7), Mason (1970), and Armas (1973). But are the adaptations efficient? In virtually all cases, the researchers report that the greater labor intensity has taken place in response to the lower volumes and/or the lower wage of the LDCs. This kind of response (as opposed to, say, a report that greater labor intensity seems to have occurred at random) does tend to support the notion that these are efficient adaptations. Also, Ranis' examples include firms that were facing substantial competition, either internally or in export markets; again, there is a presumption that this would tend to be forcing efficient adaptations. Finally, Ranis, Pack, the ILO, and Strassmann connect the adaptations with good, flexible management; again this argues for

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efficient adaptation.

The anecdotal evidence then, points in the same direction as the earlier evidence: greater labor intensity is not only feasible but is in fact occurring in some LDCs. It does, however, seem to be closely tied to good management.

(4) Big firms versus small firms. It is widely acknowledged that small firms are more labor intensive than large firms.[27] Many claim that the small firms have adopted this greater labor intensity in response to the different factor prices that they face compared to large firms: cheaper labor and more expensive capital. This kind of response, they argue, shows that it is an efficient adaptation and hence that efficient factor substitution is quite feasible.

But are the small firms efficient? A counter-argument would run as follows: The small firms may have lower capital-labor ratios, but they are inefficient, in the sense that they use more labor and more capital per unit of output than do large firms. They are still able to sell goods in the same market as the big firms, though, because their wage costs are so much lower; i.e., because the labor markets are imperfect.[28] Hence, the greater labor intensity of the small firms is not necessarily an efficient adaptation.

The output-capital ratio of the small firms compared to the large firms is critical to deciding this point. The evidence is mixed: Ranis (1962a) finds that small firms in Pakistan had higher capital output ratios than large firms; Mehta (1969) finds the same to be true for India, as does Mareden (1969) for a number of countries. But Dhar and Lydall (1961) find the opposite to be true for India, as does Sandesara (1966; 1969).

Unfortunately, truly valid comparisions between large and small firms are very difficult to construct. Not only must the same final product be produced by both firms, but they must be vertically integrated to the same extent. For example, suppose that large firms produce more of their own inputs or do more of their own distribution than do smaller firms. These extra activities probably involve different factor proportions than the main production processes that are being compared. Thus, we could observe different capital-labor ratios and different output-capital ratios between large and small, even if the main production processes were identical, and might mistakenly conclude that these indicated differences in efficiency. It does not appear that any of the studies cited above have tried to correct for this problem.

Overall, then, we can learn little from the comparisons between large and small firms. The latter are surely more labor intensive, but we simply cannot conclude anything about their efficiency. If labor and product markets were competitive, the mere survival of the small firms would strongly imply that they were efficient. But, since neither set of markets qualifies as competitive, little can be decided.

(5) Used machinery. Second-hand machinery is frequently recommended as a way for LDCs to reduce capital-labor ratios. The theoretical argument runs as follows:[29] Profit maximizing firms should find it worthwhile to replace existing machinery with new machinery either (a) when there is enough technological imporvement so that the average total costs of output produced by the new machines are below the marginal costs of output produced by old machines or (b) in the absence of technological improvement, when future discounted maintenance costs exceed the price of the new machines plus their future discounted maintenance costs. In both

cases, replacement depends on comparing one set of costs that have a heavy labor weight with another set of costs that have a heavy capital element. Thus, a high wage economy will find it economically rational to replace machinery much sooner than would a low wage economy, and low wage LDCs should find worthwhile the purchase of used machines that developed countries find marginal. In the developed country, if there is an active market in used machinery, the price of the used machine would have to fall by enough for a developed country buyer to find it worthwhile to consider the used machine as an economic alternativa to the new machine. At that price, the LDC buyar will surely find the machine more worthwhile (except for added transportation costs), because of the latter's lower wage costs.[30]

The counter argument (often presented by those who believe in fixed proportions), is that good markets in used machines do not exist, used machines are a vary risky proposition, spara parts may not be availabla, or the machinery is so technologically obsolete that the use of the machines is inefficient compared to new machines.

What is the evidence? First, it should be noted that organized markets in used machinery are present in the developed countries. Brokers, catalogues, and trade associations of used machinery dealers do exist. Second, there is a fair amount of evidence that used machinery is employed efficiently in LDCs: Cooper and Kaplinsky (1975) in jute processing; Pack (1975) in cotton textiles; Boon (1975) in engine machining; James (1973) in paper manufacture; Arnas (1973) in pineapple canning; Pack (1976) in a number of consumer goods industries in Kenya; and Strassmann (1968, ch. 6) for a number of Mexican industries. Cooper and Kaplinsky do stress tha risk element in buying used machines; it takes special skills to be able to tell which ones are the "lemons," and manufacturers' warranties will

no longer apply. Indeed, all of the studies stress the need for good management and engineering skills as a necessary adjunct to the proper choosing, adaptation, and use of second-hand machinery.

There is one additional example of an industry in which active second-hand markets exist in developed countries, spare parts are available, and technological change has not been rapid: motor vehicles. There constantly are large stock of used cars and trucks available for sale in the U.S. and Europe. It is well known that, particularly for cars, prices depreciate faster than pure utilitarian usage considerations would dictate. Spare parts are usually quite available. And technological change since World War II has been quite slow.[31] It would appear that many LDCs would do well to forego importing new vehicles on attempting the domestic production of these vehicles and instead to buy and import large quantities of used vehicles (Meyer, 1966). Repair requirements would be greater for a fleet of vehicles bought used rather than new, but there are skills that are present in most LDCs and probably should be further encouraged. Parts, if not available, could be manufactured locally. Both domestic and foreign exchange resources would be saved for better uses, and effective capital-labor ratios in transportation would be lowered.

Again, the evidence on used machinery does show the possibilities of lower capital-labor ratios.

(6) Multinational Corporations (MNCs). The MNCs are frequently pictured as the special villans of the appropriate technology effort. They are, so the argument goes (Vaitsos, 1975; Stewart, 1973a, 1973b; Streeten, 1972b, 1973), tied to their capital intensive technology in the developed countries. That is what they are familiar with; that is what their product quality and trademark image is frequently based on. It is

frequently too risky and costly for them to try to change their technology for LDC conditions. They ignore the possibilities of using local raw materials inputs. And, even if they were considering adaptations, they frequently pay higher wages than do locally-owned firms and they can obtain their capital abroad at cheaper rates, so they would have less incentive to adapt.

The counter argument is presented by Pack (1972; 1976). As noted above, he argues that good management appears to be necessary to recognize and utilize the possibilities of labor-capital substitution. And the MNCs frequently have the best management around. Even if they pay higher wages than local firms, their wages are still considerable lower than those in the home country, and thus there is a strong incentive for adaptation.

What is the evidence? Here we must be very careful in evaluating it. A number of interview and questionaire surveys of MNCs, by Reuber (1973), Baranson (1971), Yeoman (1968), Hughes and Seng (1969), and Gregory and Reynolds (1965) have concluded that only a modest amount of technological adaptation has taken place, and that has been mostly in response to lower volumes, not local factor costs. This evidence has been widely cited by those who see the MNCs as villains.

But there is an interesting paragraph in Boon (1975, p. 270) that is worth recounting at some length. He describes an interview at an engine plant owned by an MNC in Mexico. At the beginning of the interview, the management assures Boon that the Mexican plant uses exactly the same technology as that used in the parent plant in the developed country. But as the interview proceeds and Boon tours the factory, it becomes clear that in many respects the factor proportions are different. The main

machinery processes are automated, but second-hand equipment is used. And all of the auxiliary processes, like packaging, handling, transporting and storing, are done much more labor intensively. Perhaps interviewers get told what the interviewees think they wish to hear, or what the interviewees wish to believe!

Contrary to these surveys, it appears that any researcher who sticks his head into an MNC facility in an LDC and looks around is likely to find substantial adaptations of capital-labor ratios, particularly in auxiliary processes. This is the case for Boon (1975), Pack (1972, 1976), Barenson (1967, pp 59-62); Strassmann (1968, chs. 5 and 6), Mason (1970), ILO (1972b, pp. 446-450), Wells (1973), and Armas (1973), Ranis (1971, 1973, 1974, 1975), Helleiner (1973a; 1973b), and Baerresen (1971) find MNCs adapting to labor-intensive processes for export processes. Not all MNCs adapt. Pack (1972) does cite an example of a home office insisting that more capital-intensive processes be maintained, even though the branch manager recognizes that the labor intensive methods would be more profitable. And not all of the MNCs in Strassmann's sample adapted their technology. But a higher fraction of the MNCs in Strassmann's sample adapted their technology than did locally owned firms. And a higher fraction were buying and using second-hand machinery. Again, similarly to Pack's argument, the importance of good flexible management possessed by MNCs is stressed by Strassmann and by the ILO (1972b) mission to Kenya.

It appears, then, that both locally controlled firms and MNCs can and do adapt their factor proportions. But which group is more likely to adopt the more labor-intensive methods? In examining comparative evidence, it is necessary to exclude economy-wide comparisons. Here, we will always

find that MNCs are more capital intensive than locally controlled firms. This is to be expected, since the MNCs do have a comparative advantage in capital intensive products. The critical question concerns comparisons within an industry in which both groups are present. Strassmann, Pack, and the ILO mission to Kenya all find the MNCs to be more labor intensive; they explain this on good management grounds. Mason (1970; 1973) finds that for a group of matched pairs of firms, U.S. controlled firms tend to be somewhat more capital-intensive than locally owned Philippino or Colombian firms; he explains this on the grounds that the U.S. firms pay higher wages and have access to cheaper capital. Radhu (1973a) also finds foreign firms to be more capital intensive than locally owned Pakistani firms. But Cohen (1973; 1975) finds no significant differences between foreign and Korean firms producing for export markets. The evidence is clearly mixed.

Although the MNCs may not be the heroes of appropriate technology, they appear to be far from the villains that many make them out to be. They have the management expertise, and they are frequently willing to use it to adapt to labor intensive processes. Again, there is adequate evidence of factor substitutability.

(7) Factor proportions and saving rates. An argument cited earlier in favor of capital intensive methods is that they would raise the income share of capital owners, who are supposed to have higher rates of saving and reinvestment than do workers; the pace of industrialization would thereby be quickened. This kind of argument, of course, presupposes that government taxation of labor incomes for saving purposes is not feasible. But, ignoring

this, what do we know about savings rates?

The evidence reviewed by Mikesell and Zinser (1973) does indicate that saving out of labor income is very low; the marginal propensity to save rises with income, and the saving rate out of profits is high. But Oshima (1971) argues that added income to low-wage workers might reduce the dis-saving of many. If we turn to the saving rates of firms of different capital intensities, Ranis (1962b) provides evidence that medium size (less capital intensive) firms have higher saving and reinvestment rates per unit of output than do large firms. Appavadharrlu (1974) argues that small firms in India have higher saving rates than large firms.

The evidence, then, is somewhat mixed. And, given the possibility of government taxation as a form of saving, the income distribution, saving, and reinvestment argument appears to be a weak reed on which the case for capital intensity might reat.

(8) Product substitution. Some researchers have argued that, in addition to the wrong factor proportions being used, the wrong products are being consumed (Streeten, 1972c; Stewart, 1973b; 1974); Hughes, 1974), Consumer durables like automobiles, washing machines, and air conditioners have capital intensive production technologies. More appropriate products and services, like bicycles, launderers, and coolers would be more labor intensive. (We will leave the issue of the development of new products for LDCs for Section V.) Frequently it is claimed that this is the result of an inappropriate income distribution in LDCs -- too heavily skewed toward the rich -- and that a radical redistribution of income is necessary.

Though this last suggestion may be recommended on ethical grounds, it appears that income redistribution would likely have only a tiny effect on employment. A number of macro-economic models of LDCs, reviewed by Morawitz (1974) and Cline (1975), all come to that conclusion.[32]

A less radical alternative would be simply to levy excise taxes on capital intensive goods which have labor intensive substitutes. Indonesia (Sadli, 1974) taxes "modern" manufactured cigarettes more heavily than traditional kretek clove cigarettes. But India (Baron, 1975) tries to encourage the consumption of capital intensive white sugar (as compared to the less refined gur) by keeping its price low.[33]

Another way of encouraging the production of appropriate products is to orient the economy toward exports (Ranis 1971; 1973; 1974; 1975; Fei and Ranis, 1975; Helleiner, 1973a; 1973b; Porter, 1972; Balassa 1971; Baerresen, 1971; Sharpston, 1975; Little et al., 1970). Here, labor-intensive goods and processes will have a comparative advantage in world markets and hence will be the natural choice for LDCs. This is the path that the "success stories" of East and Southeast Asia — Korea, Taiwan, Hong Kong, and Singapore — and, to a lesser extent, Colombia, Brazil, and Mexico have followed.

(9) A summary on factor proportions. This section has summarized the available literature on the possibilities of labor-capital substitution in LDC manufacturing. Each sub-section has presented one aspect of the evidence. By itself, each sub-section may not appear entirely convincing. But together they do paint a rather impressive picture. There do seem to be plenty of opportunities for more labor intensive methods to be used. And

there do seem to be opportunities for a more appropriate product mix. The ranges of choice are far from complete on both the production and product sides. The economist's smoothly curved production isoquant is rarely present. It is the task of research and development to increase the range of choice, a topic we shall tackle in Section V. But the claim of fixed coefficients simply does not offer a satisfactory explanation for the absence of appropriate factor proportions in most LDCs.

IV. The Causes of Inappropriate Factor Proportions

The evidence of Section III suggests that the possibilities for labor intensive production methods are much greater than the current practice in most LDCs. If fixed factor proportions are not the reason for LDC capital intensity, what explanations can be offered?

First, the relative prices of capital and labor are frequently badly out of line with their true social worth: a wide variety of government policies have made capital artificially cheap in capital-short economies, while labor has been made artificially expensive in many of these same economies (Little et al, 1970). Capital is made cheaper through government subsidized low interest loans, favorable exchange rates or low tariffs for imported capital goods, tax holidays on new investments, and accelerated depreciation on capital goods.[34] Labor in urban manufacturing has been made more expensive through minimum wage legislation, mandated fringe benefits, restrictions on the ability to lay off workers, and government encouraged union pressures.[35] These labor provisions are most likely to be enforced in the government sector, in large firms, and in MNCs. As we argued earlier, they are a major factor in encouraging high urban unemployment. Real urban wages are frequently two or more times rural wages.[36] In a number of countries, the relative distortion of labor and capital prices, rather than getting better, has become worse during the years since the Second World War. Witte (1973) estimates that the wage/capital-rental ratio for all of Mexican manufacturing rose from an index of 100 in 1945 to 280 in 1964; for Peru, the price ratio for a number of industries rose from 100 in 1958 to a range of 190-270. Roemer (1975) reports that the same ratio in Ghana rose from 100 to 124 in 1966 (but subsequently fell to

90 in 1970). Krueger (1974, p. 235) reports an appreciable rise in Turkey for the period 1955-1970. In a contrary case, Williamson (1971) reports a falling ratio in the Philippines for 1955-1966; this is confirmed by Hicks and McNicholl (1971) and by Baldwin (1974, p. 148). But generally the pattern reported is rising real wages in manufacturing in most LDC countries, while capital remains cheap or becomes cheaper (Smith, 1969; Knight, 1975; Berg, 1971; Gregory, 1974).

The rising real wages in LDC manufacturing sometimes receive two defenses; both should be put to rest. First, it is argued that wages should rise with the increases in productivity in manufacturing. Besides mixing cause with effect, this argument is wholly inappropriate for an economy with widespread un- and under-employment. As long as there is substitutability, greater capital shallowing should be encouraged through low wages; only when labor grows scarce should real wages rise in line with rising productivity. Second, it is argued that in a world of monopolistic MNCs which escape LDC taxes through internal transfer pricing vis-a-vis the parent company, high wages may be the only way that the LDC can capture some of the profits. But the obvious solution to this is to improve government taxation and customs procedures and to reduce the MNC's monopoly power by introducing more competition (via imports, if necessary) into the domestic economy in which the MNC sells or by opening up for wider bidding the extraction and export concession that the MNC has. Using wages to try to capture those profits is a distinctly inferior and potentially quite harmful policy.

The cheap capital and high wages policies have laudable goals: to encourage investment and to raise worker incomes. But their

inevitable result is to encourage entrepreneurs to substitute away from labor and toward capital intensive processes. The econometric studies of the elasticity of substitution, if they are to be believed, certainly point in this direction. The engineering and process analysis studies, especially Pack's (1974), also tell the same story. And much of the anecdotal literature, analysis of small firms, and discussion of MNC adaptations do link changes in capital-labor ratios to relative factor prices.

Further, inappropriate factor prices make capital intensive goods cheaper and labor intensive goods more expensive, thus discouraging consumption of the latter. Not only are the wrong processes encouraged, but the wrong products are also encouraged (Cooper, 1972).

But factor prices do not seem to offer a complete explanation of the existence of inappropriate factor proportions. A second reason seems to be the strong tendency for entrepreneurs and especially engineers to think in terms of developed country mechanized technology as the ideal, regardless of factor prices. The confusion between high labor productivity and efficiency enters here. If markets are non-competitive, entrepreneurs seem willing to sacrifice some of their potential monopoly profits in order to achieve this goal of mechanization. Wells (1973) has labeled this the phenomenon of "engineering man." The argument also appears in Bruton (1973), Pickett et al (1974), and Ranis (1974). This appears to be a widely held notion. But there has been only one attempt formally to test the proposition. White (1976?) found that greater competition in Pakistani product markets forced industrialists to adopt more labor-intensive methods relative to the U.S. "ideal"; industrialists in less competitive markets were freer to pursue

their engineering goals.

Third, even in instances in which firms might be interested in more labor intensive methods and those methods do exist, information about them is frequently difficult to obtain. Search is costly, the firms are familiar with the capital-intensive processes, and the absence of competition may reduce the incentive to search. Or even with search, they may simply fail to find out about the labor intensive methods.[37]

Fourth, not all MNCs adapt their technologies. There are plenty of "engineering men" in MNCs, and, if permitted by non-competitive markets, they too will mechanize beyond socially optimal levels.

Fifth, inappropriate government policies, beyond the labor and capital pricing policies and the failure to encourage competition mentioned above, are another contributing cause. Badly conceived public projects, like the petrochemical complex cited by Morawetz (1974), are a bad use of resources and surely do not provide a good example to the private sector. The mystique of high productivity and modernity pervades the public sector as much as it does the private sector. Other poor policies include a frequent negative attitude toward the import of used machinery and used vehicles, sometimes taking the form of outright bans.[38] This is based on the belief that used machines are inferior and private entrepreneurs are mistaken in their purchases or that used machinery may be an easier vehicle for smuggling (through over-invoicing to smuggle funds out of the country or under-invoicing to reduce tariff duties, since the customs officials may be less familiar with the true value of the machinery). As argued above, such policies are sacrificing potential major improvements in labor-capital ratios.[39] And the unwillingness to tax or otherwise discourage the consumption of capital-intensive

consumer goods and the unwillingness of many governments to encourage the development of export markets for manufactured goods further push their economies toward capital intensive methods.

In short, LDC government policies can go a long way in explaining the inappropriate factor proportions observed.

V. The Evidence on Research and Development in LDCs

Though plenty of opportunities for more appropriate factor proportions exist in LDC, the range of choice is far from complete, and in many instances there is a serious need to develop new processes and products for LDCs that will be more labor intensive and, of course, that will increase the overall productivity of all factors generally.[40] This is technological progress, with research and development as the main generating agent. Unfortunately, technological progress and R&D are only imperfectly understood in the developed countries, and the data is still poor and spotty. There have been recent surveys by Kennedy and Thirwell (1972) and Kamien and Schwartz (1975). Much less is known about this area in LDCs.

First, a few clarifying remarks. Improved products and processes are the desired end result. Unfortunately, it is frequently difficult to quantify these measures properly at the micro level for testing hypotheses. Sometimes, patents are used as a proxy for the desired measures, or lists of inventions are used. More frequently, R&D personnel are used instead. But it must be remembered that these are <u>inputs</u> into the technological progress process, whereas we are really interested in the output of the process. By measuring and testing hypotheses on inputs, we must be assuming a fairly fixed relationship between inputs and outputs. Though there is evidence of a positive relationship between these inputs and outputs in the U.S., evidence on whether this is linear or not and what other factors influence it is nonexistent.[42]

There are two major hypotheses concerning technological progress and R&D. One is the Schumpeterian hypothesis that large absolute size of firm and market power are necessary to generate R&D. The

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former is necessary because of economies of scale in the R&D process itself (e.g., a laboratory or workshop may have a minimum efficient size); the latter because market imperfections are necessary to generate the funds for investing in R&D and absorbing the risks of R&D and to overcome the problem of competition stealing and copying new ideas and thus making investment in them unprofitable in the first place. A contrary set of hypotheses argues that invention and innovation is still a creative process best suited to individual or small group situations and that the best spur to invention and innovation is at least a moderately competitive market in which firms fear that if they do not innovate some other firm will do so instead, to the first firm's detriment.

There have been extensive testing of these hypotheses. Size does seem to matter in generating more R&D or patents as a percentage of sales, but only up to a point. This point seems to vary by industry. The largest firms in these industries rarely do proportionally the most R&D. But there is the problem of under-reporting by small firms (and probably over-reporting by large firms, since R&D has become a prestige area), and Jewkes et al (1969) offer plenty of stories of major inventions that have been developed by individuals or small groups. The case for market power is much weaker; some studies find that it matters, others that it does not.

Let us now turn our attention to R&D in the LDCs. Unfortunately, so much less is known that generally writers on the subject are content if they can just quantify R&D expenditures; these have been only a very small handful of empirical tests of hypotheses.[43] The Sussex Group (1970) has estimated that LDCs do only 2% of all of the R&D conducted in the non-Communist world. Frankena (1974, p. 256)

estimates that Indian manufacturing firms spend only 0.1-0.2°/o of sales on R&D; the ILO (1972b, p. 148) report on Kenya gives a similar figure for Kenyan manufacturing. Herrera (1972) estimates that Latin America spends only 0.2°/o of GNP on R&D.. By contrast in the U.S., 3°/o of GNP is spent on R&D, and manufacturing industries on average spend 2°/o of sales from their own finances on R&D (Scherer, p. 349). Katz (1973), in one of the few quantitative studies of LDC R&D, found that the R&D expenditures as a percentage of sales of Argentine firms in nine industries were only a fifth of the relative amounts spent by domestic U.S. firms in the same industries.

The reasons for the low levels of spending are many: low levels of income; shortages of trained personnel; the small sizes of firms in LDCs (Katz, 1973); the ready availability of developed country technology and the low risks involved in transferring it intact rather than trying to adapt it; the absence of competitive pressures to innovate (Frankena, 1974; Baranson, 1974); and the practice of MNCs, if they do any R&D relevant to LDCs, mostly to do it in their home countries.[44]

As a consequence of the low levels of R&D, many argue (Stewart, 1972; 1974; Streeten, 1972c; Vaitsos, 1975), labor intensive processes are not developed for LDCs, and new products that would be more labor intensive and would be more aimed at the mass markets of low income consumers are not developed. Further, there is probably a close connection between process adaptation and product adaptation. In many cases adaptation of the processes requires product adaptation, to make fine tolerances less critical and frequently to lower the general quality of the product. The MNCs come in for their share of criticism here, since their reputations are frequently based on the quality of their products and they are

reluctant to tamper with that image.

Still, it is instructive to remember that some invention, innovation, and adaptation does occur in LDCs. The anecdotes in Section III were all largely instances of firms innovating: taking developed country machinery or processes and altering them to suit the LDC conditions. Three stories of individual innovations in LDCs--Sansom (1969) on a lift pump in Vietnam, Dommen (1975) on a bamboo tube well in India, and James (1973) on paper manufacture in Mexico--would certainly fit the patterns described in Jewkes et al (1969), Strassmann (1967; 1968, pp. 172-173, ch. 7) provides examples of product and processes developed in Mexico. Khan (1974) and Duff and Khan (1974) describe innovations in the design and manufacture of small-scale agricultural implements at the International Rice Research Institute. Even a few of the MNCs have research operations in LDCs and do adapt items like cars and tires to local conditions and currently seem to be interested in providing new high nutrition food products for LDCs (USAID, 1972).

But, clearly the flow of new products and processes that are appropriate for LDCs is not fast enough. Efforts should be made to encourage more R&D and, of course, to make sure that it is aimed at the right targets. Here, the question of incentives arises again. First, Strassmann (1970; 1971) and Greene and Strassmann (1971) note that the innovations in Latin American construction methods tended to be labor saving, and they relate this to rising real wages for construction workers. They also note that the labor-saving innovations tend to be adopted more slowly where real wages are lower. Second, Pack (1972; 1976) argues that labor-intensive methods may encourage more rapid technological progress, since new processes do not have to be embedded in expensive capital goods. Third,

Cooper (1974) notes the connection between the research and consulting of the Engineering Faculty at the University of Nairobi and their teaching. The government sector in Kenya wants capital-intensive "modern" methods on its projects; it wants to hire engineering graduates and faculty consultants who know these methods. Therefore the faculty must teach these methods and do most of their research on projects relating to them. Fourth, research on appropriate products will not be encouraged if inappropriate factor prices or exchange rates make domestic production unprofitable. One report (USAID, 1972) gives the example of a Pakistani research institute developing a new pesticide, but the report's author is then puzzled as to why the institute could get no entrepreneur interested in producing it. Small wonder, when Pakistan had a badly over-valued exchange rate and pesticides could come in duty free. Fifth, Frankena (1974) notes that India's foreign exchange control regime meant that there was less competitive pressure to design new products and processes; Baranson (1974) has similarly argued that Brazilian firms do little R&D because of the absence of competitive pressures. Frankena also points out that the control regime encouraged dependence on foreign technology, since a domestic firm with a foreign collaborator to provide foreign exchange could more easily get government approval for new projects. Finally, prestige factors also play a part in assessing what kind of R&D is worth encouraging. Katz (1973), for example, describes the research potential of firms in Argentina's electrical goods industry and writes in disparaging terms of the small firms that make simple transistor radios for the domestic market. Katz's views would probably be shared by government officials deciding on the allocation of research funds. Yet these firms may have made the best

adaptations of product and process for the bulk of the market.

Research institutes in LDCs are frequently seen as a way of encouraging appropriate R&D and of transmitting new and existing knowledge of techniques to LDC firms, especially small firms. There are plenty of examples of successful research institutes (the Korean Institute of Science and Technology, IMIT, IRRI, the wheat research institute in Mexico, the Madras Leather Institute), but also of institutes which are not (Strassmann, 1967; 1968, ch. 7; Stewart, 1974; USAID, 1972; Khan, 1974; Duff and Khan, 1974). The leadership of these institutes appears to be critical to their success. The decision by an institute to solicit contracts to solve problems and to do applied research is also important.[45] The contrary decision to do basic research and try for published papers in developed country learned journals will mean another research institute spinning its wheels. Finally, there are problems of confidentiality of information, since many firms fear that publicly sponsored research institutes will reveal confidential information to the tax authorities or politicians (Strassmann, 1968, pp. 43-48).

Pressuring the MNCs to do more R&D in the LDCs is another approach. Countries might make this a condition of entry by the MNC. Again, appropriate factor prices and product taxation would certainly encourage this process, as would more competition in product markets. Indeed, much of the problem that LDCs face in paying too much for the transfer of technology (through excessive royalties, improper transfer prices on inputs, etc.) would disappear with a combination of tougher bargaining and a pro-competitive (via import competition) policy that would reduce the potential profits that the MNCs could siphon away. The picture (Barnett and Mueller, 1975; Streeten, 1972b; 1973) that is frequently described of helpless LDCs at the mercy of

a handful of monopolistic MNCs is largely false. Alternative suppliers of technology to achieve similar ends almost always exist, and LDC policy makers can and should be able to take advantage of this.[46] Even in the world automobile industry, which exhibits tight oligopoly in domestic production in every developed country, there are more than a dozen producers capable of LDC production.

Finally, the question of patents in LDCs combines the problem of incentives and MNCs. Patents provide a property right in an idea and thereby encourage the investment of resources (R&D) in the production of new ideas that would otherwise be copied at low or zero cost. But they do convey a monopoly on the idea in the process. In LDCs the vast majority of patents are granted to foreigners (Vaitsos, 1972; O'Brien, 1974), and only a tiny fraction of them are ever used in the LDC. Essentially, the patents largely protect foreign inventions from being copied domestically rather than encourage domestic invention. But the patent system does encourage some MNCs to produce in LDCs, which they otherwise would not do if they could not protect their products and processes (Penrose, 1974). The publication of the patent in the developed country reveals the basic invention (Grundmann). But there is usually non-patentable proprietary confidential information that is necessary to make the invention work. This is what the MNC is frequently bringing to the LDC, and the protection of the patent also protests this proprietary knowledge. The critical question is whether a broad patent system that possibly encourages some domestic invention and some MNC investment but that also prevents domestic firms from using foreign owned patented inventions that the foreigners are not using is worthwhile. There is simply no evidence to support strongly any conclusions.

It is probably the case that a more selective system--e.g., one that voided foreign held patents after a period of domestic non-use --would be more worthwhile.[47]

For R&D in LDCs, then, though the picture is far from bleak, it is also far from rosy. Though some R&D is done, more is needed. But, again, incentives are important, and policies should be shaped carefully. It is too easy to throw away large sums of money on ill-conceived R&D.

VI. Conclusions

The evidence summarized in this paper does suggest strongly that greater labor intensity in LDC manufacturing is feasible and would be efficient. The possibilities are not unlimited; there is still plenty of room for the discovery of intermediate technologies through well-directed R&D. But a view that LDCs are currently condemned to high capital-labor ratios, because there are no efficient alternatives, simply is not consistent with the evidence.

The evidence also suggest that incentives matter. Appropriate factor prices are an important spur to the discovery and profitable use of appropriate factor proportions and appropriate products. Effective competition in product markets can also provide an important push in the right direction, by leaving less scope for engineering instincts to dominate efficient factor use.

Large gaps, however, still remain in our knowledge of appropriate factor use. The micro studies of efficient alternative factor proportions have only been completed for a small handful of industries. It would be reassuring to have many more studies showing that alternatives exist. Also, these kinds of studies could profitably be focused on the auxiliary handling, packaging, transporting, and storage processes that figure prominently in the anecdotal examples of substitutability; again, it would be reassuring to have more precise estimates here. Further, we still do not understand very well the connection between scale effects and mechanization, nor the extent to which it is a genuine problem. And the connection between quality standards and mechanization and the extent to which mechanization serves as a substitute for skilled processing labor

and/or management supervisory skills are still largely unknown; most evidence here is still qualitative rather than quantitative. (But, it cannot be emphasized too frequently that better utilization of existing capacity--multiple shift work in particular--can greatly increase the overall labor-capital ratios of apparently capital intensive processes. and that export markets can supplement small internal markets so as to achieve possible scale economies.) Finally, the connection between good management and the ability to recognize and utilize the opportunities for labor-capital substitution needs much greater exploration.

The conclusions of this paper point directly to a number of policy implications. First, the establishment of proper factor prices is terrifically important. This has been a familiar refrain from economists over the past ten years, but it can still bear repeating. The subsidies to capital use must be ended; an important part of this would be the replacement of exchange control and over-valued exchange rates with a realistic exchange rate. If wages in the urban modern sector cannot be decreased, at least their rates of increase must be substantially moderated in many countries. This is difficult to advocate, since the wages are low by developed country standards; but they are high by comparison with the incomes of the bulk of the remaining population in the LDCs, and the wage increases in the urban sector must necessarily reduce the potential for improving the incomes of the poorer majority. If these policies of altering relative factor prices are combined with pro-competitive policies and more effective taxation policies, they need not imply a decrease in labor's share of (or claim on) output relative to capital's share. Rather, the effect will largely be an increase in the government's share (and possibly lower product prices because of the

pro-competitive policies); these extra government revenues can (hopefully) be spent on welfare increasing activities.

With respect to the small firm versus large firm problem, efforts to provide special facilities or subsidies to small firms are probably unwise. It is easy to waste funds on unproductive projects in this area,[48] and it would be a serious mistake to compound the current incentive errors by subsidizing capital for small firms. Rather, it would probably be quite adequate simply to give small firms unhindered access to resources; i.e., to stop current discrimination against small firms[49] and to let the processes of competition sort out the efficient and inefficient sizes. The current exchange control and capital funds control regimes usually do quite the opposite (White, 1974, chs. 2, 7). The establishment of an industrial extension service that would provide information on techniques and help solve problems for small businesses would probably be the best action that an LDC government could take (Hammond, 1974). But, like research institutes, effective extension services are easy to describe in principle and difficult to make work in practice.

The policy toward used machinery should also be relatively neutral. Neither a strongly pro- nor anti-used machinery policy seems warranted. Rather, reliance on the judgments of entrepreneurs--provided that the appropriate factor price and pro-competition policies are pursued --is warranted. Again, an information service to help on those judgments would be worthwhile.

The appropriate factor price and pro-competition policies, backed by some tougher bargaining by LDCs, would limit many of the possible abuses of MNCs.[50] Taxation policies on inappropriate products and an outward looking orientation that stressed labor intensive

exports would also help. And pressuring the MNCs to do more R&D in the LDCs is probably worthwhile.

Research institutes and information services, both national and international, are probably fruitful ways of encouraging more appropriate R&D by and for LDCs. But, again, it is easier to describe the good research institute than to operate it.

If the connection between good management and appropriate factor proportions is as crucial as much of the evidence suggests (with good management meaning that entrepreneurs can recognize and utilize the opportunities for appropriate factor proportions and also meaning that supervisory skills may be able to substitute for mechanization in the maintenance of quality standards), then appropriate management training institutes may be as important (or more so) as appropriate R&D institutes for discovering and applying efficient labor intensive methods.

Finally, a few words of caution: Appropriate technology is currently a fashionable topic of research and interest. There is, though, a serious risk. Appropriate technology is sometimes touted as a quick and easy way of raising LDC incomes to developed country levels. Five or ten years from now, after some (but not all) measures to encourage appropriate technology have been taken, many current enthusiasts will look around and notice that most of the people in LDCs are still very poor by developed country standards. They may then decide that appropriate technology was a fraud and will search for some other quick and easy solution. This would be unfortunate. Appropriate technology does not offer a simple solution to LDC problems; it cannot. There are no quick and easy solutions, short of a radical change in the relative supply-demand conditions for most

natural resources, comparable to that which has occurred in oil.[51] But appropriate technology can mean an improvement in the allocation of resources in LDCs, perhaps a slightly higher growth rate, a better distribution of capital resources across the economy and probably a slightly more equitable internal distribution of income, and more and better employment opportunities. The game should not be oversold, but it is definitely worth the candle.

NOTES

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1. This corresponds to the economist's notion of a set of production "isoquants.

2. Some authors (e.g., Marsden [1971]) have also included suitability for small scale production, compatability with LDC cultures, and other desirable properties of technologies as part of "appropriate." See Westphal (1974) for a critique of these wider definitions.

3. It should be stressed that the model which follows is an ideal, and no country, developed or less developed, functions in the perfect manner described.

4. Only if technological change were to alter the underlying technology sufficiently so as to increase the demand for labor would employment be able to keep pace with output.

5. This would be due, in about equal thirds, to physical capital deepening, human capital deepening, and pure technological change.

6. This has come to be called the Harris-Todaro model. See Todaro (1969), Harris and Todaro (1970), and Todaro (1971). See also Berry (1974), Fields (1975), and Godfrey (1973).

7. This hypothesis is given powerful support by Turner and Jackson (1970) who find that the rate of change of LDC urban unemployment is negatively related to LDC growth rates and positively related to the change in the ratio of urban incomes to economy-wide incomes.

8. E.g., through a wage subsidy.

9. Stewart (1974, p. 87) provides a calculation in a similar spirit.

10. The Pearson report (1970, p. 30) estimated average LDC saving at 15.0%/o and investment at 17.8%/o of GNP for 1960-1967.
11. In 1971 the ratio of fixed capital plus inventories to employees came to $20,000 (U.S. Bureau of the Census, 1973). This ignores working capital. It also underestimates replacement costs, since it is based on lower historical costs.
12. This assumes that the workers in the high productivity jobs will be able to capture some of that productivity in high wages.
13. See, for example, the ILO report cited in Kilby (1962) and see Adusei-Poku and Fiejka (1972, p. 306).
14. See Luders and Cabero (1972) for Chile, ILO (1972b, pp. 446-447) for Kenya, and Strassmann (1968, pp. 316-317) for Mexico. Occasionally, authors have been able to find cases in which LDC capital-labor ratios are higher than developed country figures. See Khan (1970a, 1970b), Bautista (1966), and Boon (1969, p. 213).
15. For more discussion of capacity utilization rates and their causes, see Winston (1971; 1974), Little, et al (1970, pp. 93-99), Kemal and Talat (1974), and Steel (1972).
16. For the original statement and estimation of the CES function, see Arrow, et al (1961).
17. This is the first order condition with respect to labor for profit maximization or cost minimization.
18. There is the problem of the possibility of selectivity of reporting: Only the favorable results may get published in journals.
19. There are also econometric problems of multicollinearity and simultaneous equations bias.
20. But Harris and Todaro (1969) and Tidrick (1970), for example, explicitly try to test for this and reject it as an explanation.

21. Some studies (e.g., Hewavitharna [1970]) do present alternatives but then simply look at comparisons of unit costs. If these costs incorporate inappropriate factor prices, the conclusions from the unit costs may not be trustworthy. But one can usually recreate the original factor proportions so as to examine the technologically efficient alternatives.
22. The abstracts in OECD (1974a; 1975) also appear to include more recent studies.
23. The costs of containers and pipes tend to increase with surface area, which rises more slowly as dimensions increase than the volume enclosed. See Silbertson (1972) and Scherer (1970, ch. 4).
24. This assumes that, despite the dilemma, it is still within the LDC's comparative advantage to produce the item rather than import it.
25. And, of course, the small producer who expects volume to grow has a yet crueler dilemma.
26. Diaz-Alejandro (1965) also tried to measure the same effect, but his study focuses only on output per worker and thus ignores the effects of varying capital intensities.
27. The literature on small firms has grown quite extensive. See Staley and Morse (1965), Dhar and Lydall (1961), Bhalla (1974), IBRD (1973), Paine (1971), Stepanek (1960), Fisher (1968), Shinohasa (1968), Oshima (1971), Watanabe (1974), and Veps (1967; 1971).
28. Or one could argue that they sell different kinds of goods or different qualities, in which case the comparisons become largely irrelevant.

29. For some further theoretical discussions, see Sen (1962), Schwartz (1973), and Smith (1974).
30. But if the productivity of the used machine falls so low that its price is simply its scrap value, then it may or may not be a good buy for the LDC.
31. See White (1971, ch. 13) on this point for U.S. cars; see Alth (1968) for trucks.
32. Also see Cline (1972) and Tokman (1974, 1975).
33. The price ceilings, though, may have had the unintended effect of discouraging the production of white sugar.
34. Winston (1970) has also pointed out that exchange control and overvalued exchange rates make smuggling a highly profitable activity and that smuggling via over-invoicing on hard to value (by customs officials) capital goods provides yet another incentive for entrepreneurs to favor capital intensive processes.
35. See also Cordova (1972).
36. See, for example, Hicks and McNicholl (1971, p. 91) for the Philippines.
37. See Cooper et al (1975) for a description of a can manufacturer who simply failed to find out about the availability of a lower cost labor intensive method of production.
38. See Rethwisch (1974).
39. Todaro (1970), though, has argued that reliance on used machinery will still tie LDCs to a pattern of increasing capital-labor ratios over time, since this has been the pattern in the developed countries from which the used machinery comes.
40. See Marsden (1971) and Schumacher (1971a; 1971b; 1972; 1973).

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41. Also, even patents may be a poor measure of the true output we wish, since there are clearly some patents which are more worthwhile than others.

42. See Kamien and Schwartz (1975) for a summary of this evidence.

43. For general discussions, see Sussex Group (1970); Stewart (1974); Eckaus (1966); Strassmann (1968, ch. 7); Herrera (1972); Nelson (1974); Solo (1966); Helleiner (1975a); and Bass (1973).

45. As Khan (1974) points out, since LDC industrial firms do not undertake much applied R&D, basic R&D by research institutes would be wasted.

46. Leff (1968, ch. 4) describes the way in which the Brazilian engineering industry was successful in obtaining foreign technology at reasonable costs: Streeten (1973) and Helleiner (1975b) also recognize that LDCs can be more effective bargainers.

47. This might have one unfortunate effect, if done in isolation. It would provide easier access to foreign capital intensive technology by local entrepreneurs and might bring out further the "engineering men" among them.

48. See Dhar and Lydall (1961) and Watanabe (1974).

49. See Di Tullio (1974).

50. For example, ending the tax concessions that make capital cheaper for MNCs would improve factor utilization and increase LDC taxes at the expense of profits. The questionarie data (if it is to be believed) indicates strongly that MNC location decisions are not affected by tax concessions (Hughes, 1969; Reuber, 1973, p. 128; Streeten, 1972b, p. 230; Schreiber, 1970, p. 75).

51. And even then, LDCs would still face serious political, social, cultural, and income distribution problems. It is not clear that Saudia Arabia is everyone's ideal of what an LDC that becomes rich should look like.

BIBLIOGRAPHY

Abed, George T. (1975), "Labour Absorption in Industry: An Analysis With Reference to Egypt," Oxford Economic Papers, Vol. 27, No. 3 (November), pp. 400-425.

Acharya, Shankar N. (1974), "Fiscal/Financial Intervention, Factor Prices, and Factor Proportions: A Review of Issues," Bank Staff Working Paper No. 183, IBRD.

Adusei-Poku, K. and Z. Fiejka (1972), "Fiscal Policy Aspects of Technological Changes in the Industrial Sector and Effects on Employment in Developing Countries," in ILO (1972c), pp. 295-312.

Ady, P. D. (1971), "Private Overseas Investment and the Developing Countries," in Peter Ady, ed., Private Foreign Investment and the Developing World (New York: Praeger, 1971).

Aharoni, Yair (1966), The Foreign Decision Process (Boston: Harvard University Graduate School of Business Administration).

Ahmed, Meekal (1975), "Employment Aspects of Industrial Growth: A Correction," Pakistan Development Review, Vol. 14, No. 1 (Spring), pp. 142-145.

Alth, Max (1968), "The Use of Old and Second-Hand Road Transportation Equipment," The Seminar on the Establishment and Development of the Automotive Industry in Developing Countries, UNIDO.

Amin, Samir (1969), "Levels of Remuneration, Factor Proportions, and Income Differentials With Special Reference to Developing Countries," in Smith (1969), pp. 269-293.

Appavadhanulu, V. (1974), "Firm Size and Saving Rate in India," Indian Economic Review, Vol. 9, No. 2 (October), pp. 183-188.

Armas, Armando, Jr. (1973), "Implications of Legislated Minimum Wages on the Choice of Technique in the Agro-Canned Pineapple Industry in the Philippines: A Micro Approach," Philippine Economic Journal, Vol. 12, No. 1 & 2, pp. 294-309.

Arrow, K.J., H. B. Chenery, B. S. Minhas, and R. M. Solow (1961), Capital-Labor Substitution and Economic Efficiency," Review of Economics and Statistics, Vol. 43, No. 3 (August), pp. 225-250.

Baerresen, Donald W. (1971), The Border Industrialization Program of Mexico (Lexington, Mass., D.C. Heath).

Baerresen, Donald W. (1975), "Unemployment and Mexico's Border Industrialization Program," Inter-American Economic Affairs, Vol. 29, No. 2 (Autumn), pp. 79-90.

Balassa, Bela (1971), "Industrial Policies in Taiwan and Korea," Weltwirtschaftliches Archiv, Vol. 106, No. 1, pp. 55-77.

Baldwin, Robert E. (1975), The Philippines (New York Columbia University Press).

Barber, Clarence L. (1969), "The Capital-Labor Ratio in Under-Developed Areas," Philippine Economic Journal, Vol. 8, No. 1, pp. 8[illegible]-89.

Baranson, Jack (1967), Manufacturing Problems in India: The Cummins Diesel Experience (Syracuse: Syracuse University Press).

Baranson, Jack (1969a), Automotive Industries in Developing Countries (Washington: IBRD).

Baranson, Jack (1969b), Industrial Technologies for Developing Countries (New York: Praeger).

Baranson Jack (1971), International Transfer of Automotive Technology to Developing Countries, UNITAR Research Report No. 8.

Baranson, Jack (1972), "Bridging the Technological Gaps Between Rich and Poor Countries," in Ranis (1972), pp. 299-311.

Baranson, Jack (1974), "The Drive Toward Technological Self-Sufficiency in Developing Countries," in Robert B. Williamson, William P. Glade, Jr., and Karl M. Schmitt, eds., Latin America-U.S. Economic Interactions (Washington: American Enterprise Institute, 1974), pp. 201-212.

Barnet, Richard J. and Ronald E. Müller (1974), Global Reach (New York: Simon and Schuster).

Baron, C.B. (1975), "Sugar Processing Techniques in India," in Bhalla (1975c), pp. 175-202.

Bass, Lawrence W. (1973), "The Role of Technological Institutes in Industrial Development," World Development, Vol. 1, No. 10 (October), pp. 27-32.

Bautista, Romeo M. (1966), "Capital Coefficients in Philippine Manufacturing: An Analysis," Philippine Economic Journal, Vol. [illegible], No. 2, pp. 2[illegible]-2[illegible].

Behrman, Jere R. (1972), "Sectoral Elasticities of Substitution Between Capital and Labor in a Developing Economy: Times Series Analysis in the Case of Postwar Chile," Econometrica, Vol. 40, No. 2 (March), pp. 311-326.

Berg, Elliot J. (1971), "Wages Policy and Employment in Less Developed Countries" in Robinson and Johnston (1971), pp. 95-107.

Berry, R.A. (1974), "Factor Proportions and Urban Employment in Developing Countries," International Labour Review, Vol. 109, No. 2 (March), pp. 217-233.

Bhalla, A. S. (1964), "Investment Allocation and Technological Choice--A Case of Cotton Spinning Techniques," Economic Journal, Vol. 74, No. 295 (September), pp. 611-622.

Bhalla, A. S. (1965), "Choosing Techniques: Handpounding v. Machine-Milling of Rice: An Indian Case," Oxford Economic Papers, Vol. 17, No. 1 (March), pp. 147-157.

Bhalla, A. S. (1974), "Small Industry, Technology Transfer, and Labour Absorption," in OECD (1974), pp. 107-120.

Bhalla, A. S. (1975a), "The Concept and Measurement of Labour Intensity," in Bhalla (1975c), pp. 11-33.

Bhalla, A. S. (1975b), "Lessons from the Case Studies," in Bhalla (1975c), pp. 309-324.

Bhalla, A. S. (1975c), Technology and Employment in Industry (Geneva: ILO).

Bhatt, V. V. (1975), "On Technology Policy and Its Institutional Frame," World Development, Vol. 3, No. 9 (September), pp. 651-663.

Boon, Gerard Karel (1964), Economic Choice of Human and Physical Factors in Production (Amsterdam: North-Holland).

Boon, Gerard K. (1969), "Factor Intensities in Mexico with Special Reference to Manufacturing," in H.C. Bos, ed., Towards Balanced International Growth (Amsterdam: North-Holland), pp. 201-218.

Boon, G. K. (1975), "Technological Choice in Metalworking, With Special Reference to Mexico," in Bhalla (1975c), pp. 255-273.

Brown, Martin and Nikoto Usui (1974), "Review of Discussions" in OECD (1974a), pp. 13-94.

Bruton, Henry J. (1972a), "The Elasticity of Substitution in Developing Countries," Research Memorandum No. 45, Center for Development Economics, Williams College.

Bruton, Henry J. (1972b), "Employment, Productivity, and Import Substitution," Research Memorandum No. 44, Center for Development Economics, Williams College.

Bruton, Henry J. (1973), "Economic Development and Labor Use: A Review," World Development, Vol. 1, No. 12 (December), pp. 1-22.

Chung, Kun Mo (1975), "Commercial Transfer of Foreign Technology to the Electronics Industry in Korea," Asian Economies, No. 3 (June), pp. 5-27.

Clague, Christopher (1970), "The Determinants of Efficiency in Manufacturing Industries in an Underdeveloped Country," Economic Development and Cultural Change, Vol. 18, No. 2 (January), pp. 188-205.

Clague, Christopher K. (1969), "Capital-Labor Substitution in Manufacturing in Underdeveloped Countries," Econometrica, Vol. 37, No. 3 (July), pp. 528-537.

Cline, William R. (1972), Potential Effects of Income Redistribution on Growth: Latin American Cases (New York: Praeger).

Cline, William R. (1975), "Distribution and Development: A Survey of Literature," Journal of Development Economics, Vol. 1, No. 4 (February), pp. 359-400.

Cohen, Benjamin I. (1973), "Comparative Behavior of Foreign and Domestic Export Firms in a Developing Economy," Review of Economics and Statistics, Vol. 55, No. 2 (May), pp. 190-197).

Cohen, Benjamin I. (1975), Multinational Firms and Asian Exports (New Haven: Yale University Press).

Cooper, Charles (1972), "Science, Technology, and Production in the Underdeveloped Countries: An Introduction," Journal of Development Studies, Vol. 9, No. 1 (October), pp. 1-18.

Cooper, Charles (1974), "Science Policy and Technological Change in Underdeveloped Economies," World Development, Vol. 2, No. 3 (March), pp. 55-64.

Cooper, C. and R. Kaplinsky (1975), "Secondhand Equipment in Developing Countries: Jute Processing Machinery in Kenya," in Bhalla (1975c).

Cooper, C., R. Kaplinsky, R. Bell, and W. Salyarskit (1975), "Choice of Techniques for Can Making in Kenya, Tanzania, and Thailand," in Bhalla (1975c), pp. 85-121.

Cordova, Efren (1972), "Labour Legislation and Latin American Development: A Preliminary Review," International Labour Review, Vol. 106, No. 5 (November), pp. 445-474.

Courtney, William H. and Danny M. Leipziger (1974), "Multinational Corporations in LDCs: The Choice of Technology," Discussion Paper No. 29, USAID, Washington, D.C.

Daniels, Mark R. (1969), "Differences in Efficiency Among Industries in Developing Countries," American Economic Review, Vol. 59, No. 1 (March), pp. 159-171.

Demirgil, Demir (1971), "Factors Affecting the Choice of Technology in Turkey and Implications for Levels of Employment," in Ridker and Lubell (1971), pp. 681-735.

Dhar, P. N. and H. F. Lydall (1961), The Role of Small Enterprises in Indian Economic Development (New York: Asia Publishing House).

Di Tullio, Kathleen (1974), "Small Enterprises in Manufacturing: The Emerging Issues," in OECD (1974b), pp. 78-100.

Diaz Alejandro, Carlos F. (1965), "Industrialization and Labor Productivity Differentials," Review of Economics and Statistics, Vol. 47, No. 2 (May), pp. 207-214.

Diaz-Alejandro, Carlos (1973), "Labour Productivity and Other Characteristics of Cement Plants--An International Comparison," in Jagdish Bhagwati and Richard S. Eckaus, eds., Development and Planning (Cambridge, Mass.: MIT Press), pp. 283-315.

Diwan, Romesh K. and Damodar N. Gujarati (1968), "Employment and Productivity--Some Questions of Theory and Policy," Artha Vijnana, Vol. 10, No. 1 (March), pp. 29-67.

Dommen, Arthur J. (1975), "The Bamboo Tube Well: A Note on an Example of Indigenous Technology," Economic Development and Cultural Change, Vol. 23, No. 3 (April), pp. 483-489.

Eckaus, Richard S. (1966), "Notes on Invention and Innovation in Less Developed Countries," American Economic Review, Vol. 56, No. 2 (May), pp. 98-109.

Edwards, Edgar O. (1974a), "Employment in Developing Nations," in Edwards (1975b), pp. 1-46.

Edwards, Edgar O., ed. (1974b), Employment in Developing Nations (New York: Columbia University Press).

Erikson, John R. (1969), "Wage Policy and Economic Development in Latin American Countries," Tijdschrift voor Sociale Welenschappen, Vol. 14, No. 4 (special issue), pp. 82-99.

Fajana, F. Olufemi (1975), "The Evolution of Skill Wage Differentials in a Developing Economy: The Nigerian Experience," The Developing Economies, Vol. 13, No. 2 (June), pp. 150-167.

Fei, John and Gustav Ranis (1972), "Less Developed Country Innovation Analysis and the Technology Gap," in Ranis (1972), pp. 312-335.

Fei, John C. H. and Gustav Ranis (1975), "A Model of Growth and Employment in the Open Dualistic Economy: The Cases of Korea and Taiwan," Journal of Development Studies, Vol. 11, No. 2 (January), pp. 32-63.

Fields, Gary S. (1975), "Rural-Urban Migration, Urban Unemployment and Underemployment, and Job-Search Activity in LDC's," Journal of Development Economics, Vol. 2, No. 2 (June), pp. 165-187.

Fisher, Douglas (1968), "A Survey of the Literature on Small-Sized Industrial Undertakings in India," in Hoselitz (1968), pp. 115-215.

Frankena, Mark (1974), "The Industrial and Trade Control Regime and Product Designs in India," Economic Development and Cultural Change, Vol. 22, No. 2 (January), pp. 249-264.

Freivalds, John (1973), "Bringing Space Down to Earth: Space Age Technology Transfer and the Developing Countries," Journal of Developing Areas, Vol. 8, No. 1 (October), pp. 83-92.

Galenson, Walter and Harvey Leibenstein (1955), "Investment Criteria, Productivity, and Growth," Quarterly Journal of Economics, Vol. 69, No. 3 (August), pp. 343-370.

Gaude, J. (1975), "Capital-Labour Substitution Possibilities: A Review of Empirical Evidence," in Bhalla (1975c), pp. 35-58.

Godfrey, E. M. (1973), "Economic Variables and Rural-Urban Migration: Some Thoughts on the Todaro Hypothesis," Journal of Development Studies, Vol. 10, No. 1 (October), pp. 66-78.

Greene, David and W. Paul Strassman (1971), "Peruvian Construction Statistics and Productivity Changes," Journal of Development Studies, Vol. 7, No. 2 (January), pp. 189-195.

Gregory, Peter (1974), "Wage Structures in Latin America," The Journal of Developing Areas, Vol. 8, No. 4 (July), pp. 557-580.

Grundmann, Helge E. (1970), "The Economic Arguments for Patents and Their Validity for Developing Countries," Indian Economic Journal, Vol. 18, No. 2 (October-December), pp. 193-207.

Guisinger, Stephen and Mohammad Irfan (1974), "Real Wages of Industrial Workers in Pakistan: 1954 to 1970," Pakistan Development Review, Vol. 13, No. 4 (Winter), pp. 363-388.

Hammond, Ross V. (1974), "Technology Transfer Systems for Small Industries," in OECD (1974b), pp. 190-200.

Harris, John R. and Michael P. Todaro (1969), "Wages, Industrial Employment, and Labour Productivity: The Kenyan Experience," Eastern Africa Economic Review, Vol. 1, No. 1 (June), pp. 29-46.

Harris, John R. and Michael P. Todaro (1970), "Migration, Unemployment, and Development: A Two Sector Analysis," American Economic Review, Vol. 60, No. 1 (March), pp. 126-142.

Helfgott, Roy B. (1973), "Multinational Corporations and Manpower Utilization in Developing Nations," The Journal of Developing Areas, Vol. 7, No. 2 (January), pp. 235-246.

Helleiner, G. K. (1973a), "Manufactured Exports from Less Developed Countries and Multinational Firms," Economic Journal, Vol. 83, No. 329 (March), pp. 21-47.

Helleiner, G. K. (1973b), "Manufacturing for Export, Multinational Firms, and Economic Development," World Development, Vol. 1, No. 7 (July), pp. 13-21.

Helleiner, G. K. (1975a), "The Role of Multinational Corporations in the Less Developed Countries' Trade in Technology," World Development, Vol. 3, No. 4 (April), pp. 161-189.

Helleiner, G. K. (1975b), "Transnational Enterprises in the Manufacturing Sector of the Less Developed Countries," World Development, Vol. 3, No. 9 (September), pp. 641-650.

Hellinger, Doug, and Steve Hellinger (1975), "The Job Crisis in Latin America: A Role for Multinational Corporations in Introducing More Labour-Intensive Technologies," World Development Review, Vol. 3, No. 6 (June), pp. 399-410.

Herrera, Amiliar (1972), "Social Determinants of Social Policy in Latin America," Journal of Development Studies, Vol. 9, No. 1 (October), pp. 19-37.

Hewavitharne, B. (1970), "Choice of Techniques in Ceylon," Robinson and Kidron (1970), pp. 431-448.

Hicks, George L. and Geoffrey McNicoll (1971), Trade and Growth in The Philippines (Ithaca: Cornell University Press).

Hirono, Ryokichi (1969), "Japanese Investment" in Hughes and Seng (1969), pp. 86-111.

Hirschman, Albert O. (1958), The Strategy of Economic Development (New Haven: Yale University Press).

Hoselitz, Bert F., ed. (1968), The Role of Small Industry in the Process of Economic Growth (The Hague: Mouton).

House, William J. (1973), "Wages, Employment, and Productivity in Kenya: Some Further Evidence," Eastern Africa Economic Review, Vol. 5, No. 1 (June), pp. 73-77.

Hughes, Helen (1969), "Conclusions" in Hughes and Seng (1969), pp. 177-210.

Hughes, Helen (1974), "The Scope for Labor Capital Substitution in the Developing Economies of Southeast and East Asia," in White (1974b), pp. 30-57.

Hughes, Helen and You Poh Seng, eds. (1969), Foreign Investment and Industrialization in Singapore (Canberra: Australian National University Press).

Husain, Ishrat (1974), "Employment Aspects of Industrial Growth in West Pakistan," Pakistan Development Review, Vol. 13, No. 2 (Summer), pp. 211-221.

Institute of Technological Research, Bogota (1975), "Capacity of the Engineering Industry in Colombia," in Bhalla (1975c), pp. 241-253.

International Bank for Reconstruction and Development, Economics of Industry Division (1973), "Small Enterprises in Manufacturing: The Emerging Issues."

Isbister, John (1971), "Urban Unemployment and Wages in a Developing Economy: The Case of Mexico," Economic Development and Cultural Change, Vol. 20, No. 1 (October), pp. 24-46.

International Labour Office (1972a), Automation in Developing Countries (Geneva).

International Labour Office (1972b), Employment, Incomes, and Equality: A Strategy for Increasing Productive Employment in Kenya (Geneva).

International Labour Office (1972c), Fiscal Measures for Employment Promotion in Developing Countries (Geneva).

Jackson, Sarah (1972), Economically Appropriate Technologies for Developing Countries: A Survey. Occasional Paper No. 3 (Washington: Overseas Development Council).

James, Dilmus (1973), "Used Automated Plants In Less Developed Countries: A Case Study of a Mexican Firm," Inter-American Economic Affairs, Vol. 27, No. 1 (Summer), pp. 31-46.

Jewkes, John, David Sawers, and Richard Stillerman (1969), The Sources of Invention, 2nd edition (New York: Norton).

Kaldor, Nicholas (1969), "The Choice of Technology in Less Developed Countries," Monthly Labor Review, Vol. 92, No. 8 (August), pp. 50-53.

Kamien, Morton I. and Nancy L. Schwartz (1975), "Market Structure and Innovation: A Survey," Journal of Economic Literature, Vol. 13, No. 1 (March), pp. 1-37.

Katz, Jorge M. (1969), Production Functions, Foreign Investment and Growth (Amsterdam, North-Holland).

Katz, Jorge M. (1973), "Industrial Growth, Royalty Payments, and Local Expenditure on Research and Development," in Victor L. Urquidi and Rosemary Thorp, eds., Latin America in the International Economy (New York, John Wiley & Sons), pp. 197-232.

Kemal, A. R. and Talat Alauddin (1974), "Capacity Utilization in Manufacturing Industries of Pakistan," Pakistan Development Review, Vol. 13, No. 2 (Summer), pp. 231-244.

Kennedy, Charles and A. P. Thirwall (1972), "Technical Progress: A Survey," Economic Journal, Vol. 82, No. 325 (March), pp. 11-72.

Khan, Amir V. (1974), "Appropriate Technologies: Do We Transfer, Adapt, or Develop?" in Edwards (1974b), pp. 223-233.

Khan, Amir U. and Bart Duff (1974), "Agricultural Mechanization Technology Development at the International Rice Research Institute," in White (1974b), pp. 97-125.

Khan, Azizur Rahman (1970a), "Capital-Intensity and the Efficiency of Factor Use," Pakistan Development Review, Vol. 10, No. 2 (Summer), pp. 232-263.

Khan, Azizur Rahman (1970b), "Some Problems of Choice of Techniques in a Mixed Economy: The Case of Pakistan," in Robinson and Kidron (1970), pp. 199-212.

Kilby, Peter (1962), "Organization and Productivity in Backward Economies," Quarterly Journal of Economics, Vol. 76, No. 2 (May), pp. 303-310.

King, J. R. (1972), "Wages, Employment, and Productivity in Kenya: A Comment," Eastern Africa Economic Review, Vol. 4, No. 1 (June), pp. 71-74.

Knight, J. B. (1975), "Wages in Africa: What Should a Foreign Firm Do?" Oxford Bulletin of Economics and Statistics, Vol. 37, No. 2 (May), pp. 73-90.

Krueger, Anne O. (1974), Turkey (New York: Columbia University Press).

Leff, Nathaniel H. (1968), The Brazilian Capital Goods Industry, 1929-1964 (Cambridge, Mass.: Harvard University Press).

Leibenstein, Harvey (1975), "The Transfer of Managerial and Technical Knowledge," in Ramati (1975), pp. 307-316.

Leith, J. Clark (1974), Ghana (New York: Columbia University Press).

Little, Ian, Tibor Scitovsky, and Maurice Scott (1970), Industry and Trade in Some Developing Countries (London: Oxford University Press).

Ludena, R. and N. Cabero (1972), "Employment and Technology in Industry: The Chilean Case," in ILO (1972c), pp. 313-336.

Maitha, J. K. (1973), "Capital-Labour Substitution in Manufacturing in a Developing Economy: The Case of Kenya," Eastern Africa Economic Review, Vol. 5, No. 2 (December), pp. 43-52.

Marsden, Keith (1969), "Towards a Synthesis of Economic Growth and Social Justice," International Labour Review, Vol. 100, No. 5 (November), pp. 389-418.

Marsden, Keith (1971), "Progressive Technologies for Developing Countries," International Labour Review, Vol. 101, No. 5 (May), pp. 475-502.

Mason, R. Hal (1970), "Some Aspects of Technology Transfer: A Case Study Comparing U.S. Subsidiaries and Local Counterparts in the Philippines," Philippine Economic Journal, Vol. 9, No. 1 pp. 83-108.

Mason, R. Hal (1973), "Some Observations on the Choice of Technology by Multinational Firms in Developing Countries," Review of Economics and Statistics, Vol. 55, No. 3 (August), pp. 349-355.

Mason, R. Hal and Il Sakong (1971), "Level of Economic Development and Capital-Labor Ratios in Manufacturing," Review of Economics and Statistics, Vol. 53, No. 2 (May), pp. 176-178.

Mehta, D. V. (1969), "Size and Capital Intensity in Indian Industry," Bulletin of the Oxford University Institute of Economics and Statistics, Vol. 31, No. 3 (August), pp. 189-204.

Meyer, John R. (1966), "Transport Technologies for Developing Countries," American Economic Review, Vol. 56, No. 2 (May), pp. 83-90.

Mikesell, Raymond F. and James E. Zinser (1973), "The Nature of the Savings Function in Developing Countries: A Survey of the Theoretical and Empirical Literature," Journal of Economic Literature, Vol. 11, No. 1 (March), pp. 1-26.

Morawetz, David (1974), "Employment Implications of Industrialization in Developing Countries: A Survey," Economic Journal, Vol. 84, No. 335 (September), pp. 491-542.

Morawetz, David (1975), "Import Substitution, Employment, and Foreign Exchange in Colombia: No Cheers for Petrochemicals," in Timmer et al (1975), pp. 95-107.

Morawetz, David (1976), "Elasticities of Substitution in Industry: What Do We Learn From Econometric Estimates?" World Development, Vol. 4, No. 1 (January), pp. 11-15.

Nelson, Richard R. (1968), "A 'Diffusion' Model of International Productivity Differences in Manufacturing Industry," American Economic Review, Vol. 58, No. 5 (December), pp. 1219-1248.

Nelson, Richard R. (1974), "Less Developed Countries--Technology Transfer and Adaptation: The Role of the Indigenous Science Community," Economic Development and Cultural Change, Vol. 23, No. 1 (October), pp. 61-78.

O'Brien, Peter (1974), "Developing Countries and the Patent System: An Economic Appraisal," World Development, Vol. 2, No. 9 (September), pp. 27-36.

O'Herlihy, C. St. J. (1972), "Capital/Labour Substitution and the Developing Countries: A Problem of Measurement," Bulletin of the Oxford University Institute of Economics and Statistics, Vol. 34, No. 3 (August), pp. 269-280.

Organization for Economic Cooperation and Development (1974a), Choice and Adaptation of Technology in Developing Countries (Paris).

Organization for Economic Cooperation and Development (1974b), Transfer of Technology for Small Industries (Paris).

Organization for Economic Cooperation and Development, Development Centre (1975), Low-Cost Technology--An Inquiry into Outstanding Policy Issues (Paris).

Oshima, Harry T. (1971), "Labor-Force 'Explosion' and the Labor-Intensive Sector in Asian Growth," Economic Development and Cultural Change, Vol. 19, No. 2 (January), pp. 161-183.

Oyelabi, J. Ade (1971), "Tests of Factor Substitution in Nigeria's Manufacturing Sector," Eastern Africa Economic Review, Vol. 3, No. 1 (June), pp. 29-39.

Pack, Howard (1972), "Employment and Productivity in Kenyan Manufacturing," Eastern Africa Economic Review, Vol. 4, No. 2 (December), pp. 29-52.

Pack, Howard (1974), "The Employment-Output Trade-off in LDC's--A Microeconomic Approach," Oxford Economic Papers, Vol. 26, No. 3 (November), pp. 388-404.

Pack, Howard (1975), "The Choice of Technique and Employment in the Textile Industry," in Bhalla (1975c), pp. 153-173.

Pack, Howard (1976), "The Substitution of Labour for Capital in Kenyan Manufacturing," Economic Journal, Vol. 86, No. 341 (March), pp. 45-59.

Pack, Howard and Michael Todaro (1969), "Technological Transfer, Labour Absorption, and Economic Development," Oxford Economic Papers, Vol. 21, No. 3 (November), pp. 395-403.

Paine, Suzanne (1971), "Lessons for LDC's from Japan's Experience with Labour Commitment and Subcontracting in the Manufacturing Sector," Oxford University Institute of Economics and Statistics, Vol. 33, No. 3 (May), pp. 115-134.

Peacock, Alan and G. K. Shaw (1971), Fiscal Policy and the Employment Problem in Less Developed Countries (Paris: OECD).

Pearson, Lester B. (1970), Partners in Development (New York: Praeger).

Penrose, Edith (1973), "International Patenting and the Less-Developed Countries," Economic Journal, Vol. 83, No. 331 (September), pp. 768-786.

Pickett, James, D.J.C. Forsyth, and N.S. McBain (1974), "The Choice of Technology, Economic Efficiency, and Employment in Developing Countries," in Edwards (1974b).

Porter, R. (1972), "Transfer of Technology--The Hong Kong View," Meeting on Transfer of Technology to Developing Countries through Subcontracting and Licensing Agreements, with Special Reference to the Automotive Industry, UNIDO.

Radhu, Ghulam M. (1973a), "Some Aspects of Direct Foreign Private Investment in Pakistan," Pakistan Development Review, Vol. 12, No. 1 (Spring), pp. 68-80.

Radhu, G. M. (1973b), "Transfer of Technical Know-How Through Multinational Corporations in Pakistan," Pakistan Development Review, Vol. 12, No. 4 (Winter), pp. 361-374.

Ramati, Yohanan, ed. (1975), Economic Growth in Developing Countries--Material and Human Resources (New York: Praeger).

Ramor, Joseph (1974), "An Heterodoxical Interpretation of the Employment Problem in Latin America," World Development, Vol. 2, No. 7 (July), pp. 47-58.

Ranis, Gustav (1957), "Factor Proportions in Japanese Economic Development," American Economic Review, Vol. 47, No. 5 (September), pp. 594-607.

Ranis, Gustav (1962a), "Investment Criteria, Productivity, and Economic Development: An Empirical Comment," Quarterly Journal of Economics, Vol. 76, No. 2 (May), pp. 298-302.

Ranis, Gustav (1962b), "Production Functions, Market Imperfections, and Economic Development," Economic Journal, Vol. 72, No. 286 (June), pp. 344-354.

Ranis, Gustav (1971), "Output and Employment in the 70's: Conflict or Complements," in Ridker and Lubell (1971), pp. 59-76.

Ranis, Gustav, ed. (1972), The Gap Between Rich and Poor Nations (London: Macmillan, 1972).

Ranis, Gustav (1973), "Industrial Sector Labor Absorption," Economic Development and Cultural Change, Vol. 21, No. 3 (April), pp. 387-408.

Ranis, Gustav (1974), "Some Observations on the Economic Framework for Optimum LDC Utilization of Technology," in White (1974b), pp. 58-96.

Ranis, Gustav (1975), "Employment and Labor Absorption in Development," in Ramati (1975), pp. 149-167.

Rethwisch, Kurt (1974), "Prohibitive Tariffs on Used Vehicle: Aid or Obstacle to the Development Process?" Journal of Development Studies, Vol. 10, Nos. 3 & 4 (April/July), pp. 395-402.

Reuber, Grant L. (1973), Private Foreign Investment in Development (London: Oxford University Press).

Ridker, Ronald G. (1971), "Employment and Unemployment in Near East and South Asian Countries: A Review of Evidence and Issues," in Ridker and Lubell (1971), pp. 6-58.

Ridker, Ronald G. and Harold Lubell, eds. (1971), Employment and Unemployment Problems of the Near East and South Asia (Delhi: Vikas).

Reynolds, Lloyd G. (1965), "Wages and Employment in a Labor Surplus Economy," American Economic Review, Vol. 55, No. 1 (March), pp. 19-39.

Reynolds, Lloyd G. and Peter Gregory (1965) Wages, Productivity and Industrialization in Puerto Rico (Homewood, Ill.: Richard D. Irwin).

Rhys, D. G. (1974), "Motor Manufacture in Underdeveloped Countries," Philippine Review of Business and Economics, Vol. 11, No. 2 (December), pp. 145-156.

Robinson, E.A.G. and Michael Kidron, eds. (1970), Economic Development in South Asia (London: Macmillan).

Robinson, Ronald (1965), "The Argument of the Conference," in Ronald Robinson, ed., Industrialization in Developing Countries (Cambridge), pp. 5-53.

Robinson, Ronald and Peter Johnston (1971), Prospects for Employment Opportunities in the Nineteen Seventies (London: HMSO).

Roemer, Michael (1975), "The Neoclassical Employment Model Applied to Ghanaian Manufacturing," Journal of Development Studies, Vol. 11, No. 2 (January), pp. 75-92.

Ruprecht, Theodore K. (1968), "Output Stimulation and Employment Stagnation--Policy By-Products in the Philippines," Economic Development and Cultural Change, Vol. 17, No. 1 (October), pp. 77-89.

Sadli, Mohammad (1974), "Application of Technology and Its Employment Effects: The Experience in Indonesia," in Edwards (1974b), pp. 363-372.

Saito, Masaru (1975), "Introduction of Foreign Technology in the Industrialization Process--Japanese Experience Since the Meiji Restoration (1868)," The Developing Economies, Vol. 13, No. 2 (June), pp. 168-186.

Sandesara, J. C. (1966), "Scale and Technology in Indian Industry," Bulletin of the Oxford University Institute of Economics and Statistics, Vol. 28, No. 3 (August), pp. 181-198.

Sandesara, J. C. (1969), "Size and Capital-Intensity in Indian Industry: Some Comments," Bulletin of Oxford University Institute of Economics and Statistics, Vol. 31, No. 4 (November), pp. 331-334.

amson, Robert L. (1969), "The Sector Pump: A Case Study of Innovation and Development," Oxford Economic Papers, Vol. 21, No. 1 (March), pp. 109-121.

Scherer, F. M. (1970), Industrial Market Structure and Economic Performance (Chicago: Rand McNally).

Schreiber, Jordan (1970), U.S. Corporate Investment in Taiwan (Cambridge, Mass.: Harvard University Press).

Schumacher, E. F. (1971a), "Employment Possibilities of Different Types of Technological and Structural Innovations," in Robinson and Johnston (1971), pp. 134-142.

Schumacher, E. F. (1971b), "Industrialization Through 'Intermediate Technology'," in Ronald Robinson, ed., Developing the Third World: The Experience of the Nineteen-Sixties (London, Cambridge University Press).

Schumacher, E. F. (1972), "The Work of the Intermediate Technology Development Group in Africa," International Labour Review, Vol. 106, No. 1 (July), pp. 75-92.

Schumacher, E. F. (1973), Small is Beautiful (New York: Harper & Row).

Schwartz, Sandra L. (1973), "Second-Hand Machinery in Development, or How to Recognize a Bargain," Journal of Development Studies, Vol. 9, No 4 (July), pp. 544-555.

Sen, Amartya Kumar (1962), "On the Usefulness of Used Machines," Review of Economics and Statistics, Vol. 44, No. 3 (August), pp. 343-348.

en, Armartya Kumar (1964), "Choice of Techniques of Production: ith Special Reference to East Asia," in Kenneth Berrill, ed., Economic Development, With Special Reference to East Asia (London: Macmillan), pp. 386-398.

Sen, Amartya Kumar (1972), Choice of Techniques, 3rd edition (Oxford: Basil Blackwell).

Senga, W. M. (1973), "Wages, Market Imperfections, and Labour Absorption in Kenya Manufacturing Industries," Eastern Africa Economic Review, Vol. 5, No. 1 (June), pp. 55-72.

Sethurman, S. V. (1971), "Prospects for Increasing Employment in the Indian Manufacturing Sector," in Ridker and Lubell (1971), pp. 587-638.

Sharpston, M. J. (1973), "Capital/Labour Substitution Possibilities: An Empirical Approach," IBED.

Sharpston, Michael (1975), "International Sub-Contracting," Oxford Economic Papers, Vol. 27, No. 1 (March), pp. 94-135.

Shinohara, Miyohei (1968), "A Survey of the Japanese Literature on Small Industry," in Hoselitz (1968), pp. 1-113.

Sicat, Gerardo P. (1970), "Capital-Labor Substitution in Manufacturing in A Developing Economy: The Philippines," The Developing Economies, Vol. 8, No. 1 (March), pp. 24-38.

Silberston, Aubrey (1972), "Economies of Scale in Theory and Practice," Economic Journal, Vol. 82, No. 325s (March, supplement), pp. 369-391.

Smith, Anthony D., ed., (1969), Wage Policy Issues in Economic Development. (London: Macmillan).

Smith, M. A. M. (1974), "International Trade in Second-Hand Machines," Journal of Development Economics, Vol. 1, No. 3 (December), pp. 261-278.

Solo, Robert (1966), "The Capacity to Assimilate an Advanced Technology," American Economic Review, Vol. 56, No. 2 (May), pp. 91-97.

Staley, Eugene and Richard Morse (1965), Modern Small Industry for Developing Countries (New York. McGraw Hill).

Steel, William F. (1972), "Import Substitution and Excess Capacity in Ghana," Oxford Economic Papers, Vol. 24, No. 2 (July), pp. 212-240.

Stepanek, Joseph E. (1960), Small Industry Advisory Services (Glencoe, Ill.: Free Press).

Stewart, Frances (1972), "Choice of Technique in Developing Countries," Journal of Development Studies, Vol. 9, No. 1 (October), pp. 99-121.

Stewart, Frances (1973a), "Economic Development and Labor Use: A Comment," World Development, Vol. 1, No. 12 (December), pp. 25-28.

Stewart, Frances (1973b), "Trade and Technology," in Paul Streeten, ed., Trade Strategies for Development (New York: John Wiley & Sons), pp. 231-263.

Stewart, Frances (1974), "Technology and Employment in LDCs," in Edwards (1974b), pp. 83-132.

Stewart, Frances (1975), "Manufacture of Cement Blocks in Kenya," in Bhalla (1975c), pp. 203-240.

Stewart, Frances and John Weeks (1975), "The Employment Effects of Wage Changes in Poor Countries," Journal of Development Studies, Vol. 11, No. 2 (January), pp. 93-107.

Strassmann, W. Paul (1967), "Causes of Technological Stagnation in Manufacturing During Early Industrialization," Oxford Economic Papers, Vol. 19, No. 3 (November), pp. 345-358.

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Strassmann, W. Paul (1968), Technological Change and Economic Development (Ithaca, N.Y.: Cornell University Press).

Strassmann, W. Paul (1970), "Innovation and Employment in Building: The Experience of Peru," Oxford Economic Papers, Vol. 22, No. 2 (July), pp. 243-259.

Strassmann, W. Paul (1971), "Construction Productivity and Employment in Developing Countries," International Labour Review, Vol. 101, No. 5 (May), pp. 503-518.

Strassmann, W. Paul (1972), "International Transfer of Technology in Construction and in Manufacturing," in Robert A. Solo and Everett M. Rogers, eds., Inducing Technological Change for Economic Growth and Development (Michigan State University Press).

Streeten, Paul (1972a), The Frontiers of Development Studies (John Wiley & Sons: New York).

Streeten, Paul (1972b), "The Multinational Corporation and the Nation State," in Streeten (1972a), pp. 223-238.

Streeten, Paul (1972c), "Technology Gaps Between Rich and Poor Countries," in Streeten (1972a), pp. 381-400.

Streeten, Paul (1973), "The Multinational Enterprise and the Theory of Development Policy," World Development, Vol. 1, No. 10 (October), pp. 1-14.

Subido, Chita (1973), "Employment Effects of Direct Foreign Investments," Philippine Economic Journal, Vol. 12, Nos. 1 & 2, pp. 251-270.

Suh, Sang Mok (1974), "Size, Technology, and Other Economic Characteristics in Malaysian Industry," Development Research Center, IBRD.

"Sussex Group" (1970), "Science and Technology in Less Developed Countries," in Richard Jolly, Emanuel de Kadt, Hans Singer, and Fiona Wilson, eds. (1973), Third World Employment (Baltimore: Penguin).

Thorbecke, Erik (1973), "The Employment Problem: A Critical Evaluation of Four ILO Comprehensive Country Reports," International Labour Review, Vol. 107, No. 5 (May), pp. 393-424.

Thormann, Peter H. (1972), "Labour-Intensive Irrigation and Dam Construction: A Review of Some Research," International Labour Review, Vol. 106, No. 2 (August), pp. 151-166.

Tidrick, Gene M. (1970), "Wages, Output, and the Employment Lag in Jamaica," Research Memorandum No. 40, Center for Development Economics, Williams College.

Timmer, C. Peter (1975), "The Choice of Technique in Indonesia," in Timmer et al (1975), pp. 1-29.

Timmer, C. Peter, John M. Thomas, Louis T. Wells, and David Morawetz (1975), The Choice of Technology in Developing Countries (Cambridge, Mass.: Harvard University).

Todaro, Michael P. (1970), "Some Thoughts on the Transfer of Technology from Developed to Less Developed Nations," Eastern Africa Economic Review, Vol. 2, No. 1 (June), pp. 53-64.

Todaro, Michael P. (1971), "Income Expectations, Rural-Urban Migration, and Employment in Africa," International Labour Review, Vol. 104, No. 5 (November), pp. 387-413.

Tokman, Viktor E. (1974), "Distribution of Income, Technology, and Employment: An Analysis of the Industrial Sectors of Ecuador, Peru, and Venezuela," World Development, Vol. 2, No. 10-12 (October-December), pp. 49-57.

Tokman, Viktor E. (1975), "Income Distribution, Technology, and Employment in Developing Countries: An Application to Ecuador," Journal of Development Economics, Vol. 2, No. 1 (March), pp. 49-80.

Turner, H. A. and D.A.S. Jackson (1970), "On the Determination of the General Wage Level--A World Analysis; or 'Unlimited Labour Forever," Economic Journal, Vol. 80, No. 320 (December), pp. 827-849.

Turnham, David (1971), The Employment Problem in Less Developed Countries (Paris: OECD).

Tyler, William G. (1974), "Labor Absorption with Import-Substituting Industrialization: An Examination of Elasticities of Substitution in the Brazilian Manufacturing Sector," Oxford Economic Papers, Vol. 26, No. 1 (March), pp. 93-103.

U.S. Agency for International Development, Office of Science and Technology (1972), "Appropriate Technologies for International Development: Preliminary Survey of Research Activities" (Washington, D.C.).

U.S. Bureau of the Census (1973), Annual Survey of Manufactures, 1970-1971 (Washington, D.C.).

United Nations Economic Commission for Latin America (1970), Development Problems in Latin America (Austin, University of Texas Press).

United Nations Industrial Development Organization (1969), Textile Industry, UNIDO Monographs on Industrial Development No. 7.

United Nations Industrial Development Organization (1974), Industrial Development Survey.

Vaitsos, Constantine (1972), "Patents Revisited: Their Functions in Developing Countries," Journal of Development Studies, Vol. 9, No. 1 (October), pp. 71-97.

Vaitsos, Constantine V. (1974), "Employment Effects of Foreign Direct Investments in Developing Countries," in Edwards (1974b), pp. 331-349.

Vaitsos, Constantine (1975), "Foreign Investment and Productive Knowledge," in Guy F. Erb and Valeriana Kallab, eds., Beyond Dependency (Washington, D.C.: Overseas Development Council), pp. 75-94.

Van der Spek, Peter G. (1975), "Mexico's Booming Border Zone: A Magnet for Labor-Intensive American Plants," Inter-American Economic Affairs, Vol. 29, No. 1 (Summer), pp. 33-47.

Vepa, Ram K. (1967), Small Industries in Japan (Bombay: Vora).

Vepa, Ram K. (1971), Small Industry in the Seventies (Delhi: Vikas).

Vernon, Raymond (1972), "United States Enterprise in the Less Developed Countries: Evaluation of Cost and Benefit," in Ranis (1972), pp. 215-228.

Watanabe, Susumu (1972), "Exports and Employment: The Case of the Republic of Korea," International Labour Review, Vol. 106, No. 6 (December), pp. 495-526.

Watanabe, Susumu (1974), "Reflections on Current Policies for Promoting Small Enterprises and Subcontracting," International Labour Review, Vol. 110, No. 5 (November), pp. 405-422.

Weeks, John (1974), "Employment Growth in Kenya Manufacturing: Another Look at Labour Absorption," Discussion Paper No. 21, Department of Economics, Birbeck College, University of London.

Wells, Louis T. (1973), "Economic Man and Engineering Man: Choice in a Low Wage Country," Public Policy, Vol. 21, No. 3 (Summer), pp. 319-342.

Westphal, Larry E. (1974), "Research on Appropriate Technology," in White (1974b), pp. 7-29.

White, Lawrence J. (1971), The Automobile Industry Since 1945 (Cambridge, Mass.: Harvard University Press).

White, Lawrence J. (1974a), Industrial Concentration and Economic Power in Pakistan (Princeton: Princeton University Press).

White, Lawrence J., ed., (1974b), Technology, Employment, and Development (Manila: Committee for Asian Manpower Studies).

White, Lawrence J. (1976?), "Appropriate Technology, X-Inefficiency, and a Competitive Environment: Some Evidence from Pakistan," Quarterly Journal of Economics (forthcoming).

Williams, Randolph L. (1974), "Capital-Labor Substitution in Jamaican Manufacturing," The Developing Economies, Vol. 12, No. 2 (June), pp. 169-181.

Williamson, Jeffrey G. (1971a), "Capital Accumulation, Labor Saving, and Labor Absorption Once More," Quarterly Journal of Economics, Vol. 85, No. 1 (February), pp. 40-65.

Williamson, Jeffrey G. (1971b), "Relative Price Changes, Adjustment Dynamics, and Productivity Growth: The Case of Philippine Manufacturing," Economic Development and Cultural Change, Vol. 19, No. 4 (July), pp. 507-526.

Winston, Gordon C. (1970), "Overinvoicing, Underutilization, and Distorted Industrial Growth," Pakistan Development Review, Vol. 10, No. 4 (Winter), pp. 405-421.

Winston, Gordon C. (1971), "Capital Utilization in Economic Development," Economic Journal, Vol. 81, No. 321 (March), pp. 36-60.

Winston, Gordon C. (1974a), "Factor Substitution, Ex Ante and Ex Post," Journal of Development Economics, Vol. 1, No. 2 (September), pp. 145-163.

Winston, Gordon C. (1974b), "The Theory of Capital Utilization and Idleness," Journal of Economic Literature, Vol. 12, No. 4 (December), pp. 1301-1320.

Witte, Ann D. (1971), "Alternative Estimates of Capital-Labor Substitution in Manufacturing in Developing Economies: Comments on Professor Clague," Econometrica, Vol. 39, No. 6 (November), pp. 1053-1054.

Witte, Ann Dryden (1973), "Employment in the Manufacturing Sector of Developing Economies: A Study of Mexico and Peru," Journal of Development Studies, Vol. 10, No. 1 (October), pp. 33-49.

Yeoman, W. A. (1968), "Selection of Production Processes for the Manufacturing Subsidiaries of U.S. Based Multinational Corporations," unpublished doctoral thesis, Harvard University.

ATTACHMENT D

POLICIES TO ENCOURAGE THE USE OF INTERMEDIATE TECHNOLOGY*

(By Howard Pack, Department of Economics, Swarthmore College, April 1976)

Introduction

This paper has several purposes; to indicate the policies which an LDC government may choose to alter the relative costs of using the various factors of production; to indicate how much is known empirically about the efficacy of such changes; and finally, to consider how a program to aid LDC governments undertake such changes can best be pursued given the absence of large leverage in the form of any concessionary aid.

The focus on policies which may affect factor prices assumes that if such prices were changed, methods of production could be introduced which are more labor intensive than those currently in use and which will be more profitable at the new factor prices than techniques currently in use. An alternate possibility is that a country is currently using quite labor intensive techniques and the policies considered here are designed to maintain the desirable pattern of factor use. Though it is not our purpose to survey the literature on choice of technique, a summary of some of the conclusions we have reached on the basis of

*This paper has been prepared for the AID Committee on Intermediate Technology.

recent literature is germane at this point.[1]

(1) In a large number of industrial activities a product is producible with a considerable range of alternate ratios of capital to labor. Much of the potential substitution of labor for capital stems from use of labor intensive methods in "peripheral" production activities; labor, with little if any capital, can be used to transport material within the factory, to pack cartons, and store the final product. The evidence for these statements is drawn from observation of both D.C. and LDC factory operations and engineering specifications.

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[1]Three recent surveys of the rapidly growing literature on micro-substitution possibilities provide a large number of examples of such findings for specific industrial products as well as in construction activities. These are: S.N.Acharya, "Fiscal/Financial Intervention, Factor Prices and Factor Proportions; A Review of Issues, "Staff Working Paper 183, IBRD, 1974; David Morawetz, "Employment Implications of Industrialization in Developing Countries; a Survey" The Economic Journal, Sept., 1974. Frances Stewart, "Technology and Employment in LDCs" in Edgar O. Edwards, (ed.) Employment in Developing Nations, (New York, Columbia University Press, 1974). A recent ILO volume, A. Bhalla, ed. Technology and Employment in Industry (Geneva, ILO, 1975, 1975) provides yet more evidence, as do a number of the studies being completed by the Technology and Employment Branch of the World Employment Program. A complete list of these studies is provided in I.L.O. World Employment Programme Research in Retrospect and Prospect (Geneva, I.L.O., 1976) pp. 21-31 and Appendix I. Acharya's review provides an insightful analysis of the difficulties with industry-wide cross section and time series estimates of the elasticity of substitution and thus provides the rationale for emphasis on evidence from individual process level micro-analyses.

(2) Evidence is also accumulating that the core production process itself, whether cooking of food or production of yarn, offers efficient possibilities for using less expensive equipment and more labor per unit of output. Adaptation of existing equipment, for example, changing the "normal" speed of operation offers still further opportunities to save capital and increase the relative use of labor. Finally, extensive under-utilization of industrial capacity provides considerable scope for increasing the effective labor/capital ratio.

(3) There are some industries that probably offer limited possibilities for altering the capital/labor ratio compared with that prevalent in advanced economies. These are typically activities in which most LDCs have no comparative advantage and where the basic problem is to forestall their introduction (typically behind tariff walls) rather than to suggest methods of changing production in a more labor intensive direction.

A. The Role of Factor Prices

1. Competitive Environment.

The ratio of labor to capital costs is usually assumed to play a decisive role in determining the ratio of capital to labor used in the production process. Before considering these costs explicitly, some caveats are in order about the simple relationship. The importance of relative factor prices flows from the assumption of a competitive milieu. There is abundant anecdotal and some numerical evidence[1] which suggests that factor prices may play a limited role in non-competitive environments. A firm currently realizing a 30 percent rate of return on equity capital, though using an inappropriately high ratio of capital to labor, may have little incentive to search for more appropriate methods which may raise its return to 35 percent. The losses from foregone leisure and the difficulties often alleged to result from management of a larger labor force make such behavior perfectly plausible. If factor prices are to exert pressure toward adopting socially appropriate techniques, some competitive forces must be present. Given the typical small markets of many LDCs, such pressures are best engendered by international competition rather than the proliferation of large numbers of

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[1] James Pickett, D.J.C. Forsyth, and N.S.McBain, "The Choice of Technology, Economic Efficiency, and Employment in Developing Countries," in Edgar O. Edwards (ed), Employment in Developing Countries, (New York, Columbia University Press, 1974).

small domestic companies, none of which are likely to reach economically efficient sizes. In the presence of high rates of effective protection of value added, changes in relative factor prices may have some beneficial effects, but they are likely to be highly attentuated. Thus, an integral component of any determined effort to achieve more desirable factor proportions must be some increase in competitiveness in the product markets in which industrial firms participate.

2. Factor Price Distortions

An LDC company considering beginning or expanding its operations has a variety of methods of production which it may adopt, the actual decision depending on the cost levels of the factors of production; labor, capital and raw materials. It has become conventional to assert that labor costs are "too" high, capital costs too low, and raw materials prices distorted, though not in one direction. What is the precise meaning of these statements? Let us briefly consider each of the first two factor costs.

a. Wages

The hiring of a worker entails the payment of a cash wage, and one or more of the following: payments in kind (housing), non-cash fringe benefits (social security), and in some countries such supplements as "thirteenth month" salary. The cost of hiring a worker is "too" high if the

value of the cash wage and other benefits exceeds the income which the worker could command elsewhere, given his abilities, both inherited and obtained by education and on-the-job experience. It has long been noted that the typical employee in a modern enterprise, be it a factory, bank office, or government agency, earns considerably more than a worker in small scale artisan shops or in self-employment such as barbering. Modern employment also provides incomes considerably in excess of that of agricultural workers and small scale peasant farmers. It is generally believed that the observed income differentials do not represent a reward for greater productive ability, but are artificially high and institutionally supported, reflecting government minimum wage legislation, union bargaining success, and a guilty aversion to paying lower, more appropriate wages which typify other activities. Nevertheless, there have been no studies confirming the hypothesis that such high wage incomes are not the result of greater work related skills; though considerable anecdotal evidence exists which suggests that recipients of high wages are frequently unskilled when initially hired, their productivity may well increase as a result of learning on the job. Even if some of the observed high wage structure is related to productivity, it is likely that union pressure and government minimum wage legislation add to any productivity based differentials.

The statement that wages are too high thus refers to the norm of alternate income possibilities for a similarly skilled worker, either in the urban craft sector or in a variety of rural activities. It does not imply that these wages are excessive in comparison with those in developed countries or that such workers are able to afford a luxurious living standard. High wages accruing to the small group lucky enough to obtain modern sector jobs do imply that production will be undertaken with fewer workers than if wages were lower, thus condemning those not fortunate enough to obtain such jobs to a lower standard of living than would have been possible with a generally lower wage structure. Instead of a million workers employed in the modern sector, each receiving a wage of $500 per annum, 200,000 workers may receive a wage of $900, with the remaining workers earning $150 per annum.

b. The Cost of Plant and Equipment

The cost of utilizing plant and equipment reflects the purchase price of a factory building or machine, and the interest costs incurred in financing it. More precisely, the cost of using plant or equipment is best viewed in terms of the annual expenditure (depreciation of the initial acquisition cost and a yearly financing charge incurred as the

result of a decision to purchase the capital item.[1] The purchase cost of equipment is too low in most LDCs in the sense that the net effect of government foreign trade policies is typically to artificially lower the amount of domestic currency which must be given up to pay for an imported machine. Most LDCs have engaged in a sustained import substitution program, one of whose characteristics is to maintain an overvalued exchange rate i.e., the domestic currency buys too much foreign currency. For many industrial products this artificial cheapening of foreign goods is offset by a relatively high, often prohibitive tariff imposed on imported goods which compete with domestically produced goods. However, no tariff is imposed on imported equipment, ostensibly to encourage domestic investment. Thus, LDC firms purchasing new equipment pay a lower price than would exist if governments did not discriminate between different types of imported goods. low purchase price of course is reflected in low annual depreciation charges, one of the two major components of the annual cost of using equipment.

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[1]For a precise measure of the cost of using capital see Dale Jorgenson, "Capital Theory and Investment Behavior, "American Economic Review, May, 1963.

As mentioned earlier, the second major cost is the financing charge. The interest rate paid by larger companies in the urban sector is too low as a result of governmentally imposed limitations on the rate of interest. At the existing, low ceiling levels of rates, the total demand for loanable funds exceeds the supply, and the existing supply is rationed among competing companies, none of whom are charged more than the legal maximum. Companies which are unsuccessful in this competition are forced to compete in a gray or black market in which the rates often are three- or fourfold the official one. They are nevertheless quite willing to borrow at these rates, suggesting profitability at least equal to this higher rate. However, the financing charge for new equipment or building will clearly be greater for those (usually small) firms which are forced to compete for funds. Viewed alternately, large firms, receiving as it were, subsidized loans, pay too low an annual financing charge for the capital which they use.[1]

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[1] It has been argued by Ridker that a firm receiving loans at subsidized rates may then relend these competitively, if its internal rate of return is less than the black market rate. If this is the case with respect to loans, allocations of import licenses etc., the validity of the view that capital is underpriced is open to doubt. The implicit position of most analysts has been that such resale is a quantitatively unimportant phenomenom. Clearly more work is required given the implications of an active resale market. See R.Ridker, "Employment and Unemployment in Near East and South Asian Countries, a Review of Evidence and Issues," in Ronald G. Ridker and Harold Lubell, Employment and Unemployment Problems of the Near East and South Asia (New Dehli, Vikas Publications, 1971)

Apart from measures which lead to too low a purchase price and interest rate for many investors, numerous tax regulations further reduce the annual charge for using equipment. For example, investment credits and accelerated depreciation are likely to have adverse effects on the choice of production methods, particularly in view of the already high rates of return being earned by investors, who hardly require additional incentives.[1]

The net effect of the existing set of distortions in wages and the cost of capital has presumably been to bias the choice of individual firms towards unnecessarily capital intensive production methods. There is little direct evidence on the excessive use of very modern equipment; rather, much of the literature depends on inferences drawn from the large observed discrepancy between the growth of output and employment in the industrial sector. It is possible, of course, that such differences arise from gains in productivity either reflecting improving workers' skill or better management. Yet given the continuing large flow of new

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[1]For the effect of such tax practices on the cost of using capital see Jorgenson, op. cit. A detailed list of the existing tax legislation in a large number of Latin American countries is provided in "The Role of Fiscal Incentives for Employment Promotion in the Manufacturing Industries in Central America and Selected Countries in the Carribbean" in Fiscal Measures for Employment in Developing Countries (Geneva, ILO, 1972) pp. 183-212.

equipment from DCs to LDCs, some of this must be inappropriate, given DC wage levels for which the equipment is presumably appropriate, and the fact that equipment is not typically altered. To remove the incentives towards adoption of socially inappropriate equipment, the imperfections in factor markets must be reduced.

3. Types of Factor Price Policies Required.

The following sets of actions are open to LDC governments:

(1) Removal of the minimum wage, particularly for new employees, or reducing it to the levels prevailing in the craft sector.

(2) Undertaking policies to shift the supply curve of wage goods in order to reduce their price.

(3) Limiting the growth of wages paid by the government sector which often serve as a guidepost for private sector wages.[1]

(4) Limiting the fringe benefits such as social security currently in force.

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[1]For a detailed analysis of this question and its importance in one LDC see, Republic of Kenya, Report of the Commission of Inquiry. (Public Service Structure and Renumeration Commission) (Nairobi, Government Printer, 1971).

(5) Allowing the official exchange rate to move towards its equilibrium value, i.e., that at which the supply and demand for foreign currency will be equal, without the imposition of tariffs, administrative limits on imports and so on. Alternately, and less desirably, the imposition of tariffs on imported capital goods could be introduced to raise their cost in domestic currency.

(6) Removal of interest rate ceilings.

(7) Elimination of tax incentives which reduce the cost of utilizing capital in production.

(8) Elimination of the licensing of imported raw materials, a practice which has often been shown to discriminate against small labor intensive enterprises.

Two extended comments on this group of proposals are in order: first, is it politically feasible; second, will it work? It would be difficult to construct a set of policy proposals which would generate more intense disagreement among many of the most politically powerful groups who perceive the probability of substantial reductions in income. Highly paid, often unionized workers

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concentrated in urban areas would be adversely affected. the management of large companies currently enjoying subsidized equipment, low interest rates and access to raw materials would have to contemplate a reduction in windfall profits. Those who would benefit most, workers and entrepreneurs in the craft and small scale sectors, while surely more numerous, are poorly organized and likely to be less politically active. It is easy to see why alterations in factor prices, even where the potential aggregate benefits are understood by the government, may not be attractive to it.[1]

A more immediate, technical question is whether factor price changes will work. Changes in technique are most easily made in new production decisions. Existing buildings and equipment most often have limited flexibility not permitting a decrease in the capital/labor ratio. Will firms facing a changed economic environment react in the anticipated direction when expanding their capacity, assuming that scope exists for employing more labor intensive techniques? Put another way, what might intervene between a change in relative factor prices and a change in method of production?

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[1]A good discussion of some of the political issues is to be found in Warren F. Ilchman and Norman T. Uphoff, "Beyond the Economics of Labor Intensive Development: Politics and Administration, Public Policy, Spring, 1974.

First, as mentioned earlier, unless a reasonably competitive environment exists, the rates of return available in particular highly protected industries may be such that limited effort is forthcoming to adjust factor proportions. The small increment to profits resulting from economizing on the now more costly inputs may not be worth the effort, as long as "reasonable" profitability can be maintained. Even assuming desire to restore or augment profits, a limited amount of managerial time may better be spent cajoling a somewhat higher nominal protection rate for a firm's output, looser quotas on critical inputs, etc., than in adjusting factor proportions. The potential for additional profits in this direction may simply be perceived as greater and more probable than those obtainable by more intensive exploration of other production methods. Avenues to increased profitability other than improved productive efficiency must be closed if changes in factor prices are to provide the strongest impetus to exploration of alternate techniques of production.

Secondly, it is possible that despite the objective existence of more labor intensive production methods, this knowledge is not widely diffused among entrepreneurs. Knowledge of appropriate techniques requires not only

familiarity with production equipment per se, but with alternate methods for carrying out a variety of subsidiary operations such as intraplant movement of material, storage and so on. These operations often provide a major share of employment where the process has not been prematurely mechanized. Moreover, labor intensive peripheral activities are likely to be the least cost method for most LDC companies unless their production volume is atypically large.[1] However, these alternatives are not likely to be advocated by the (large) company's engineer, the equipment salesman, nor the various government agencies. Nevertheless, companies in at least some LDCs do utilize appropriate core equipment and peripheral processes in response to the low wage of labor.[2] If there is reason to believe that adaptation to changed factor prices is unlikely to be forthcoming due to lacunae in existing knowledge or understanding, some government or private aid will be needed to supplement the eight policies listed above.

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[1]For calculations of such costs for a typical process see H. Pack, "The Substitution of Labour for Capital in Kenyan Manufacturing, The Economic Journal, March 1976.

[2]Pack, ibid., and G. Ranis, "Industrial Sector Labor Absorption", Economic Development and Cultural Change, April, 1973.

B. A Survey of Evidence on the Effects of Changes In Factor Prices.

There have been only a few conscious attempts by LDC governments to alter relative factor prices: the factor mix effects of these have not been systematically analyzed. It could, of course, be argued that the effect of changes in relative factor prices is implicit in the substantial number of studies[1] which utilize the relationship between value added per worker and the wage rate to infer the ease of substitution between capital and labor. A positive estimated relationship is presumptive evidence of the responsiveness of factor proportions to the real wage. The difficulty here is that wage growth over time in an LDC may reflect labor's share of increasing productivity which is itself attributable to organizational changes and learning-by-doing. The growth of wages is thus not exogenous as required for the statistical estimating procedure. The relation between the value added per worker and the wage may thus provide information about wage bargaining rather than the responsiveness of factor proportions to exogenous changes in the level of wages.[2] More direct

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[1]For example those cited in the surveys by Acharya and Morawetz, op.cit.

[2]See H.Pack, "Employment and Productivity Growth in Kenyan Manufacturing," Yale Economic Growth Center Discussion Paper 190, especially pp. 27-29.

evidence on the responsiveness of factor proportions to changes in relative factor prices is thus desirable for robust inferences about the potential effectiveness of a changed economic mileu. Unfortunately, little such evidence is available, as the following survey suggests.

1. Effects of Policy Induced Changes in Factor Prices.

The classic "stories" of successful alteration of factor prices and resultant sustained employment growth are South Korea and Taiwan, both of which allowed market forces to determine (heretofore pegged) rates of interest in commercial and savings banks.[1] In South Korea this change occurred in 1965. Taiwan followed a high real interest policy throughout the 1950's and 1960's.[2] Table 1

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[1]Analyses of the changes in policy in South Korea are given in G. Brown, Pricing and Fiscal Policies in South Korea in the 1960's and David N. Cole and Princeton N. Lyman, Korean Development, The Interplay of Politics and Economics, (Cambridge, Harvard University Press, 1971). Unfortunately neither volume, though very useful in other respects, provides systematic analyses of the response of factor proportions to relative price changes. A comparison of South Korea and Taiwan in many dimensions of performance during the 50's and 60's is provided by John C. H. Fei and Gustav Ranis, "A Model of Growth and Employment in the Open Dualistic Economy: the Cases of Korea and Taiwan," The Journal of Development Studies January 1975. However, there is only limited explicit analysis of the response to changed factor prices.

[2]For a description of Taiwan interest rates see A. G. Chandavarkar, " Some Aspects of Interest Rate Policies in Less Developed Economies, The Experience of Selected Asian Countries," International Monetary Fund, Staff Papers, March, 1971.

Table 1

Compound Rates of Growth

	1953-58		1958-63		1966-69	
	Q	N	Q	N	Q	N
Taiwan	9.0	1.9	13.1	2.8	20.0	13.2
S. Korea	16.1*	5.6**	10.0	8.3	28.8	13.7

* 1954-58

** 1955-58

Q is an index of industrial production

N is the number of employees

Data Source: U.N. The Growth of World Industry, various issues

presents the growth rates in employment and output for three periods for each country.

In South Korea the growth of employment and output diverged quite substantially between 1954 and 1958, were quite similar between 1958 and 1963, and again diverged in the period 1966 to 1969. It is striking that in the period immediately preceding the interest rate reforms of 1965 the growth of average labor productivity was quite low but increased after the reform was implemented. As there has been little systematic investigation of production in Korea, we do not know whether the similar growth rates of output and employment in the 1958-63 pre-reform period indicate no capital deepening or whether it reflects few gains in disembodied technical progress. Conceivably, the increased growth of average labor product after the reform might represent productivity gains as the large group of workers hired in 1958-63 accumulated experience. However, the reform witnessed a growth in the real industrial wage from 100 in 1965 to 132 in 1968 whereas between 1958 and 1963 it fell from 109 to 102.[1] Thus, it could be argued that the rise in the interest rate helped to forestall an even more rapid growth in average labor product as producers responded to a growing real wage. Moreover, improved allocation of new funds, particularly the greater share accruing to efficient small businesses may have accelerated the growth

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[1]Cole and Lyman, op. cit. Table 7.3

of productivity after 1965. If this is true, the reform and the increase in the cost of capital relative to the real wage may in fact have resulted in a stationary or declining capital-labor ratio whose effect is obscured by productivity growth. Without more knowledge of the movement of the capital stock (despite acknowledged measurement difficulties), it is impossible to infer precise results from this experiment in altering relative factor prices.

The data on Taiwan are equally ambiguous. From 1953 to 1963 there was substantial growth in labor productivity. Yet Fei and Ranis find only a 33 percent increase in capital per worker in the industrial sector between 1952 and 1969; a small increase must have characterized 1953 and 1963. If the data are correct, this implies that the 1953 to 1963 growth in labor productivity must have been attributable to intersectoral shifts and/or intrasector productivity growth, perhaps stimulated by the high real interest rates. However, between 1966 and 1969 there was a marked increase in the rate of job growth relative to that of output, perhaps reflecting a decrease in the potential for further disembodied productivity growth. In sum, it is difficult to easily identify the impact of appropriate factor prices on Taiwan's employment performance, certainly not at the aggregate level.

A paper by Williamson designed to explore the effects of changes in relative factor prices in the Phillipines brought about by import liberalization and devaluation indirectly considers changes in the ratio of capital to labor costs on the rate of growth of employment.[1] Williamson finds that the elasticity of substitution of labor for capital is greater than unity and that the speed of adjustment of companies to changes in the wage rate is fairly rapid. However, he does not explicitly use the price of capital in his analysis and his method is open to many of the objectives mentioned by Acharya. He does find that during the period of liberalization intersectoral resource allocation dramatically improved, an oft-predicted but rarely verified benefit of liberalization. If this indeed occurred, output could grow more rapidly than employment for the entire industrial sector even if capital deepening were discouraged by the change in relative factor prices.[2]

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[1] J. G. Williamson, "Relative Price Changes, Adjustment Dynamics and Productivity Growth: The Case of Phillipine Manufacturing" Economic Development and Cultural Change, Oct. 1971.

[2] Williamson notes that intra-sector productivity growth was negative during this period so that there was limited aggregate growth in industrial productivity despite the gain from reallocation.

Another study of Williamson,[1] also analyzing the impact of factor prices in the Phillipines, uses the price of capital and the capital stock explicitly, thus leading to more confidence in the results.[2] Williamson finds that changes in the ratio of wages to the user cost of capital explain a substantial fraction of the growth of capital-labor ratios in the Phillipines between 1960 and 1966. Despite the growth in the user cost of capital, nominal wages rose more rapidly, inducing increasing capital intensity.

We briefly note the experience of Singapore during the 1960's as an illustration of the potential effects of a constant or slowly rising nominal wage. Between 1968 and 1971, the rate of growth of output in the industrial sector was 24.0, that of employment 17.7, and that of real wages · 2.3 percent per annum.

Finally, the effect of import quotas has often been cited as a major deterrent to the success of small, labor

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[1] J. G. Williamson, "Capital Accumulation, Labor Saving and Labor Absorption Once More," Quarterly Journal of Economic, Feb., 1971.

[2] See, however, Gary Saxonhouse's comment on Williamson, Quarterly Journal of Economics May, 1975.

intensive craft firms who do not have the ability to "lobby" for a fair allocation of raw materials. After the liberalization of Pakistan's foreign exchange regime in the early 1960's, many of the efficient, smaller machine producing firms were able to expand their scale as imported raw materials could be purchased in the open market. As the system gradually moved back towards quantitative controls, these firms complained of difficulty in obtaining sufficient materials to continue their expansion, thus slowing the rate of growth of both output and employment.[1]

The preceding survey of the response of employment to changes in relative factor prices omits an important effect, namely, the more rapid growth of capital accumulation generated by a substantial response of total private saving to increased real interest rates. In South Korea, Brown found a substantial correlation of the private saving rate with the real rate of interest.[2] Thus, private saving as a percentage of GNP increased from 3.9 percent in the year immediately preceding the interest reform to 9.8 percent by 1967. Moreover, statistical analysis confirms this increase was entirely attributable to the rise in the real

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[1]For an extended discussion see Hiromitsu Kaneda and Frank C. Child, "Small-Scale, Agriculturally Related Industry in the Punjab," (Davis, 1971) Working Paper 11.

[2]Brown, op. cit. and G. Brown "The Impact of Korea's 1965 Interest Rate Reform" (mimeo).

interest rate and not to higher real income.

Unfortunately, there are no other analyses of the interest responsiveness of total private saving rather than of one form of saving such as savings accounts,[1] but if such interest responsiveness is typical, its potential for aiding capital accumulation and hence employment is evident.

The preceding survey of the little evidence available indicates that changes in factor prices, particularly that of capital, are difficult to document as a source of the rapid growth of industrial employment in Taiwan. and South Korea. Relatively constant wages seem to have played an important role in Singapore's successful employment performance, while the increased price of capital appears to have had limited effect in the Phillipines given relatively rapid growth in industrial wages. Whether or not the success, such as it was, of Singapore, South Korea and Taiwan are replicable in other economies is open to question. A number of special factors exist. In the two latter countries strong governments, made stronger by immediate external threats, were able to obtain the acquiescence of sectors

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[1] Raymond F. Mikesell and James E. Zinser, "The Nature of the Savings Function in Developing Countries: a Survey of the Theoretical and Empirical Literature," Journal of Economic Literature, March, 1973.

or classes who might otherwise have opposed policies leading to potential losses from the change in economic environment. In Singapore, recent racial clashes and the separation from Malaysia may have had similar effects on cooperation. Secondly, all three countries are relatively well endowed with entrepreneurs: thus, given a change to a more favorable economic environment, we would expect greater adaptation to the new opportunities than might characterize more skill-constrained economies. The ability to search for new production methods, to adapt central core processes[1] and to exploit new labor intensive product lines made profitable by the altered factor prices may be a relatively rare capability. Moreover, in all three economies, domestic abilities were augmented by considerable foreign skill, usually in the form of direct investment. Few LDCs are likely to be as open to such aid, given current ideological propensities.[2] A third factor was the openness of these economies. The competitive structure, especially the emphasis on exports, undoubtedly increased the responsiveness to changed relative factor prices, for reason indicated earlier. Finally, in at least two of the countries (Singapore and Taiwan) either a strong agricultural sector or the

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[1] For examples see Gustav Ranis, "Industrial Sector Labor Absorption," Economic Development and Cultural Change, Oct.,1973.

[2] On the probable benefits from direct MNC investment see G. Helleiner, "Manufactured Exports from Less Developed Countries and Multinational Firms." The Economic Journal, March, 1973.

imports of food from a relatively stable world market allowed the price of a major wage good to be kept steady, thus reducing any upward pressure which might have developed on the nominal wage paid by industrialists.

2. Effects of Differences in Factor Prices Facing Firms of Different Size

Given some of the difficulties in interpreting the classical cases of policy induced changes in factor prices and the possibility that these may be unusual-entrepreneur or skill-rich nations-are there alternate empirical bases on which to base an assessment of the potential beneficial effects of moving towards a more rational factor price configuration? There is a rapidly accumulating body of evidence whose major implication is that differentials in factor prices faced by firms of different sizes have indeed led to alternate methods of production. The higher wage and the lower interest rates typically paid by large firms appear to have resulted in sharp variations in factor proportions among firms within the same industry in a given country. Such cross sectional evidence suggests that a change in factor-price ratios is likely to be effective if combined with competitive pressures in the output market. We turn to a review of the available evidence.

A large number of empirical studies have examined differences which exist among firms of different size (as measured

by number of employees). Of particular interest is the increase in the capital-labor ratio as the size of firm increases for a given two digit industry such as textiles or food processing. This pattern at least partly represents the increase in the use of equipment, tools, and mechanical conveyors in response to increasing wage levels as firm size goes up; it being well documented that the wage per worker is highly correlated with firm size. The earliest demonstration of these now conventional findings appeared in analyses of Japanese manufacturing[1] and the results have been verified for almost all LDCs which have

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[1]Among the studies of Japan are two by T. Watanabe, "Economic Aspects of Dualism in the Industrial Development of Japan," Economic Development and Cultural Change, April 1965 and "Industrialization, Technological Progress and Dual Structure" in L. Klein and K. Ohkawa, Economic Growth: the Japanese Experience Since the Meiji Era (Homewood, Richard D. Irwin, 1968).

The results of a large number of analyses of the dual structure of Japanese industry are summarized by M. Shinohara in B. Hoselitz, ed. The Role of Small Industry in the Process of Economic Growth (The Hague, Mouton, 1968).

Among the studies which confirm the general qualitative pattern of increasing capital-labor ratios by firm size within two or three digit branches are:

Gustav Ranis, Industrial Efficiency and Economic Growth: A Case Study of Karachi, (Karachi, Institute of Development Economics, 1961);

A. R. Khan, "Capital Intensity and the Efficiency of Factor Use-A Comparative Study of the Observed Capital-Labor Ratios of Pakistani Industries," The Pakistan Development Review, Summer, 1970;

Saul Trejo, Industrialization and Employment Growth: Mexico 1950-65 (Ph.D. Dissertation, Yale University, 1971);

Patricio Meller, "Production Functions for Industrial Establishments of Different Sizes: the Chilean Case", Annals of Economic and Social Measurement, Fall, 1975;

I.L.O. Sharing in Development-a Programme of Employment, Equity and Growth for the Phillipines (Geneva, ILO, 1974).

been investigated, the major exception being Taiwan. Table 2 presents fairly typical wage patterns by firm size for the entire manufacturing sector in Mexico in 1965 and Pakistan in 1960. Disaggregation by two digit branch reveals a similar pattern.

Thus, even if companies of all sizes paid the same interest rate and had equal access to imported equipment at the same price, such wage differentials provide presumptive evidence that larger firms devote more effort to economize on labor than smaller ones. However, equal access to loan finance and equipment are not good descriptions of reality.[1] Typically, small firms finance their expansion from the saving of the entrepreneur, his relatives and close friends; a group likely to have limited resources. If borrowing outside of this primary group occurs, it is usually from "grey" market lenders who charge two to four times the going rate charged by commercial banks. On the other hand, commercial banks and governmentally sponsored industrial development banks usually lend to the larger firms at relatively low interest

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[1]See, for example, George Rosen, Some Aspects of Industrial Finance in India (Glencoe, The Free Press, 1962); Report on the Economic Survey of Bombay (Bombay University of Bombay, 1959); ILO. Sharing in Development, op. cit.; Trejo. Industrialization and Employment Growth, op. cit.

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Table 2

Wage per Worker by Size of Firm

Mexico - 1965		Pakistan - 1960	
Firm Size (number of employees	Wage Index (over 500 = 100)	Firm Size (number of employees	Wage Index (100 and over = 100)
1-5	21	1-9	58
6-15	41	10-19	76
16-25	55	20-49	89
26-50	61	50-99	96
51-75	6[illegible]	100 and over	100
76-100	70		
101-250	78		
251-500	88		
> 500	100		

Sources: Trejo, op. cit., p. 112

Ranis, op. cit., p. 33

rates. If interest rates of 10 or 12 percent are charged by these large institutions, smaller firms will typically pay 30 to 40 percent.[1]

The pattern of wage and interest differentials (as well as differential access to import licenses) must be assumed to play a major role in the pattern of increasing capital-intensity by size of firm as shown in Table 3 for Pakistan and Mexico.

The pattern depicted for all firms regardless of branch typically also holds when the firms are disaggregated to the two digit level, though inevitably some exceptions arise. The smallest companies exhibit very low capital-labor ratios, high average product of capital and usually a somewhat lower average product of labor. As size increases, the capital-labor ratio and output per worker increase and the output per unit of capital declines. Further analysis typically reveals that the smaller firms are at least as efficient as the larger ones in the sense that if both were to face the same socially relevant factor prices (say the wage rate paid by small firms and an interest rate which

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[1]See the evidence provided by Chandavarkar, op. cit. pp. 61-62.

Table 3

Capital-Labor Ratios by Firm Size

Mexico		Pakistan	
Size (number of employees)	Capital per worker (pesos)	Size (number of employees)	Capital per worker (rupees)
1-5	10,489	1-9	.63
6-15	31,488	10-19	1.96
16-25	48,603	20-49	2.13
26-50	57,498	50-99	2.37
51-75	62,072	≥ 100	2.92
76-100	63,789		
101-250	80,384		
250-500	96,180		
> 500	104,777		

Sources: Trejo, op. cit., Table 18

Ranis, op. cit., Table 2

measures the rate of return either in agriculture or small scale industry), the average cost of production in smaller firms would be competitive with that of larger firms, indeed often lower.

While features of production other than differences in factor price ratios might explain some of the observed characteristics by firm size,[1] most studies have concluded that they play a major role. Thus, the examination of capital-labor ratios by firm size provides a rich body of data which confirms the likely responsiveness of entrepreneurs to changes in their cost structure. Such studies have been executed for a sufficiently large number of diverse countries so that one may infer such responsiveness is a fairly universal phenomenon in Asia and Latin America, not limited to countries with a particular history or culture. It characterizes both large and small countries, those which are usually thought to be skill-rich and those which are not.

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[1]For example, production functions in which capital becomes increasingly efficient relative to labor as the desired level of output goes up. See, H. Pack and M. Todaro, "Industrialization, Employment and the Choice of Alternative Vintage Equipment in Less Developed Countries," Discussion Paper 95, Economic Growth Center, Yale University, mimeo.

In addition to the analysis of census and survey data, a substantial literature exists based on interview techniques and confirms the robustness of the small scale sector. A number of these studies detail the skilled entrepreneurship which characterizes many craft firms in LDCs.[1]

However, it should be noted that neither the presence of abundent entrepreneurship nor many examples of efficient small-scale craft firms have been confirmed in sub-Saharan Africa. A recent ILO study of Kenya,[2] despite its emphasis on the potential role of the "informal sector," offers little empirical evidence that craft firms, with say 2 to 25 employees exist. Rather, the informal sector consists primarily of self-employed craftsmen such as tailors and carpenters who do not produce products which can compete with typical industrial goods in contrast to the craft firms found in the

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[1] For example, Edward H. Smith, "The Diesel Engine Industry in Pakistan's Punjab," (Islamabad, A.I.D., 1970); Leonard Dudley, "Learning and Productivity Change in Metal Products," American Economic Review, Sept., 1972 analyzes the Colombian metal working industry; H. Kaneda and Frank Child "Small Scale Agriculturally Related Industry in the Punjab," (Davis, 1971). For a very useful survey of additional studies see Bruce Johnston and Peter Kilby, Agriculture and Structural Transformation (New York, Oxford University Press, 1975), Especially chapters 3,7, and 8.

[2] Employment, Incomes and Equality in Kenya, (Geneva, ILO, 1972)

Indian subcontinent or Latin America.[1] The absence of smaller firms and able entrepreneurs would, if generally true, require a different approach to obtaining labor intensive development, as the response to changes in factor prices may not be adequate.

C. Policy Advice to LDCs

1. The Need for LDC Government Agreement

I will take as a point of departure that a labor intensive development process will require the active cooperation of the central government of an LDC. Although it is possible to attempt to stimulate labor intensive production without a redirection of government policies, this appears to me to be unsustainable in the absence of changes in relative factor prices and increased competitiveness in product markets. One might envision, for example, advice on an individual basis from A.I.D. financed private advisers on small business and appropriate technology to a target group of companies in an LDC. However, the aid recipients will not, in the aggregate, be able to obtain an increasing share of investible funds unless current policies of arti-

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[1] A careful study of Nigerian small business can be found in Peter Kilby, Industrialization in an Open Economy: Nigeria 1945-1966 (Cambridge, Cambridge University Press, 1969). Chapter 10, in particular, emphasizes the lack of success of small manufacturing firms.

ficially low interest rates combined with credit rationing are abandoned. While small businesses usually exhibit high rates of return and could successfully compete for capital in a competitive market, their very smallness and absence of collateral work against them in a rationed market. Similarly, the extensive use of import licenses in the allocation of both capital and intermediate goods works to their disadvantage as it necessitates substantial allocations of managerial time, to say nothing of cash payments, to obtain the requisite licenses. In another vein, unless wage good output is increased and its price thus kept low, the growth of nominal wages to both small and large firms will produce strong incentives to rely on increasingly capital intensive techniques. In sum, the requisite changes in the allocation of investment funds, import licenses, and the price of wage goods are beyond the influence of private, non-profit organizations and any other industrial extension agencies which work directly with LDC firms.

Often it is argued that extension activities will generate a sufficient number of success stories so that the demonstration effect will induce a perhaps unwilling government to pursue a labor intensive strategy, including a liberalization of the credit and foreign exchange markets. Such a strategy raises fundamental moral and political

questions which are presumably sufficiently obvious that they need not be discussed here. Apart from this, it is unlikely to work. Although a small number of firms may, with intensive advice, identify new products, purchase appropriate equipment and undertake labor intensive low cost production, it is difficult to understand how this can occur on a sufficiently large scale without a prior change in government policies; who will lend to large numbers of small enterprises at low officially sanctioned interest rates given the perceived risks, the absence of collateral, and disproportionately high administrative costs. Yet if the "demonstration from below" approach is to be persuasive it is necessary for it to occur simultaneously on a large scale in a number of industries and regions and thus requires substantial amounts of investment funds.

More generally, this "private-non-government" approach is, in a fundamental sense, predicated on the absence of entrepreneurs: it assumes that the critical constraint which has limited the growth of firms with appropriate techniques is the scarcity of able and knowledgeable businessmen. Yet this assumption, for many countries, is counterfactual. The same group of studies which analyze the production and factor price characteristics of firms of different sizes also show that large numbers of small firms

(say with less than 50 employees) are present in many non-African LDCs in most branches of production; that on the basis of reported data they have made correct factor choices given the factor prices they face; and that they exhibit extremely high rates of return on their invested capital. For example, in Pakistan, the rate of return on fixed capital was over 18 percent for medium size firms (20-49 employees) and less than 12 percent for firms with more than 100 employees.[1] These are not the characteristics one would expect if the true bottleneck on expansion of firms using appropriate technology were the absence of entrepreneurial skills. Indeed, they are more suggestive of remarkably adaptive behavior in an economic environment which is skewed to favor large enterprises. While private technical aid efforts can undoubtedly improve existing performance, particularly in suggesting new products and indicating relevant sources of tools and equipment, there is little reason to doubt that had small businesses been able to obtain access to critical inputs, such growth would already have occurred in many countries.[2] It is for these

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[1] Ranis, Industrial Efficiency and Economic Growth, Table 14. Similarly high rates of return have been found in other countries.

[2] Trejo op.cit., pp. 125-30 finds substantial growth for those small Mexican companies which were able to borrow externally. Also see the references in footnote 1 , page 26.

reasons that I take as the starting point the need to convince the central government of the desirability of pursuing a more labor intensive policy in those cases where this has not been true.

It should be emphasized that the emphasis on the need to change the economic environment does not imply that a variety of technical services cannot be beneficial to LDCs, only that by themselves they are unlikely to exert sufficiently large quantitative effects to alter the course of an otherwise capital intensive development policy. Similarly, the emphasis on the probable efficiency of relatively small companies is not meant to deny the possibility that large companies may be efficient and capable of adopting correct factor proportions in their production processes. Indeed there is evidence that such firms are, given the correct set of incentives and capable management, quite adroit in identifying and adopting labor intensive techniques.[1] While larger firms, too, may derive benefits from technical advice, in the absence of economic incentives there may be no reason for them to seek or utilize such aid.

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[1]See the Kenyan examples in Pack, "Employment and Productivity Growth in Kenyan Manufacturing," op. cit.

2. Aggregate Implications of Correct Factor Choice

Governments may be unaware of the range of choices open to them in pursuing greater employment growth and of the magnitude of the additional jobs which could be created. Their existing policies may not be malevolent but a response to perceptions, such as a shortage of investment opportunities, which are not accurate descriptions of the reality of their economies. Indeed, many of the most harmful government interventions were designed to increase domestic industrial output and employment in a world in which it was thought that international trade could only be harmful to LDCs because of the alleged deterioration in the terms of the trade.[1] It is ironic that the policies undertaken to effect import substituting industrialization, originally advocated by those most concerned with income distribution and unemployment, are now cited as presumptive evidence of the opposition of LDC governments to policies which could ameliorate current income maldistribution and improve low level employment opportunities. While to be sure there are now some groups,

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[1]For an excellent discussion of these issues see I. Little, T. Scitovsky, and A. Scott, Industry and Trade in Some Developing Countries, (New York, Oxford University Press, 1970).

both business and labor, deriving considerable windfall benefits from the existing system, there is also extensive evidence of the recognition by many governments of the need to alter current policies if violent change is to be avoided.

Given my premise that changes in technique require changes in factor prices, it is necessary to follow a two pronged strategy of advice: (1) where governments are insufficiently aware of the employment gains which will result from a change in policy, a demonstration is needed of the aggregate gains:[1] (2) enhancement of the govern-

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[1]The continuing blindness of many LDC governments and intellectuals to the perversity of capital intensive development policy is shown with exemplary clarity in the following:

> In this latest effort to improve the country's image, a typical example is "From Blueprints to Bricks," an expensively prepared booklet recently published by the Indian Embassy in Washington. Indian sensitivity about the ...oxcart as a metaphor for the country's backwardness is reflected in the fact that the booklet ... devotes an entire page to answering the question: "Is India still dependent on the oxcart?" (New York Times, March 2, 1976) p.7

The article then details the concern of the Indian government to extol mechanized production of all types, and Nehru is cited as having referred to modern, capital intensive projects as "the new temples of Modern India." The same article quotes an economist in Bombay:

ment's ability to achieve the employment goals.

a. Effects on Employment and Output.

There have been a large number of studies of the choice of technique at the process level, ranging from flour milling to can sealing to methods of road construction.[2] Despite the demonstrated availability of alternate techniques at the process level, there are nevertheless very few studies of the aggregate effects which would be forth-

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1 cont'd

> I go overseas and my friends think of India as a long line of hungry, half-naked peasants. Why, the mechanized assembly lines are as much a symbol of where India's going as the bloody ox-cart that everybody always writes about.

Despite a decade of attempts to show the relationship between capital intensive industrial production and underemployment in urban areas, there is little evidence that the message has been absorbed by LDC leaders.

[2]See the references in footnote 1, page 2.

coming if all sectors adopted appropriate techniques.[1] A fortiori, LDC policy makers cannot know these magnitudes. Thus an important contribution to generating LDC interest in the possibilities offered by labor intensive techniques can be made by:

(1) a systematic cataloging of the economically efficient techniques by industry, which have so far been established. This would include for each process specific production alternatives such as the type of core production equipment available, alternate peripheral processes, the sources and costs of relevant equipment. Some sample cost accounting analysis such as that shown in Table 4 below might aid the understanding of officials.

(2) The use of the above information in projection of some plan or set of growth objectives which the LDC government finds plausible or desirable. Such a plan may be the

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[1]An exception is Victor E. Tokman, "Income Distribution, Technology and Employment in Developing Countries: An Application to Ecuador," Journal of Development Economics, May, 1975. Tokman's estimates of the aggregate gains do not take account of potential substitution possibilities in many production activities in which considerable scope for additional labor intensity has been demonstrated. Nevertheless, even within this fairly restricted framework, it is shown that total manufacturing employment could be increased by 17 percent over a ten year period above that which would be generated by continuing to use current techniques in expanding production capacity.

official plan document but this is not necessary. Projections can be made of probable total employment growth without altering current production methods and with say two alternative factor price regimes using more labor intensive techniques. The saving in capital obtained by producing the planned output in a less capital intensive manner should also be calculated, as this is a major benefit that is insufficiently emphasized in most analyses. The output of some projects which were not included in the original plan, but which now become feasible because of the freed investment resources, should be calculated.

An illustration of the method is presented in Table 4 using data from a study on the choice of technique in textile production. Four methods of producing woven shirting material were identified, each exhibiting considerably different labor requirements and capital costs. Columns 1 and 2 indicate the inputs required to produce an additional 100 million square yards of material, an increase well within the goals of some development plans. Column 3 indicates the capital-labor ratio associated with each type of process. Column 4 shows the amount of investible funds saved by adopting the Lancashire loom, the least capital intensive one, rather than each of the others. Column 5 indicates the additional employment which would be generated by investing the funds so saved in an activity whose capital-labor ratio was no

Table 4

Aggregate Effects of Alternate Weaving Techniques

Type of Loom	Requirements per 100 million square yards per annum (1) Manyears	(2) Investment	Capital/Labor Ratio (2)/(1) (3)	Investment Funds Saved Using Lancashire (4)	Additional Indirect Employment (5)	Percentage Increase In Output (6)
Lancashire	2,180	$ 3,582,000	$ 1,645			
Battery	1,110	7,163,500	6,454	$ 3,581,500	2,177	100
Airjet	820	7,877,700	9,665	4,295,700	2,611	120
Sulzer	510	15,006,300	29,715	11,424,300	6,944	319

Source: Underlying data were obtained from Cotton and Allied Textiles (Manchester, The Textile Council, 1969). The data are analyzed more extensively in H. Pack, "The Choice of Technique and Employment in the Cotton Textile Industry," in A. Bhalla, ed., Technology and Employment in Industry, (Geneva, International Labour Office, 1975).

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greater than that of the Lancashire loom. These, of course, must be added to the differences shown in Column 1 to derive the total employment differentials. Finally, column 6 presents the percentage increase in output which could be generated by investing the saved funds in additional weaving capacity. Obviously, other possibilities will be open, the output gain calculated here simply provides some orders of magnitude.[1]

The potential contribution of AID or a sponsored organization in systematizing information on available techniques and analyzing their implication for a given LDC is obvious. Existing evidence on the benefits to be derived, industry by industry, assure that these are likely to be enormous and such calculations are likely, at the least, to stimulate LDC governments to consider some of the policies necessary to realize them.

b. Other Policies

Convincing the government of a country of the desirability of changing the economic policies to establish a climate more favorable to labor intensive development is necessary, but may not be sufficient to obtain such development.

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[1] For a more detailed discussion of these and other issues see H. Pack, "The Choice of Technique and Employment in the Textile Industry" in A. Bhalla, ed. Technology and Employment in Industry, Geneva (International Labour Office, 1975).

Although we know that firms of diverse sizes use different techniques, the speed with which changes to appropriate production methods will be made may be accelerated by the presence of good advisory services, especially when there is a demonstrated absence of entrepreneurship.

1. Extension Services

Extension-type activities are likely to be best implemented by those who have been involved in industrial production management over a long period. These managers are likely to have seen the continuous evolution of production methods and are aware that the 1976 method differs considerably from 1956, to say nothing of 1936 and that the latter two were quite viable in their time. Labor intensive methods, particularly in the peripheral processes, characterized American and Western European production until well after World War II.

These older techniques can still be used to produce many high quality products which are in no way inferior to those produced with more recent equipment. Thus, a large pool of westerners exist who have been involved in relevant production management who could convey both the physical feasibility of labor intensive production as well as some of the organizational methods and innovations which surely ocurred and increased productivity. They will be more attuned to the possibility of manufacturing with something other than the latest method, especially where wages are a fraction of the U.S. 1955 levels and interest rates are

four to five times those in the western countries. By contrast, recent graduate engineers with little production experience are unlikely to be quite so open to alternate production possibilities. They have been exposed to the latest edition of a textbook in food processing and may be unaware that earlier editions showed different equipment. Moreover, most engineering texts and courses concentrate almost exclusively on the technical aspects of production, such as the chemical changes which occur, rather than on costs. Rarely are there discussions of the number of workers used by a machine or the relative costs of different types of equipment. Without exposure to the concepts of costs and the discipline of product prices, engineers are likely to be less open than those with production experience, who may, in fact, have had similar academic training.

Most of the empirical studies of successful use of labor-intensive methods in LDCs are based on factory visits. Plant managers who have been successful in such adaptive behavior are often articulate advocates of the physical feasibility and economic rationality of substituting labor for capital. Thus, in addition to aid from western managers, visits by industry teams of successful adaptive managers from LDCs could constitute an important source of advice and encouragement. These visits would in

addition have the not unimportant side benefit of conferring prestige on manufacturers who successfully avoid capital intensive patterns; they will demonstrate to the recipients of technical counseling that there are avenues to achieve supra-national recognition other than installing an automated rolling mill. Moreover, such missions may even lead to a strengthening of the position and prestige of the successful managers in the country of origin of the advisers.

No apriori case can be made about the size of firms which are likely to derive the greatest benefit from extension advice. The evidence cited in Section B on the characteristics of firm by size suggests that smaller firms have had, by force of circumstance, to undertake more labor intensive production in the past. Presumably, they possess more knowledge about the sources of used or appropriate new equipment and the types of adjustments that may be made to take advantage of inexpensive inputs. Nevertheless, such past adaptation might have been more extensive and productive with more information and advice. Some production alternatives and potential products may not have entered the set of choices among which small firms made past decisions. On the other hand, large companies with perhaps limited experience in choosing labor intensive processes, may initially need guidance in identifying sources of information. However, they may require less aid insofar as they employ a technical

staff which may be used in these activities. Thus, the provision of industrial extension services should, at the outset, be neutral with respect to size until information on the intensity of need can be obtained.

2. Tax Policies

Although higher interest and foreign exchange costs are likely to provide strong incentives to the search for more labor intensive equipment, some measures are open to the government to augment these incentives, yet perhaps reduce opposition to the impending changes. Most LDC governments levy some form of business profits tax: indeed, the wide variety of tax holidays and accelerated depreciation are directed at reducing these taxes in the hope of generating greater investment. As indicated earlier, many of these devices decrease the cost of using capital and implicitly encourage capital intensive production methods and should thus be ended. An alternate set of tax provisions for reducing the tax burden might be substituted which would further encourage the search for labor intensive techniques. Reductions in the average rate applicable to a given level of income could be made contingent on companies presenting a costing of alternate production processes when considering either replacement or expansion. Presentation of detailed cost estimates for at

least one more labor intensive process, including peripheral activities, could be made the standard for being placed in a preferred tax category. If the company chose the more capital intensive process despite lower costs at the prevailing market prices of factors, its average tax rate would be increased, rather than lowered.

Table 4 illustrates the calculation, along with supporting evidence, which would be submitted by companies. Some fairly difficult issues are embedded in these calculations, particularly with respect to the interest and wage rates to be used by firms. If the prevailing market levels are not socially appropriate, the computations will have limited usefulness as a guide to tax policy. However, some firms may find that even, at existing factor prices, labor intensive equipment yields the lowest costs.[1]

Clearly, given limited administrative ability, all firms could not be required to submit such proposals. Presumably, it would be best to start with the largest companies and then move down through the size distribution until administrative ability is exhausted. An

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[1]See, for example, the study of Pickett *et al.*, *op. cit.*

Table 4

Costs of Weaving Shirting Material

(dollars per 100 yards)

	Lancashire Loom	Airjet (Elitex)	Sulzer Loom
Space	.198	.093	.152
Power	.385	.385	.291
Weft Waste	.035	.408	.338
Pirning	.472	-	-
Capital Costs* (including depreciation and interest charges, assuming an interest rate of 20 percent per annum)	.658	2.167	3.796
Cost of Labor (wage=$832 per year)	1.744	.652	.404
Average Unit Costs	3.493	3.705	4.981

Source: Cotton and Allied Textiles, Vol. II, p. 83 for lines 1-4. Line 6 calculated from pages 86-90.

*including transport and installation costs equal to 20 percent of the cost of a battery loom.

obvious and important potential role for bilateral advice would be a catalogue of alternate processes as well as training for LDC administrators, facilitating their ability to establish the accuracy of the alternatives presented. Compliance with tax provisions could be aided by the extension service.

Such tax provisions require some confidence that more efficient, labor intensive alternatives exist whose adoption would, in fact, result in lower costs for the firm. That such choice exists in most industrial activities is an underlying assumption of this paper. At a corrected set of interest and foreign exchange rates more labor intensive techniques are, in fact, likely to be the least cost techniques for producing a large number of products.

3. Strengthening Ability to Finance Loans

One other area in which a considerable contribution could be made by AID is strengthening the ability of LDC lending institutions. The arguments made earlier for increasing the access of small scale, labor-intensive firms to capital ignored the ability of the existing lending institutions to effectively implement lending programs. Clearly, not all loan applicants will have a reasonable chance of success. Some screening must take place even with high rates of interest which should discourage the

less efficient firms from applying. Moreover, the bookkeeping involved after the loans are made is not an easy task given the potentially large number of borrowers and the relatively limited experience found in the financial sector in many LDCs. Augmenting the administrative capacity of the lending sector may thus allow the removal of a critical bottleneck to small scale lending. Fortunately, the bookkeeping for these loans should be a fairly labor intensive activity, providing jobs for many high school graduates. Assuming that both the processing and bookkeeping of loan programs will not be automated, the training would best be undertaken by those who have had administrative experience before routine banking activities were themselves automated. This criterion suggests older middle level banking officials in the DCs or some of the demonstrably successful ones from LDCs as the "teachers."

Conclusions

The emphasis of this review of issues has been on the necessity of convincing LDC governments of the benefits to be obtained by a labor intensive approach to their future economic development and the need for them to alter the prices which businesses pay for their factors of production in order to align the private profit decision with that of the national interest. The major beneficiary

of the proposed changes would be the small business sector which in many countries has been found to be labor intensive and highly profitable, but severely discriminated against by current policies with respect to credit and the availability of imported raw materials. Increasing the price that larger companies pay for capital goods by freeing the interest rate from legal limits, as well as raising the price of foreign equipment, is also likely to result in their changing the mix of capital and labor used in their production. If this first order of the agenda can be achieved, it would constitute an important change in perception and commitment, without which almost all other actions are likely to be futile. Nevertheless, it would be pollyanish to assume that changes in factor prices are a magic wand whose movement will immediately lead to a maximum adjustment in factor proportions.

Even without technical aid or extension services, the labor intensity of aggregate output should increase as the result of the expansion of the quantitative importance of small firms and adjustments by larger ones. Both sectors, though, would almost certainly benefit from a variety of technical advice which would increase familiarity with efficient, but older, equipment and peripheral processes, such as material movement. The particular form which such

aid should take has not been specified, though the individuals who should provide it are identified as those who have had production experience in particular industries before some of the recent mechanization. These advisers could be organized by AID or international organizations; they might be resident in a country for a year or visit for shorter periods; they would be expert in well specified production processes such as meat packing rather than "food processing" generalists; they would thus be older businessmen rather than academics, production managers or supervisors rather than staff engineers.

Such technical advice should strengthen the adjustment in factor proportions to changes in factor prices, providing yet more concrete evidence to governments of the beneficial effects of the latter. But, it must be noted that without a change in the set of economic incentives faced by business, there is little reason to believe that technical advice by itself will lead to substantial changes in the labor intensity of production.

The entire discussion of this paper has been in terms of the options open to affect the development of the manufacturing sector. Although in many LDCs manufacturing employment is a relatively small part of total employment, it is nonetheless true that an increase of 50 percent in the number

of satisfactory jobs provided by this sector could make a substantial dent in the number of poor currently engaged in informal urban activities.

The potential for labor intensive development in other sectors can also be shown to exist. The import of most analyses of the green revolution is the potential labor intensiveness of the new technology, a potential often not realized because of distorted price structures, particularly the subsidization of modern farm equipment such as tractors.[1] The correction of distorted factor prices would thus result in greater numbers of agricultural jobs, reducing the absorptive burden of the industrial sector.

A number of studies are beginning to appear about the possibilities of substituting labor for capital in construction activities such as roads and housing.[2] These analyses confirm the possibility of limiting the use of equipment in some, though not all, phases of construction

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[1] For a good review of the issues see Johnston and Kilby. Agriculture and Structural Transformation, op. cit.

[2] Examples are George Irwin, Roads and Redistribution (Geneva, ILO, 1975) and a forthcoming ILO study on alternate techniques available in home construction, by W. Paul Strassman. A number of IBRD studies are also in process.

projects. While here, too, factor prices faced by private contractors and/or government agencies will be of importance, other obstacles such as the organization of huge numbers of workers, difficulties with the seasonal supply of workers, and so on will be considerably more important than in the manufacturing sector; thus, organizational improvement would probably require more emphasis than in the manufacturing sector.

The priorities outlined imply substantial scope for AID: arranging for advisers who can persuade LDC governments of the need for change; providing these advisers with a detailed information system about available production options (including peripheral operations as well as core equipment); and providing advice on techniques for altering factor prices including the use of variations in profit tax rates to induce a search for appropriate equipment. Provision of technical production advice will also require substantial AID efforts in identifying individuals who are not among the traditional purveyors of development wisdom. Intensive search within the business community will thus be necessary.

These activities, carefully implemented for (initially) a limited number of countries should be instrumental in augmenting the number of employment opportunities which allow higher incomes than those earned by the poorest segments of the non-rural population.

APPENDIX E

APPROPRIATE INSTITUTIONS FOR APPROPRIATE TECHNOLOGY: A FRAMEWORK FOR ANALYSIS AND GUIDELINES FOR AID ROLES

(By Dr. Bruce Koppel and Dr. Gary Hansen, East-West Technology and Development Institute, Honolulu, Hawaii, April 1946)

INTRODUCTION

What is appropriate technology? From some points of view it describes a category of particularly adaptive and ingenious technical choices that have been an attribute of rural areas and poorer countries for several decades. The current appropriate technology movement from this perspective is an attempt to acknowledge and encourage this sort of creativity and, through various approaches to exchanging information, an attempt to proliferate recognition that there is an alternative. Another perspective on appropriate technologies is that it represents a viable path to economic growth that it is especially suited to the resource limitations and endowments of poorer areas and offers an alternative to the unsatisfactory transfer of advanced technologies; and reliance on the trickling down of the benefits of advanced technology utilization to less advantaged sectors. The current appropriate technology movement from this vantage is an attempt to legitimize and elaborate the option, to incorporate it into the profiles of national planning, and, through various approaches to generating and diffusing "appropriate technologies," an effort to reduce unbalanced economic growth, and increase employment in areas with chronic shortages of resources necessary for more rapid growth under other alternatives.

This paper will argue that a distinction can be drawn among appropriate technologies that crosses between these two perspectives and which may provide a more useful basis for thinking in practical terms about the roles of appropriate technologies in social and economic change. It will then be argued that the basic problem for research and extension is to actively incorporate into planning a more complete

specification of the diffusion profile of anticipated and desired users. Processes to implement that inclusion are discussed and roles for effective allocation of AID resources identified.

Two types of appropriate technologies can be defined in relation to the problems uniquely addressed and the objectives and means characteristically offered. The two types are: product design and production technology.

The major problem addressed by product design appropriate technologies is the lack of access by low and moderate income producers and those in certain production (e.g., rice), service, or infrastructure (energy) functions to capital choices which can enhance output and return. In developing solutions to the problem of access sets of private and social objectives have been specified as objectives. The private goods to be maximized are increases in output and improvements to returns to labor. The social goods to be maximized are increases in output and conservation of critically short or maldistributed resources (cash, access to credit, fuel). Since the principal resource constraint is capital, --ranging from farmers lacking cash or credit to purchase equipment to the high foreign exchange costs of importing equipment, the preferred means to realize the objectives noted above is to substitute a smaller, simpler, more economical technology for high-cost capital.

The major problem addressed by production technology alternative technologies is the scarcity of perceived viable alternatives to capital expansion paths; paths which are typically labor displacing and

characterized by high per-worker and per-workplace investment. In developing solutions to the problem of marginally viable alternatives, the basic private goods to be maximized are increased or maintained output levels, returns to investment and market position. The principal social goods to be maximized are increased or maintained output and product quality and increased employment. The principal resource constraint is uncertainty about firm expansion paths which are not capital intensive. Uncertainty and risk can be attributed to several factors, including the desmonstration effects of comparable product output in industrialized societies, but a more basic set of factors is the perceived inconsistency between non-capital intensive paths and attempts to increase standardization, to enhance the predictability in estimating required inputs and attainable outputs, and to break critical input and output bottlenecks. In developing appropriate technology solutions to the problem of the uncertainty of alternatives to capital-intensive expansion, the preferred means is to reduce the uncertainty by substituting effective combinations of labor and capital to capital alone.

The next two sections will discuss the major "costs" which are typically confronted in evaluating alternative means within each of these two types of appropriate technologies, the major routes developed for trade-offs between objectives and costs, the problems of defining and locating appropriate target groups, and the principal derived or second generation problems of appropriate technology utilization. An outline of the argument for each type of appropriate technology is presented and then illustrated through discussion of problems of

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agricultural development and rural industrialization. In Section III, the discussion is focused on the problem of identifying R and D functions. In Section IV, a set of roles for AID are identified which address both short and long run objectives concentrated on enhancing R and D effectiveness and appropriateness.

SECTION I: AN OUTLINE OF THE ARGUMENT

	Product Design	Production Technology
1. What are the major "costs" which are typically confronted in evaluating alternative means?	1. Labor may be displaced. 2. The skills and/or infrastructure required to effectively utilize the product may not be present or may be distributed in a fashion that is inconsistent with the group initially identified as lacking access.	1. Dislocations in work organization. These can arise from new demands on supervision, planning task organization, group rather than individual skills, etc. 2. Inefficiency, that is, maintenance or deterioration of quality control, standardization, and overall competitiveness. This will be particularly problematical in dual economies and/or economies just beginning import substitution emphases in the products and markets involved. 3. Increased administrative costs associated with recruitment and training and coping with the possibly increased likelihood of work interruptions.
— What are the major routes for trade-offs between objectives and costs?	1. Specification of "acceptable" levels of labor displacement. 2. Specification of "acceptable" distortions in product diffusion. 3. Clearer link between the skills required and the labor markets that are to be reached.	1. Specification of "acceptable" levels of dislocation, inefficiency, and increased administrative costs. 2. Provision of alternative forms of labor subsidization and compensation. 3. Rationalization of industry involved to improve competitive position through product differentiation and sub-contracting.

	Product Design	Production Technology
	4. Provision of alternative employment opportunities. This route assumes that the costs have a spatial dimension which amounts to encouraging migration and/or invites providing new forms of employment at the origin or the destination.	4. Provision of various input and marketing facilities to reduce uncertainties and costs. This can proceed on a national basis through various forms of regulation, etc. or it can proceed on a local or regional basis through development of appropriate infrastructure.
	5. Provision of delivery and support structures which enhance the probability of effective diffusion and back up subsequent utilization. This ranges from direct concern with marketing to the organization of information services.	
2. The Diffusion Profile A. How is the "target" group identified?		
--Industry	1. Primarily in terms of output bottlenecks in activities already characterized by high labor input and/or low possibilities for additional labor input without reducing marginal return.	1. Primarily in terms of labor substitution possibilities (without output or return reduction).
--Size	1. The major criterion is access, low or non-access can be measured through cash income, but it can also be measured in terms of relationship to	1. Small and medium firms, usually defined in terms of number of actual workers, amount of investment, and with judged potential for expansion given market structure.

	Product Design	Production Technology
	existing formal and non-formal money markets given the cost of available technologies.	
—Location	1. The usual assumption is that end-users in addition to lacking sufficient resources to acquire existing technologies, do not even have real access to those technologies. This suggests that end-users will be found in concentrations. For rural industrialization or agricultural development, this means weakly developed or non-existent intermediate towns and market systems. The emphasis is therefore on the spatial aggregation of potential users.	1. The usual assumption is that firms will or do have access to markets, —for new labor, for supplies and outputs. When tied to rural industrial ization, emphasis will be placed on market centers and firms located there The emphasis is therefore on assumed or required linkages.
—Special Group Characteristics	1. Most work has been in agriculture. Special attention is usually given to particular crops and/or particular tenure classes.	1. The focus of efforts is often on firms which have indigenous entrepreneurs. 2. Specific programs may be directed not at the firms directly but at particular groups of unemployed whose skills background, etc., are to be maximized.
B. How are "target" groups reached?		
—Organization	1. The Private Sector. Fabricators in the private sector often will do product production and will be involved in marketing.	1. Industrial extension, —usually tied to a managementand/or engineering capability.

	Product Design	Production Technology
	2. Marketing and production are often integral components of broader policies directed at the increase in production of some commodity. This can vary from subsidies to producers of the technology to subsidies to end-users to purchase the technology.	2. The Private Sector. This is less common, but private consultancies may play the same function. 3. Indirectly, through subsidy or compensation policies which alter incentive strategies for some "typical" target firm to move to labor-intensive expansion.
—"Style"	1. Extension work is generally couched in terms of recommendations. This results from two basic factors. First, products are designed for some typical commodity production function. They are increments to existing functions and as such, there is much less concern for particular adaptive stresses. Second, the assumption is that large numbers of end-users face virtually identical problems. Face-to-face meeting with each user is often not possible.	1. Extension work is generally diagnostic. This results from what is ultimately a firm by firm form of analysis, although referenced to industry production-functions and labor substitutabilities. Dualism and work organization characteristics require sometimes extensive modification of industry elasticities to each case. Appropriate Technology as reconfiguration yields firm-focused analysis.
C. What are the major problems which typically characterize efforts to reach "target" groups.	1. Inability to deal with all users often leads to focus on certain users; --but these may not be the target group. This problem is derived from emphasis on number of adopters.	1. Location of optimal farms can be expensive and uncertain. Reliance on existing sources of information (tax records, etc.) may exclude the very firms that are the target. A related problem is the inability in many cases to know whether the sample chosen is even representative of the target population.

	Product Design	Production Technology
	2. Some product design appropriate technologies require utilization patterns that differ from current production patterns. In agriculture, the typical example is a pump which requires a number of farmers to coordinate activities that were formerly conducted with significantly less coordination.	2. The emphasis on management and engigineering inputs may underestimate work organization related problems, --particularly quality control and standardization.
	3. Provision of follow-up in terms of materials (spare parts, service) and information is more difficult to institutionalize, particularly for low access groups.	3. Evaluation in terms of increased employment may skew firm selection to already expanding firms or lead to labor addition with very low marginal productivity.
D. What are the major routes to reduce problems in reaching "target" groups.	1. Organization of user cooperatives.	1. Designation of particular market centers or urban areas in addition to industry or size designations can provide more manageable parameters for firm selection.
	2. Assignment of diffusion functions to local-level planning on governmental institutions.	2. Organization of extension to reach marginal firms. This can vary from preliminary organization of firm associations to utilizing marketing structure as an entry point.
	3. More active utilization of existing private sector capabilities either through subsidies, etc. to local agribusiness sector and/or subsidies to users to create a more effective demand for complementary private investment in agribusiness.	

3. What are the principal derived or second generation problems of appropriate technology utilization.

Product Design

1. Intermediate technologies may be a link to a next level of capital choices. This will be true for end-users but more significantly for the agri-business and relevant private sectors for which more capital choices is their logical market expansion and for policies which encouraged by any successes may look for further capital possibilities. All of this can have serious employment and migration consequences.

2. Product design appropriate technologies may increase dependence on external markets for parts, servicing, etc., that may inject a major element of uncertainty.

3. For the types of economic activities typically covered by product design appropriate technologies, capital choices may represent irreversible alterations in production functions.

4. The relationship of particular technologies to established social patterns in which the activity is embedded may not become clear until after technology adaptation. This

Production Technology

1. Certain types of appropriate technologies, e.g., second-hand equipment, may only be short-run solutions to employment and expansion problems and they place firm in position of dealing with new and more difficult problems of equipment maintenance and repair.

2. Appropriate-technology capital-labor configurations may not be effective options for small and medium firm survivability in dual and import-substitution economies.

3. Increased employment may require control and coordinating functions that place significant stress on organizational operation. Task decomposition for example as part of a capital stretching strategy can lead to the necessity of compensatory incentives for old labor used to broader autonomy and complex management and planning functions to reduce the uncertainties of absorbing and coordinating new labor and new tasks.

4. The relationship between socio-technical systems within the firm, the emergent social properties of the firm within the community and assessments of labor substitutability often do not get recognition until stress has been placed on existing firm and firm-community organization.

Product Design

can take the form of dislocations in patterns of goal-setting, cooperation, labor recruitment, etc., and/or in recognition of patterns which are more or less critical for the effective utilization of technologies.

Production Technology

5. The reliance of particular labor expansion paths on local and regional infrastructure, --particularly labor markets, --and the fragility of those markets given broader changes in labor incentives. This is part of the larger problem of the assumptions about labor and output markets that often characterize production technology appropriate technology work. An example is the experience which has accompanied workplace dispersion approaches. Both markets and labor projections prove unreliable.

SECTION IIA: PRODUCT DESIGN

For low-income farmers, increases in output and/or improved returns to investment can be attained through a wide range of alterations in the role of technology in agricultural production functions. Mechanical seeders, dryers, threshers, tillers, pumps, and milling devices are only a few examples of equipment which, if properly introduced and utilized, can yield substantial income gains for the agricultural producer. It is frequently the case however that these items and other forms of agricultural equipment are available on the market at a price which exceeds the purchasing power of low-income groups and at a scale inappropriate for smaller parcels. Broader accessibility to these capital goods can only be achieved by reducing the cost of the equipment and/or enhancing the purchasing power of the end user. Equipment redesign frequently exists as a cost reducing alternative. Many agricultural devices are frequently imported and incorporate overly elaborate design characteristics. In-country modification of imported equipment or development of new models can yield substantive cost reductions through the application of simplified design requirements, the utilization of local materials, and/or the employment of low-wage labor in small-scale fabrication firms. Such cost reducing modifications can also yield significant savings of foreign exchange through decreased dependency on equipment imports.

While a wide range of product design are available to improve small farmer incomes, the question of "appropriateness" must be comprehended within a larger social context. In more conventional terms, the appropriateness of any one particular technology choice must include

some assessment of externalities or social opportunity costs (i.e., what may be good for the small farmer may or may not be consistent with the larger public good). Some candidate technologies may yield substantial gains without any significant concomitant social costs but the more common example is less benign. For example, the introduction of more efficient milling equipment may yield higher levels of rice output but at the same time exact a heavy price in the corresponding displacement of traditional methods of handpounding, a highly labor intensive operation. The result in social terms can be a sizeable loss of employment and income for the rural labor force.

The problem of assessing the appropriateness of a particular technology suggests that a range of trade offs are available to the decision maker in coping with the task of minimizing opportunity costs and that certain compensatory actions (public works projects, resettlement programs, etc.) to offset the costs in loss of income for displaced labor may be required.

The above example suggests that anticipating and calculating social repercussions of any technological change constitutes an integral component of any evaluation process to assess whether a particular product design is appropriate or inappropriate.

Another major component is the likelihood that the product will reach the desired target group. For example, even if measures are taken to reduce the cost of equipment, market outlets may be so distantly located as to prohibit the small and low-income farmers from getting real access to these products. In addition, market outlets may be unavailable for absorbing the expected production increased arising from the use of new equipment.

In brief, the choice of any particular product design will likely necessitate additional assessments of certain policy and organizational measures to assure that target groups are able to benefit from the proposed technical change. In many cases the process of assessment should illuminate significant relationships between the problem of product design and the kinds of institutional capabilities available for undertaking the tasks of securing its diffusion and adoption within a particular clientele group. Thus, proposed designs which contain moveable parts and attendant requirements for high-precision fabrication may entail a reliance upon larger scale manufacturing firms. While these firms, in contrast to smaller metal working industries, are able to produce more sophisticated designs they may not have established market outlets in more remote areas. In addition, these firms may enjoy the status of being shielded from normal competitive pricing by virtue of government allowances which provide assured access to credit and imported raw materials. These advantages may incline firms to price their products beyond the reach of lower income farmers.

In the first line production of a particular design, it may be necessary to overlook the above constraints and engage the services of larger fabricating firms. Larger firms are in a more secure position to invest more resources in distribution and marketing services. While the initial diffusion profile may be skewed in the direction of higher income groups in areas of close proximity to urban centers, the eventual entrance into the market of more competitive and perhaps smaller scale producers may give rise to a somewhat more equitable diffusion profile. These diffusion bottlenecks can also be partially removed by supplementary

policy actions in the provision of subsidies for producers or for the target clientele.

While the pattern of institutional involvement and diffusion profiles may be somewhat constrained when assessing the appropriateness of high precision product designs, the boundaries of choice are somewhat more elastic when considering the manufacture and marketing of less sophisticated designs. In those instances where product design requires less attention to precision and quality control, there is much greater prospect for embedding the proposed technical change within traditional patterns of market and production capabilities. Under these conditions small scale fabrication shops can assume a major role in the production and marketing of a new product design, a feature which likewise assures the provision of locally available back-up repair and maintenance services. The utilization of small firm manufacturing capacities also serves to generate second order employment and income effects in that their production functions are largely characterized by labor intensive methods with material inputs from local sources. While maximizing the role of the small farm sector may yield substantial gains with respect to the wider distribtuion of a new product and the generation of attendant spill over growth in a more decentralized fashion, it also places a heavy burden upon the industrial extension service in their efforts to introduce a new product line among a widely dispersed and extremely diverse array of small fabrication shops. An assessment of alternative policy and organizational measures for product diffusion would therefore entail some weighing of the short- and long-term costs and benefits of engaging the production and marketing capacities of the small firm sector.

In some cases, however, the particular dimensions of a proposed product design will require major organizational and institutional changes in order to secure its acceptance and effective utilization by the target group. This is especially the case in the diffusion of some so-called "indivisible" technologies, where the product design cannot be scaled down into smaller self contained units to meet the needs of individual small farmers. The appropriateness of these innovations, and more particularly their capital expense, can only be justified if the end users are organized to fully utilize the proposed design. The full dimensions of this problem are implied in both the acquisition and utilization of new product designs. Thus, the capital costs of some technical inputs exceeds the purchasing power of the individual farmer, a condition which necessitates a mutual sharing of saving and investment burdens among an aggregated clientele. A similar need for organized responses within the target group would also apply with respect to product utilization. The use of tubewells, tractors and other indivisible technologies may require a considerable degree of regulation and planning in the allocation of their services at peak demand periods, a condition which in turn entails significant modifications and indigenous social innovation in the collective organization and allocation of work patterns within villages.

In summary, the introduction of new product designs characterized by the need for group responses in the diffusion profile may require substantial and sustained extension programs to strengthen or establish new mechanisms of reciprocity and collaborative decision-making within the clientele group. It is often the case, however, that government

extension services and other auxiliary public agencies are unable to provide an adequate level of support for new organizational structures within village communities. New capital equipment consequently remains either under-utilized or falls under the control of groups not identified with the target clientele. Cumulative research on the establishment of agricultural cooperatives designed to assist low-income farmers indicates that in most developing areas control over these organizations and the benefits they provide eventually accrue to the more privileged and higher income groups within the rural sector. In summary, the appropriateness of a particular product design will need to be assessed with respect to the likely capacities for generating sustained organized responses within the target group in order to avoid unacceptable distortions in the diffusion profile.

Calculation of an initial cost-benefit estimate for a particular product design along with an attendant assessment of anticipated bottlenecks and distortions within the diffusion process needs to be supplemented by analysis of likely intended and unintended social and institutional implications of the extensive acceptance of a particular technological innovation. On the supply side of the equation, a widespread adoption profile will likely necessitate the increased provision of institutional services (spare parts distributors, maintenance and repair shops, credit facilities, etc.) in sustaining the optimum utilization of a particular product innovation. Likewise, on the demand side, the extensive adoption of a new product design will likely entail major increases in output and a larger marketable surplus. In the case of agricultural commodities characterized by low elasticities of demand,

substantial production increases at the aggregate level will result in price reductions and attendant income losses for small-scale producers. A downward price spiral of this kind would defeat the intent of a technological change designed to assist small farmers and would need to be mitigated by such compensatory actions as the introduction of a price support program, a measure which implies a more encompassing range of institutional services within the rual sector. The problem of initiating compensatory policies becomes even more complicated in the case of small-scale production of export commodities where producers are highly vulnerable to the cyclical fluctuations of supply and demand in world trading patterns.

Anticipating the secondary and tertiary effects of technological change assumes greater significance when seen from the perspective that a proposed product design innovation may foster increased producer dependency upon market services. Since most small farmers are without capital resources as a cushion against temporary vacillations in market performance, any adoption of a new product design which involves less insularity from market forces will pose high levels of uncertainty and risk for the small-scale producer. These vulnerabilities are magnified when new product designs enhance producer specialization in one or two commercial crops at the expense of abandoning traditional and more diversified cropping strategies for home consumption and sale. A temporary price decline under conditions of increased specialization can represent a substantial loss of income for some small producers and an attendant decline in their access to requisite consumption items within the larger market arena. This problem is further compounded if

product designs cannot be re-deployed or substituted for other production functions thereby preventing small farmers from engaging in compensatory actions in the pursuit of more profitable cropping strategies. Likewise, the widespread adoption of certain product designs may constrain a farmer from reverting to former production practices, a condition which would have serious repercussions given a sudden scarcity of complementary production factors or the demise of adequate technical services. Thus, intermittent or prolonged shortages of petrol and/or spare parts may make it prohibitively expensive to sustain the operation of a motorized tilling device but equally expensive and impossible to revert back to animal power, given their past replacement and increasing unavailability as an alternative production input.

Potential stresses and bottlenecks mentioned above increase geometrically under conditions where the successful diffusion and adoption of one product design leads distributors and consumers to seek new avenues of capital substitution and expansion for new or complementary production functions. In these instances, one or several technical innovations may unleash an accelerated pace of technological change which is both unanticipated and undesired when viewed from a larger perspective of the spill over effects and disruptions these engendered in patterns of cooperation, income distribution and labor allocation within village communities. Much of the contemporary literature in rural development is a chronicle of how proffered and well intended technical changes have triggered a chain of social and economic reactions which could neither be constrained by public policy or adequately accommodated within the larger social system. It would seem imperative therefore that the

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proposed diffusion of a new product design would involve both projection of anticipated secondary and tertiary ramifications with respect to the existing social order and an assessment of the prospect of mounting an effective set of policies and administrative instrumentalities in coping with these changes.

SECTION IIB: PRODUCTION TECHNOLOGY

The concern for introducing appropriate changes in production technologies is very much associated with the problem of how to accelerate the transmission of growth opportunities to the rural sector and secondly the need for reducing capital expenditure costs per unit of increased employment. In the first instance, it is frequently the case that industrial growth patterns tend to cluster around larger urban areas where modern production processes characterized by capital intensity and high wage labor assume an important if not dominant role in shaping the larger configurations of investment and employment patterns within the national economy. At the same time, however, a spatial distribution of growth opportunities in favor of larger urban areas creates a corresponding loss of economic momentum in rural areas serving to further exacerbate intersectoral discrepancies in income and employment generation and accelerating the pace of rural to urban migration. One corrective action in overcoming this sectoral dualism and the attendant dysfunctional consequences in welfare and income disparities is to undertake a program of industrial dispersion whereby new production capacities are deliberately distributed and assimilated within the rural sector. The second concern for enhancing labor-capital ratios simply reflects the need for production technologies compatible with labor abundant and capital scarce resource endowments. In this situation, an industrial profile based upon capital intensive production technologies serves to exact a heavy price in social opportunity costs by making a scarce resource less available and underutilizing an abundant resource (labor).

The assessment of appropriate production technologies requires an understanding of the organization of production within identified target firms and the direction in which these production structures can be modified in order to attain both higher output and greater use of labor. A preference for descaling production technologies into smaller units reflects not only an effort to capitalize on the pre-existing pattern of traditional small-scale production units within the rural sector, and the attendant range of resources (capital, labor, and management) at their disposal, but the interest in small production units also reflects a concern to avoid the large resource investments for infrastructure improvement usually required in support of larger production units.

With small and medium firms as the identified target group an assessment is then in order with respect to the range of possible and appropriate changes in production technologies within these structural constraints. An initial analytical component would be the charting of likely expansion paths for smaller firms (market surveys), in order to establish probable opportunities for increased production, and/or improvements in existing product lines, or the adoption of new product lines. Once a new product design has been identified the next analytical phase would be an assessment of the range of alternative production technologies available for utilization in the production process. A final assessment would entail some calculations concerning the capacities of the target firms and society within which they are embedded to absorb and sustain a proposed range of technical innovations. In each step of this analysis, assessments concerning calculations of appropriateness

with respect to expansion paths, alternative production technologies and absorptive capacities, are made from the perspective of the cost and benefits a particular innovation will yield, and the various trade-offs available in optimizing some values without at the same time exceeding certain levels of specified stress or costs with respect to other priority concerns.

In many instances, assessments of expansion paths and the identification of candidate product designs constitute areas of analytic concern which link directly to the problem of selecting appropriate production technologies. Thus, new products containing high precision components and/or the requisite need for standardized parts will in turn most likely necessitate the adoption of production technologies which are relatively rigid in their factor requirements. In these instances the prospects may be somewhat limited with respect to moderating capital costs and expanding the scope for labor substitution. Constraints of this kind assume a more prominent role when new and complex product designs are in competition with products already imported from abroad or under production by capital intensive firms within the indigenous modern sector. Requiring and preserving a market position under these conditions will place great pressure upon small firms in maintaining high levels of quality control and efficiency in order to compete with established trade mark brands.

Assessments concerning the appropriateness of a particular expansion path and the choice of certain production processes require some evaluation of rural sector social structures and their capacity to absorb and sustain a proposed range of modifications in production processes, and similarly

some anticipatory projections of the secondary and tertiary social and economic repercussions likely to be generated by these changes. Studies of small and medium scale firms undergoing transition from simple to more complex production processes indicate that a wide range of problems and obstacles are encountered in adopting new patterns in the organization of work and management practices. It is frequently the case that traditional structures of work and authority are not openly responsive to changes associated with the introduction of more complex production technologies. In trying to anticipate probable sources of elasticity and rigidity in the relationships between technology and work organization and a larger set of cultural and social constraints, the primary assessment task becomes one of measuring the capacity of the target firms and community to support and sustain a proposed range of technology innovations and specifying both the acceptable levels of social stress and/or probable distortions in organization and production performance. Thus, in some instances, certain components of a proposed change in production technology might need to be discarded with perhaps some concomitant marginal declines in quality control and output, a cost judged acceptable however, given the benefits acquired in not having to sustain major remodifications in traditional work patterns. In other instances, certain production processes are likely to be more rigid in their technical and factor requirements, and consequently less amenable to redesign adjustments in achieving greater compatibility with traditional structures of authority and work organization.

Assessment of technology choices needs to include consideration of the probable secondary and tertiary costs involved in the adoption of

new production and organizational processes. In many instances, the requisite demands for social change accompanying the introduction of a new technology may be quite substantial and pose a high level of risk and uncertainty for many of the participants in the target audience. In other cases, new forms of work organization involving more structured and impersonal types of labor-management relations may have their replication and spill over effects in other parts of community life as attendant increases in labor mobility and higher levels of group conflict serve to undermine traditional patterns of affiliation and group solidarity. All of these tensions are magnified when the target groups are subject to the destabilizing influences of producing for high risk markets. Vulnerability to fluctuations in market demand along with likely irregularities in servicing more distant markets (transport bottlenecks, tariff impositions, etc.) can exact a heavy price in communities where traditional and diversified sources of employment and income have largely been supplanted by the performance of small industries dependent upon a wide range of decision-making structures far removed from their control. In these instances, policy and institutional measures designed to sustain and reinforce acceptable measures of community resilience and economic diversity may be in order where the assessment procedure reveals anticipated high levels of dislocation and stress attendant upon the introduction of new work and production processes.

Once the assessment process has encompassed a set of evaluations concerning appropriateness of a projected range of expansion paths, an examination of alternative production technologies, a profile of variations in absorptive capacities, and anticipated social changes associated with

the support of a particular technology innovation, the analysis should move to a concern for problems of diffusing and sustaining the innovations within the target firms and the identification of various institutional measures necessary to adequately perform this support function.

The first task in this exercise entails the identification of the target or candidate firms, a process which includes consideration of such criteria as firm potentials for high levels of labor-substitution with low concomitant expenditures for new capital investment, firm location in proximity to existing infrastructure and market services, and likely firm dispersion in areas of high labor or unemployment densities. Other variables could be added to these calculations and certain assessments would need to be made in terms of the trade-offs associated with alternative strategies for firm selection. It is possible for example that firms with high potentials for labor substitutability would not be located near required infrastructure services, or that firms with adequate market centers would not be located in spatial areas where policy measures intend to provide the major focus of economic assistance. In this latter case, where development targets are defined primarily in terms of spatial dimensions (an impoverished province or district) or group characteristics (low-income labors), it may be that the range and number of existing small and medium scale industries will be quite limited, and that major emphasis will have to be placed upon the development of new firms. In addition to new firm generation, in any of the above cases, compensatory or ancillary measures for such investments as infrastructure improvement or higher levels of expenditures

for capital outlay may have to be accepted as an additional cost factor in the attainment of a desired range of development benefits.

The assessment process for the selection of candidate target firms also needs to include consideration of appropriate assistance programs to introduce and sustain a proposed range of technical changes. Conventional definitions of industrial extension services usually limit the scope of services to engineering and management assistance, and while these capabilities may be adequate in situations where marginal modifications in production processes are in order, where more substantial changes are warranted with respect to firm production processes and workplace organization, a wider range of social science expertise would need to be made available in order to properly assess not only levels of managerial and technical elasticity, but more importantly to anticipate the range and thresholds of stress patterns under conditions of innovative change within the firm structure. The need for these analytical capacities is particularly important when the establishment of new firms requires some familiarity with social and psychological processes tied to the identification and development of new entrepreneurs.

The task of formulating a generalized development strategy for small and medium scale firms is somewhat encumbered by the fact that technical, managerial and organizational problems may vary widely from one firm to another, requiring that extension programs remain relatively responsive to the provision of a wide spectrum of assistance profiles. This flexibility in the diffusion of services is particularly important in cases where knowledge of existing firm structures is relatively limited, and where there is some risk that initial firm samples are not sufficiently

representative of conditions in the field. In these cases, a premature effort to design a generalized assistance program may result in the provision of inappropriate services and the omission of a more pertinent and vitally needed resource package.

The provision of extension services is only effective when complemented by a broader range of policy adjustments. In some instances the provision of subsidies or other compensatory measures would be warranted in order to reduce perceived risks and encourage new entrepreneurial ventures. In other instances, revisions in tariff structures and related tax measures may be necessary to generate appropriate expansion paths among target firms. Major policy reforms in support of small firms are particularly important in dual economies where modern sector industry plays a prominent role in shaping basic patterns of production and consumption within the larger national economy. Without some policy measures designed to reduce the frequently protected and privileged role of firms within the modern industrial sector and attendant actions to provide greater access and incentives to the more traditional small firm sector, the prospects for expanding employment would appear limited.

The assessment of appropriate policy actions and assistance programs in support of small firm expansion also requires some consideration of diffusion mechanisms and more explicitly an evaluation of alternative extension approaches. It is frequently the case that government organized industrial extension services will be used as the primary diffusion agent, with perhaps some participation from private sector consulting firms. Government extension services usually have an already established set of

branch and network offices in the target areas although these structures are frequently understaffed and their personnel poorly trained with respect to administering sophisticated extension programs. Thus, some form of supplementary assistance from either public or private sources is usually required to enhance skill and assessment capacities for the extension function.

Finally, under conditions where the supply of trained extension agents is limited, the problem of working with a large number of dispersed small firms may require some consideration of alternative extension processes in order to achieve a greater focus in the provision of engineering and managerial assistance. The establishment of demonstration plants and training centers, and the organization of target firms into production associations or the creation of other similar institutional arrangements may enable extension agents to more effectively transmit and sustain innovational changes within the recipient firms.

SECTION III: R AND D FUNCTIONS

The principal implication of our discussion for R and D is the complexity but importance of incorporating active concern for anticipated diffusion profiles into the R and D problem identification and project selection processes. Incorporation of anticipated diffusion profiles can be summarized as

1. Anticipating likely stresses that would be generated by particular products or process designs.
2. Making explicit the assumptions which constitute or support expectations of diffusion and "success."
3. Anticipating those stresses and/or altered conditions which can be expected to accompany diffusion or will be required to facilitate diffusion which cannot be adequately confronted through modification of the appropriate technology and which will require therefore
   a. specification of acceptable levels of stress and/or specification of altered conditions which may be less critical;
   b. specification of time or phasing expected;
   c. some attention to forms and costs of supplemental activities.

Incorporating Diffusion Profiles into Product Design R & D

Target groups (usually externally identified) or likely target groups (a specification which can be made internally) need to be analyzed in terms of

a. Hardware and software assumptions. This applies ot only to the end-user but to those support facilities or capacities critical for

equipment maintenance. The major hardware concerns are assumptions about inventories of or access to complementary or compatible equipment. This would range from fuel and other inputs where required to ownership of or access to tools for normal upkeep. Software assumptions can be placed in two groups: intra-process and extra-process. Intra-process software assumptions refer to characteristics of the process only which will be directly affected by the product design:

1. The major intra-process concern is: How interdependent are the various steps in the process affected? Where interdependence is very high, either technologically (output of one stage is input of another and the pace of the second is dependent on the first) or socially (limited labor allocated sequentially), the introduction of any modifications may have effects outside of or broader than might be expected from simple substitution.

2. The major extra-process concerns are: How socially and culturally embedded is the process? How difficult is it to distinguish organization of the process from organization of the extended family, village, etc.? Difficulties in distinctions will lead to problems of extension entry and complicates understanding of production and marketing orientation.

b. Relationships between alternative product designs and the organization and range of production technologies. In point a.,

hardware support assumptions applied to servicing and backup for a product already in the hands of an end-user. In this point, the reference is to the hardware and software assumptions attached to the production of particular product designs. Fabrication assumptions will be derived principally from two common appropriate technology criteria: low cost, maximize utilization of indigenous resources. The IRRI agricultural engineering shop provides an illustration. They have consistently sought to gear their agricultural equipment designs to the production capacities of firms in the countries where diffusion was expected. However, more generally, the specification of fabrication capacity can be done in a manner that spills over to production process appropriate technology (i.e., choose capacities in which fuller utilization will be associated with employment generation) or one that seeks capacities in terms of output scale and marketing attributes (i.e., choose capacities in which fuller utilization may be associated with lower cost). Another factor is the extent to which the relevant industry is location specific, and what the implications of that are for transportation and marketing (in other words, the more relevant question may be marketing rather than production capacities). A major question is whether the production industry is dualistic and if so, whether the distribution of management, and marketing skills may either preclude certain type firms from viable participation or whether participation would have to be subsidized through transfer payments, technical assistance, organization of marketing cooperatives, etc.

c. Assumed inventories of skills. This is true for user and producer. For the user, there is the problem of what skills are required to effectively utilize equipment and what learning costs are implied. This will often not be a source of significant stress and/or nonadoption or nonutilization, but is is important to address the question explicitly since

1. This in many ways is a core attribute of appropriate technologies, i.e., it does not place unusual stress on existing skills.

2. If relearning is required, then attention will need to be given to the organization and costs. Where extension facilities are not available in the private sector (e.g., agribusiness servicing) or public sector (appropriate extension services), then the feasibility of adapting other organizations (e.g., schools in rural areas, nonformal approaches, etc.) will have to be addressed. This point relates back to a.2. If the end-use process is socially and culturally embedded (e.g., organized around religious values and operated as a village activity) then the question of who are the actual users, what are existing mechanisms for skill transference, etc., may have to be understood to assess the feasibility of alternative learning approaches.

d. Estimation of likely process-skewing effects. The end-use process can be skewed or distorted through two broad classes of appropriate technology effects.

1. Reorganization of inputs. For a number of reasons, both economic (product designs which break output bottlenecks and yield greater marginal return to labor may lead to a reallocation of labor inputs) and social (people may want to be associated with a new product, to the extent of reallocating time even if the marginal returns to increased equipment-time are diminishing), the reallocation of labor and time may lead for example to increased specialization, to the subcontracting of formerly performed operations, etc. The question of whether these steps are good or not requires reference to broader questions referenced in point e. below but it is important to anticipate, weigh and assess likely changes.

2. Reorganization of outputs. For reasons similar to those discussed in d.1., equipment which breaks an input bottleneck may lead to specialization of outputs. Product focus will be good or bad, of course, in relation to broader market factors but the point of sections d.1. and d.2. is that skewing may occur and that particularly in somewhat fragile environments, skewing may be irreversible immersion into market viscissitudes that may prove problematical. This is most true for small-scale industrial enterprises but it is potentially true in agriculture as well. A portable dryer can encourage HYV planting and input investment on the assumption the product will be marketable, but it will probably lead to a broad range of labor-substituting input reallocations (technology for labor

e.g. pest and weed management through chemicals rather than hard labor). A hired tractor can facilitate better land preparation but it may encourage reduction of multiple cropping already practiced, and increased dependence on the market for home consumption.

e. Assessment of the durability of the current policy environment and its relationship to user incentives. Assessment of both the existing and prospective policy environments is an important element of any process of target group identification. It relates to the durability of particular problems, bottlenecks, incentives and represents a guage against which to assess not simply user costs (how long will a particular product design pay) but research and development costs (what contribution will a product design make to output, income, etc.). For example, a paddy rice dryer would be considerably less worthwhile if acceptable moisture-content levels were raised, if support rice prices increased enough to make even penalized moist rice a paying proposition. Another example is the current Direct Seeding Program in the Philippines. This is an approach to rice planting which seeks to make maximum use of average rainfall curves by direct seeding a rice crop before or at the start of a rainy season, harvesting in the height of the rainy season, and planting a second transplanted crop for harvest in a relatively dry period. Dryers will be necessary for the first crop. It is easy to imagine a number of plausible scenarios which would make the dryer a poor investment.

1. The investment forces a commitment to a pattern of land utilization that may accelerate nutrient depletion; thus requiring at the least, significant complementary investment in fertilizers.

2. Removal of adequate support levels, giving additional advantage to larger or locationally more well-placed producers, etc.

To illustrate how these types of questions might be incorporated into R & D project selection for product design a form of analysis we will call Likely Stress Points (LSP) will be utilized. This can be seen as a decision-making aide since the problem at base is one of determining needs, assessing possibilities, anticipating costs and stresses, evaluating alternative modifications and complementary activities, and then deciding that a particular design and a particular package of production, marketing, utilization and follow-up assumptions are appropriate. Figure 3-1 is an LSP for Product Design. The columns are defined by a major dimension of product design utilization; --the relation of the product to an existing process. Three types of relationships are noted. Variable means that the content of the function involved and the function as performed with the product is characterized by a broad range of empirical possibilities. This would apply in situations where a variety of outputs were being produced and the function involved (e.g. packaging) varied accordingly. Uniform means that the content of the function does not vary with output. Uniform functions would be found where there was specialization and finer divisions of labor.

FIGURE 3-1

PRODUCT DESIGN LIKELY STRESS POINTS

Product Design Utilization
The relation of the product to existing process:
The function is:
The product's translation of the function will be:

			NOVEL		UNIFORM		VARIABLE	
			IS	WILL BE	IS	WILL BE	IS	WILL BE
Process Social Embeddedness Current embeddedness is: Embeddedness assumed by new product will be:	LOW	IS						
		WILL BE						
	HIGH	IS						
		WILL BE						

Organization of Utilization: Increasing Indivisibilities

Process Transformation: Increasing Production Function Modifications

IN TERMS OF: regional market organization, group identifiability, follow up required and likely, etc.

Novel means that the function is not a well-established part of or well-integrated into the larger production process.

The rows are defined by a second dimension, the social embeddedness of the process. Two types are noted for discussion, low and high. Low embeddedness implies that the organization of the process is distinct from the organization of the community. The social effects problem will tend to be restricted to within firm people. High embeddedness implies that the organization of the process is closely intertwined with that of the community. In this situation, alternatives in process can be quickly translated into broader social change, which may or may not be problematical. The two dimensions form the core relationship. The question then is to assess

1. the implications of changes in one dimension for what may be required of or will be elicited from the other dimension;
2. the linkages between relationship 1. and major diffusion profile factors in terms of degrees of change which might be stress producing; complementarity and process assumptions which may not have been clear, leverage points for introducing and multiplying change or for modulating its intensity, etc.

An Illustration

Tugaya, a small town in the Southern Philippines is the major brassware manufacturing site in the country. The process is very labor intensive and highly embedded--being a community activity in which decison-making, skill transference are closely tied to broader cultural patterns

of leadership and socialization. A major output bottleneck is wastage due to lack of control over temperature in the brass-molding phase of the process. With the extension of electricity to Tugaya, a proposal is being made for several simple electric ovens which could maintain the uniform temperatures needed. The present heating method is variable, that is, it has wide variation in performance to accommodate a broad product mix and because of unpredictable components used in the heating process. The suggested product design would make that function uniform. Individuals are to be trained to operate these ovens and these individuals would be the target of periodic retraining as agents for communication of new brassware ideas.

The shift from variability to uniformity is a case of specialization that, in a highly embedded activity, will make unnecessary skills developed over time to predict and cope with variability. If that coping skill is relatively high in the apprenticeship and cultural scales of the community, what are the possibilities for non-acceptance unless a short-term approach to minimizing this obsolescence is developed? The attempt to select a set of individuals to operate the new ovens and to subsequently utilize them as extension contacts assumes a relatively low degree of embeddedness, i.e., these individuals can operate external relationships without jeopardizing internal ones. But if task roles and skill transference are closely linked to the distribution of authority and prestige, is it feasible to assume that individuals selected externally can function as desired or that individuals selected internally will be chosen on the basis of relevant criteria? A compromise is to expand the training to operate through the apprenticeship hierarchy; and to devote

additional emphasis to a variability area that has not been well developed: marketing.

This is a simple example, but it serves two purposes. First, it suggests the sequence of questions that need to be asked and relates those to a core relationship--in this instance the effect of a change in the relationship on certain other factors. Second, it provides further evidence of the multidisciplinary character of the appropriate technology problem.

Incorporating Diffusion Profiles into R & D for Production Process

Incorporation of a diffusion profile in this category of appropriate technology R and D is characterized by many of the same questions which pertained to product design--particularly a,c,d,e, and f. However, there are additional questions which derive from the direct reorganizing thrusts of appropriate technology for production process and from the predominant thrust to generate employment without losing market position; a different trade-off than that faced by appropriate technology for product design (increasing output capacity without incurring high fixed costs). Three major additional questions need to be addressed:

1. What are the optimal possibilities for labor expansion in sociotechnical terms? Economic analyses of the possibilities for labor substitution are couched in a form of analysis that is basically output-(and hence, returns) related. But the capital-labor substitutability research and the microeconomic recommendations which come from it need to be enriched through integration with sociotechnical "tracer" analysis. The latter examines the social

organization of particular technical processes with special emphasis on the interrelationship of production indivisibilities and interdependencies with control and management attributes. The combination of C/L analysis and tracer analysis would offer considerable potential for assessing the management feasibilities of alternative C/L paths and it would provide insight on the process distortions which may result from labor-capital substitutions at particular points. For example, C/L analysis which suggests that some capital stretching strategy such as shifts would expand employment, need to be assessed in terms of the coordinative requirements demanded by shift labor.

2. What are the interrelationships between firm and community, --particularly in terms of labor pools, labor recruitment, and skill transference? Expanded demand, particularly for any special set of skills can place stress on existing firm-community linkages. the feasibility and costs of going beyond existing labor markets can be very high--in economic terms (cost of developing new recruitment mechanisms), in technical terms (the problem of finding or developing skills required and the intermediate costs in terms of output quality, market deadlines, etc.) and in social terms (in terms of residential and occupational migrants as outsiders and the broader alienation costs vis-a-vis the community).

3. What are the interrelationships between the possibilities and problems in altering production processes and characteristics of the industry and region. The linkage to industry has been widely recognized and while in policy terms small or medium enterprises may be the focus of appropriate technologies, in more operational

terms, the question reduces to small or medium firms in industries presumed to have special labor elasticities and growth possibilities. The significance of dualism, a structural feature of many industries in developing countries, usually requires interpretation in light of the production functions which characterize a particular industry.

The role of regional structure has been recognized much less often, even though one of the more popular books in the appropriate technology field, Schumacher's Small is Beautiful devotes considerable attention to it. The viability of existing workplaces and the possibility for their expansion or dispersion can be related to several dimensions of regional organization:

a. The distribution of intermediate market centers. This factor is particularly true in rural areas. It suggests that for both efficient collection of inputs and viable marketing of outputs, growth possibilities will require certain minimal externalities and that externalities tend to be found in the collection of functions present in intermediate centers.

b. The linkages between regional settlements. Settlement size, in terms of functional diversity and for some products, in terms of market size, is only one dimension. A related but distinct dimension is the set of linkages which tie settlements into systems. These systems can be arrayed hierarchically as functional diversity is related to linkage diversity. The idealized pattern has been a neat ordering of overlapping service areas. But in most areas of the third world, this pattern is not found. Instead patterns which

reflect administrative and colonial demands are found and these place several stresses on the range of choices present in designating certain industries and classes of firms within those industries as suitable growth prospects through appropriate technology. Three patterns can be identified which yield special stresses.

1. The Primate City. The concentration of a nation's industrial, service and financial resources in a single major urban center is perhaps the most common and most serious problem pattern. While externalities are certainly present, they take the form of critical diseconomies. First of all, there may be too small a market to support the large number of sellers. Second, the possibilities for individual firm expansion through more labor-intensive production must be weighed against the social costs of strengthening any "pull" factors for rural-urban migration. Third, as the term primate implies, urban infrastructure may be so weakly developed outside the major center that the costs of reaching that market do not provide an effective alternative to the primate city domestic market, --a factor that strengthens primacy and leads to distortions in economic growth strategies as recent ILO missions have indicated.

2. The Extractive City. For many developing societies, the principal mechanism for participation in international trade is the export of unprocessed or partly processed local natural resources. The settlement pattern that typically accompanies this is one characterized by a port city connected to dispersed

smaller settlements. The system is organized to facilitate movement out rather than between and it is this factor which places limits on growth possibilities. The effective market for any of the dispersed collection points will be quite small. The port town will have limited production externalities, principally because it is mainly a transfer point. Most goods are imported and most functions will be service oriented. The real economic base of such a region is highly delicate. A crop disease, a fall in world prices, demand for the crop, a rise in shipping costs, --any of these factors can virtually put the region "out of business."

3. The Administrative Town. This is a pattern which makes sense as an approach to revenue collection, maintaining peace and order and other administrative objectives. Centers are developed to transmit higher level desires down and taxes up. They do not have significant local or indigenous functions and thus are not able to serve as effective catalyzers of economic relationships. While that does not preclude such relationships from developing, it can make the growth possibilities very limited by making access to distantly located administrative resources a critical necessity. For example, if credit allocation decisions and policies are made in Bangkok, what are the implications for small enterprise entrepreneurs in the Northeast who seek assistance in developing markets and hiring more people.

A significant dimension of these three patterns is that they all tend to deflect extension attention away from rural areas and from non-administrative

centers. Much of the recent discussion on labor migration (Todaro), for example, suggests that the probability of finding employment in an urban center relative to an origin area is a major factor in migration decisions. If that is so, then it follows from the high unemployment characteristic of cities that the major long-term growth possibilities and short-term need are outside the big city, the extractive port, and the administrative center. But, the patterns described briefly require that careful assessment be made of the assumptions defining target group selection in terms of short and long run costs, competition and complementary investments needed.

Figure 3-2 is a Likely Stress Points (LSP) diagram for incorporating diffusion profile concerns into Production Process R and D. The columns are defined in terms of the degree to which production must yield standardized output (borrowed from Woodward). Unit production will be outputs that are made to specification, made to order. The variability and often low volume for any single order, makes even simple forms of capital stretching, i.e., jigs and fixtures, uneconomical. Batch production is also production to varied specification, but the volume is sufficient to permit, to differing degrees, the devotion of certain equipment to the same function for long enough periods and large enough outputs to provide opportunities for a variety of capital stretching and labor absorbing strategies (jigs and fixtures, shifts). Continuous production in addition to representing continual production of the same outputs, --thus encouraging significant capital investments,-- is also characterized by a concomitant development: a high level of task decomposition for the application of capital investment that significantly increases the complexity

FIGURE 3-2

PRODUCTION TECHNOLOGY LIKELY STRESS POINTS

Process Interdependence
The Mode of Production:
Current Mode of Production is:
The Mode of Production will be:

Workplace Organization: Control System		CONTINUOUS IS	CONTINUOUS WILL BE	BATCH IS	BATCH WILL BE	UNIT IS	UNIT WILL BE
Current control system is:	PERSONALISTIC IS						
Control system assumed by new process will be:	PERSONALISTIC WILL BE						
	MECHANICAL IS						
	MECHANICAL WILL BE						

Organization of Inputs: Increasing Specialization

Product Output: Increasing Standardization

IN TERMS OF: infrastructure assumptions and requirements, labor markets, degree and importance of dualistic industry structure, etc.

and interdependence attributes of the process. The rows are defined by the control systems characteristic of work places. Two types are noted. Personalistic control is a highly flexible form of control, adapted to varied outputs and to supervising not simply job performance, but skill transference. While such control systems may be highly centralized or decentralized, effective control tends to be fragmented across actual work-groups. It is the work-groups which allocate labor and define the overall task sequencing. Mechanical control is a form of control best suited to coordinate complex and highly specialized inputs into optimal patterns for output production. Control cannot be fragmented because particular stages are dependent on other stages.

These two dimensions form the core sociotechnical system relationship. The LSP proceeds through analysis of that system and its interrelationships to the diffusion profile factors discussed earlier.

An Illustration

The construction of wooden ships in eastern Indonesia is a process that has gone on unchanged for many generations. A group of artisans. organized in relation to a 20 year apprenticeship, contract themselves to an entrepreneur who has found a buyer and the raw materials. It is a system in which seasonal unemployment is high and in which supply lags behind demand; --the latter condition weakening the wood shipbuilding industry as a whole. The system is a unit process with highly personalistic control.

With expansion of demand for sailing ships and with the possibility for motorizing the ships to give them supplemental power, there are growth

possibilities that are constrained by two factors: 1) the present contracting system which leaves workers unemployed and 2) the skill transference process which is premised on the construction of one boat design only. To confront these problems, i.e., to meet demand and increase employment, the following proposals have been made:

1. Create a "shipyard" to which buyers would come rather than the complex system which currently links buyers and entrepreneurs.
2. Convert the organization of production from apprentice-focused work group--each capable of building a boat--to specialization focused work groups, --each capable of producing a particular boat part. Instead of the same group producing a boat from log to finished product, each boat would be worked on by different groups at different times. Specialization, in turn, would facilitate the introduction of appropriate technologies for wood curing, more precision in cutting, etc.
3. The control function would shift from apprentice-based to coordination derived from plans. The plans would represent the range of "models" possible with the components available.

These changes represent a number of assumptions about factors which would not be stress-producing; --assumptions which would need testing:

1. The creation of a stationary labor force will not displace the current mobile labor force.
2. The reduced need for long apprenticeship will not displace the current highly skilled labor force.

3. The increase in specialization will not stretch existing managerial capabilities and will not suffer from the absence of a process to replace existing master craftsmen.

4. The assumed expanding market will not be saturated or reduced by competition with other forms of ships and thus replace seasonal unemployment with no employment.

These assumptions do not include the problems of introducing change to begin with. The recommendation is to work through the entrepreneurs. However, since the entrepreneurs have only an indirect connection with actual production, that recommendation amounts to an usurpation of craftsmen functions by entrepreneurs or the training of new people entirely.

The reorganization is justified in order to meet a demand for a flexible product, to support an expanded demand for ships, and to facilitate the introduction of managerial process adjustments to improve product equality and precision and the addition of a motor to ship design. A number of trade off strategies could be explored to reduce the potential social dislocations and, it might be added, the unpredictable direction of change in ship quality and competitiveness.

1. A configuration for the addition of engine power could be explored which had narrower ramifications on overall ship design and construction.

2. A shipyard could be formed without sacrificing the existing work-group organization. The grounds for this tradeoff would be to alter labor recruitment rather than skill acquisition processes, limiting specialization to <u>new</u> functions (motor installation), and

seeking to incorporate improvements of existing functions into existing work organization (wood curing, rib measuring, etc.).

3. To prepare for a time when specialization would be unavoidable, a consolidated shipyard might be encouraged to take on other construction-related jobs.

R and D Functions Summarized

What should be clear by this time is that the problem of appropriate technology is highly multidisciplinary. The relative importance of particular questions will vary from case to case, but because we do not believe that it is possible to develop a small fixed set of questions to fit all situations, we conclude that a large number of questions must be held in readiness. The decision which questions to ask is the critical R and D function and while as will be explored below there are orgaizational answers to structuring proper question raising, there is no substitute for what those organizational alternatives seek to accomplish: the presence of a variety of viewpoints focused on defining and dealing with a particular problem.

There are three additional factors. First, R and D must be sensitized by an active link to relevant policy agencies and processes. In a policy environment unfavorable to subsidizing labor expansion, certain target groups may simply not be reached through technological inputs alone. In a policy environment encouraging survival of small-scale enterprises or rural industrialization, the feasibility of certain product design and production process appropriate technologies increases dramatically. Second, R and D must be sensitized by an active link to varying elements in the

relevant private sector. This is a delicate matter because in welfare terms, some elements may lose through broader industry reorganizations implied by some appropriate technologies, but it is also the case that in most situations the target group itself, if not the success of the target group, will come to rest on the private sector. Third, R and D needs exposure to unmediated feedback on its problem perceptions and alternative solutions and that implies some type of extension function.

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SECTION IV: A ROLE FOR AID

AID can move in either or both of two broad directions. First, an emphasis can be placed on the short-run goals of enhancing the capabilities of indigenous institutions to work on appropriate technologies. Second, an emphasis can be placed on developing a multidisciplinary capacity independent of or in conjunction with the assets and liabilities of particular institutions.

The Short-Run: Enhancing Institutional Capabilities

Two approaches can be identified at the outset:

1. Arrangements can be developed to facilitate the distribution of goods produced in the U.S. This may have the advantage of leapfrogging certain R and D time, but it may necessitate even more R and D time to deal with the inappropriateness of such technologies.

2. An alternative would be encourage the development of adaptive research capabilities to reduce the inappropriateness of imported technologies. If that goal is complemented by some interest in developing or enhancing an indigenous capability to do adaptive research, various forms of technical assistance can be productive (e.g., Georgia Tech SSI work). This approach has a broad constituency in developing countries and capacities for adaptive research already exist or are being developed in a number of places. A variant of this approach that has considerable potential is the development of intermediate technology information networks, linking research institutes, universities and in some instance the private sectors in several countries (e.g. Technonet).

Given our own argument, alternative 1. would rarely seem appropriate unless the technologies were selected by and were the result of a thorough process of feasibility and assessment research. Alternative 2. is a reasonable strategy provided that its' most severe limitation can be overcome. It does not lend itself to the development of sustainable capabilities. This is because the needs for recognition of the benefits of this style of indigenous problem solving may not be well developed given the demonstration effect of used or obsolete Western technologies and because the resources typically provided by external assistance for institutional or program start-up are not complemented by local contributions and goal-setting early enough to enhance possibilities for local assumption of comparable responsibilites upon the termination of assistance. The latter point is quite complex because the performance criteria often used by external assistance organizations place greater emphasis on immediate input-output accounting and less on growing local capabilities which may not be reflected in immediate or high level output accomplishments.

However, alternative 2. can be improved by raising the questions: What are the advantages and diadvantages of varying types of institutions and what are their major needs to make them appropriate institutions? Table 4-1 suggests in outline form an answer to these two questions. There are two ways to summarize this table. The first is a distinction between diversifying the capabilities of institutions already working on appropriate technology questions and diversifying the functions of institutions with capabilities that fit appropriate technology questions but not currently being applied in that manner. Universities and private

TABLE 4-1

INSTITUTIONAL BALANCE SHEET

TYPE OF INSTITUTION	ASSETS	LIABILITIES	NEEDED TO BECOME AN APPROPRIATE INSTITUTION FOR APPROPRIATE TECHNOLOGY
Universities	Possess diverse resources; not accountable in narrow economic terms alone; Broad range of research is legitimate.	Relevance in terms of problem-oriented, action-research often not well established; resources may not permit an action focus; many competing demands for limited resources; better Universities usually concentrated in urban areas; organizational innovation very difficult.	Better links to policy and private sectors, development of internal evaluation criteria which support action research; access to broader resources.
Research Institutes	Possibility of specialization and well defined problem focus.	Often have little connection with application or utilization of research output; specialized focus may be too narrow; difficulties in surviving success, that is, knowing the limits of particular approaches.	Better links to extension and utilization evaluation; problem oriented rather than discipline oriented internal organization.
Extension Agencies	Often quite sensitized actual problems, needs and possibilities	Absence of R and D capability often results in misapplication or overuse of particular materials; internal performance criteria tend to reward performance in less complex situations	More direct and continuing links to R and D capabilitie revised performance criteria

TABLE 4-1 (continued)

INSTITUTIONAL BALANCE SHEET

TYPE OF INSTITUTION	ASSETS	LIABILITIES	NEEDED TO BECOME AN APPROPRIATE INSTITUTION FOR APPROPRIATE TECHNOLOGY
Management Institutes	Focus on decision-making and risk is highly relevant; substantial continuity and coherence in programs.	Work is often characterized by no critical evidence for appropriateness of particular approaches and assumptions; non-performance typically blamed on 'culture'; scope of what can be managed often overestimated; decision-making for appropriate technologies not well-developed; more marginal and embedded economic activities typically ignored.	Needs to be supplemented by alternative viewpoints; requires link to research and extension capabilities which deal constructively with inappropriate assumptions
Private Industry	Possibility of mobilizing resources often very high; many 'networks' for implementation already in place; economic considerations ensure a form of assumption testing.	Profit motivation may not address basic appropriate technology questions adequately; private industry operations complicated by dualism.	Needs links to public sector institutions to ensure public good and welfare objectives are being addressed.

industry in developing countries may be examples of the second. Research Institutes, Extension Agencies and Management Institutes may be illustrations of the first. A second form of summarization is to draw a distinction between effective approaches to a particular problem and developing capacities to engage a broad range of problems. Universities, extension agencies and private industry probably have the best potential for the second; research institutions and management institutions problably have the best potential for the first.

With these questions and distinctions in mind, a more effective allocation of technical assistance and other AID inputs becomes discernable. The category "Other AID Inputs" can be summarized as efforts to link existing capabilities in common efforts. This could involve programs ranging from support for the establishment of consortia (a relatively loose confederation of diverse institutions to work on a broad range of problems related to appropriate technologies) and task forces (the organization of several institutions into functional groups, with each group tackling a major component of the same appropriate technology problem) under the aegis of some key institutions to the consolidation of existing capabilities into some new institution. The major challenge for activities in the institution-building approach is to enhance indigenous problem-solving capabilities and to sustain those capabilities once developed. This may require the incorporation of representatives of common target groups into R and D planning, a step that will invite the kind of accountability necessary to ensure institutions stay on their toes. A major challenge for AID will be to avoid accountability for itself strictly in terms of the distribution of intermediate

technology hardware or even the creation of jobs through such hardware, but rather to become accountable in terms of contributing to the development of institutions that can weave together diverse capabilities in a focused fashion and continue to do that after AID leaves in a manner that defines a problem indigenously, i.e., it sees the problem from the point of view of the user and immediate benefactor aware that it is the social good which needs maximization and sees the problem from the point of view of those directly and indirectly affected aware that acceptance requires maximization of private goods.

The Long-Run: Enhancing Indigenous Problem-Solving Through Expanding Disciplinary Boundaries

This is a long-run objective, but it can be met through short- and long-run activities. The basic objective is to support the establishment of a field which might be called development technology. One pillar of the field would be basic technological and engineering skills. But several other pillars would together be given equal weight: the individual, the individual and work organization; work organization and the region; the individual, work organization and the region. A four-year sequence is presented for illustration in Table 4-2. Students each year would be involved in a problem seminar on appropriate technology which would progress from exercises involving uses of intermediate technologies and inventorying existing technologies to progressively more complex problem-solving. For undergraduates and/or for a graduate version of the same curriculum provision could be made for specialization in terms of:

TABLE 4-2

A DEVELOPMENT TECHNOLOGY CURRICULUM

	Year 1	Year 2	Year 3	Year 4
Focus:	The Individual	The individual and the organization	The organization and the region	The individual, the organization and the region
	Microeconomics*	Industrial Sociology*	Regional Development	Industrial Economics
	Social Science Research Methods*	Macroeconomics	Economic Geography	Economic Anthropology
	Psychology	Theories of Entrepreneurship	Rural Sociology*	Alternative Extension Approaches
		Social Psychology		Alternative Evaluation Methodologies

TECHNOLOGY RELATED CURRICULUM

Continuing Seminar: Problems in Development Technology:

- -R and D Management
- -Action-Research
- -Diffusion of innovations
- -inventrying local technologies
- -etc.

*2 semesters

-- R and D management (problem identification, screening alternative solutions)

-- Appropriate technology extension and evaluation

-- Agricultural or industrial focus (with greater degree of specialization possible also)

-- Urban or rural development.

The same profile of curriculum inputs could be decomposed or recombined into modular training packages ranging from several months to a year each. With appropriate types of follow-up, this latter option could be fruitfully combined with alternative 2. in short-run objectives and serve as a "shakedown" for broader degree applications. Modules and curriculum should be implemented on a regional basis to ensure a reasonable degree of initial relevance and where possible on a national basis to increase possibilities for linkages to the policy and private sectors. An example of this latter course would be the establishment of regional centers for graduate education in development technology. The centers would be located at universities with the potential for meeting regional as well as national needs.

A Role for AID Summarized

Optimally, both the short- and long-run objectives need to be addressed. A way of conceptualizing a program which sought to do this is presented in Table 4-3 and Figure 4-1. The key words of this conceptualization are feasibility, institutionalization and continuity. Whatever is to be done must be feasible--for AID and for the institutions with which AID would work. The critical capacities which we have already

TABLE 4-3

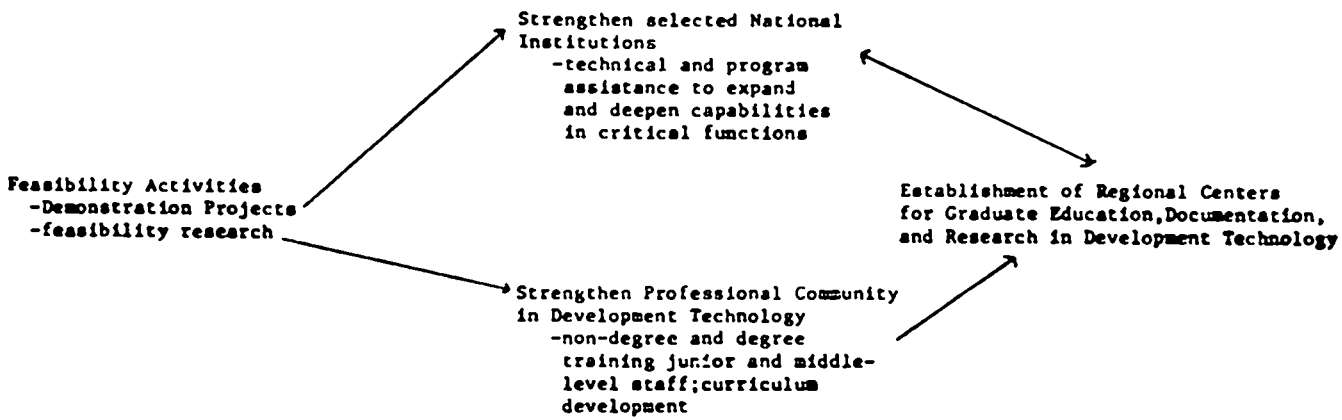
A ROLE FOR AID

Phase:

	FEASIBILITY	INSTITUTIONALIZATION	CONTINUITY
Broad Objective	Demonstrate the possibility of institutions doing multi-disciplinary work on appropriate technologies	Strengthen capabilities of selected institutions to do effective R and D and extension	Encourage development of a professional multidisciplinary community to evolve and maintain standards
Major AID Instruments	Technical assistance and grants for pilot and demonstration projects and feasibility research	Technical assistance and program grants to institutions; short-term training in U.S. and/or at specially assisted non-U.S. institutions	Educational grants for U.S. and/or indigenous training; Program grants and technical assistance where needed for curriculum development, testing, codification
Major Indigenous Institutions	Selected from Table 4-1 and appropriate public agencies	Selected from Table 4-1	Universities, Research Institutes

FIGURE 4-1

A FLOW CHART FOR THE GROWTH OF DEVELOPMENT TECHNOLOGY



discussed require two characteristics before any significant change in appropriate technology activity can be expected. One is the need to institutionalize capacities, to locate critical masses of capabilities in places where the likelihood of impact is highest. The second is the need to create and/or enhance the professional infrastructure which will guide the long-range course of this type of work and thus ensure that the learning process is a) cumulative and b) not restricted to individual experiences within a few institutions. In other words, it is the professional infrastructure which will provide continuity.

AID can begin with selected feasibility activities to demonstrate the possibilities of organizing for and programming around multidisciplinary approaches to technological R and D. AID can then embark on a carefully designed program to strengthen selected national institutions and prepare them for the assumption of regional roles as the professional manpower for regional institutions is created through non-degree training of junior and middle-level staff.

CONCLUSION

Most discussions of appropriate technology are cast in terms of economic and engineering decision-making. The question of social effects is always present but rarely given sustained attention. We have no quarrel with attention to economic and engineering decision-making, --only an objection to the tendency to disembody the decision-makers from the social milieu in which decisions are made or to pursue adequately the linkages between choices, decisions and social milieu. Those objections might be peripheral were it not for the social and cultural situations into which appropriate technologies are to be insinuated. In these situations, the category social effects is not even the whole story because what roles technologies will actually have and how they will actually be utilized will be an "effect" of local social and cultural organization.

We have tried to strike a middle but feasible ground between the biases of the existing mainstream and the biases of a more system-oriented view. We do not deny that change is often disruptive nor do we suggest that it be avoided because of that. Instead, we have tried to make three points.

1. The decision-problem in appropriate technology is not how to satisfy lists of eloquent and often inconsistent criteria of what appropriate technologies are or ought to be. The decision problem is a trade-off problem in which hard judgments need to be made about costs and benefits, impacts and opportunities.
2. In making those kinds of decisions, it is first necessary to anticipate as best as possible what the terms of trade-offs will

be and having made those decisions, it is even more important to continue assessing the terms of the trade-offs. One way to do all this without sacrificing change is to compare intervention and explication strategies. The former seeks to minimize social effects, the latter tries to utilize them.

3. External assistance can make a short-range contribution by providing the materials to enter a diffusion stream. The role of assistance is then defined in relation to alternative forms of initiating and maintaining a diffusion stream. External assistance can make a long-range contribution by going to the heart of the problem--it is currently one defined by multidisciplinary fields--and seeking to create an integrated professional community which can develop and maintain perspectives and standards, cumulate, evaluate and transmit experience. The role of assistance is then defined in relation to wedding alternative substantive strands.

BIBLIOGRAPHY

Bhalla, A.S. (ed.), "Technology and Employment in Industry." Geneva: International Labour Office. 1975.

Bigart, Robert James, "Indian Culture and Industrialization." American Anthropologist. 1972.

Boon, Gerard K., "Economic Choice of Human and Physical Factors in Production." Amsterdam: North-Holland Publishing Co.

Gotsch, Carl, "Tractor Mechanisation and Rural Development in Pakistan." International Labour Review. (1973) No. 2.

Hansen, Gary, Seminar Proceedings on the Generation and Diffusion of Adaptive Technology, Technology and Development Institute, East-West Center, October 1972.

International Labour Office. "Sharing in Development: A Program of Employment, Equity and Growth for the Philippines." Geneva: ILO, 1974.

Khan, Amir, "Appropriate Technologies: Do We Transfer, Adapt or Develop," in Employment in Developing Nations, Edgar Edwards (Editor), New York: Columbia University Press.

Koppel, Bruce and Morse, Richard, Field Problems in Industrial Extension: Decision Criteria for Appropriate Technologies for Small-Scale Enterprises (papers and bibliography from Training Course held in Spring, 1975). East-West Center. 1975.

Manne, Alan S., "Investments for Capacity Expansion: Size, Location and Time-Phasing." Cambridge, Massachusetts, The MIT Press.

Marsden, K., "Progressive Technologies for Developing Countries" in International Labour Review, Vol.101, No. 5 (May 1970).

OECD. Choice and Adaptation of Technology in Developing Countries. Paris: OECD. 1974

OECD. Promotion of Small and Medium-Sized Firms in Developing Countries Through Collective Actions, Inter-Regional Symposium on the Exchange of Experience, Paris, 25-29 September, 1967.

Okita, Saburo, "Choice of Techniques: Japan's Experience and its Implications" in Economic Development with Special Reference to East Asia, edited by Kenneth Berrill, London: MacMillan and Co. Ltd.

Oshima, Harry, "Labor-Force Explosion and the Labor-Intensive Sector in Asian Growth," in Economic Development and Cultural Change, Volume 19, Number 2, January 1971.

Pratten, C.F., Economies of Scale in Manufacturing Industry. London: Cambridge University Press. 1971.

Stewart, Francis, "Technology and Employment in LDC's," in Employment in Developing Nations, Edgar Edwards (Editor), New York: Columbia University Press.

Strassman, W. Paul, Technological Change and Economic Development. Ithaca, New York, Cornell University Press.

Timmer C. Peter et.al., "The Choice of Technology in Developing Countries: Some Cautionary Tales." Cambridge, Massachusetts: Harvard Studies in International Affairs, No. 32. 1975.

Trist, E.L. and Bamforth, K.W., "Some Social and Psychological Consequences of the Longwa-l Method of Coal-Getting." Human Relations (1951).

UNESCO. Science and Technology in Asian Development, Conference on the Application of Science and Technology to the Development of Asia, New Delhi, 1968.

Woodward, S., Industrial Organization: Theory and Practice. London, Oxford University Press.

ATTACHMENT F

Extracts From Papers on Appropriate Technology

APPROPRIATE AGRICULTURAL TECHNOLOGY: ASSESSMENT OF NONFARM IMPACTS

(By Clark Edwards, Economic Research Service, U.S. Department of Agriculture)

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CONCLUSIONS AND IMPLICATIONS

An objective of economic development in less developed countries (LDC's) is to increase agricultural output as a means toward improving the availability of food and at the same time toward generating a surplus which can be used to foster further economic growth. There is concern both with the efficiency of producing and with the equity of distributing food and income. Intermediate agricultural technologies, which are efficient and also appropriate to social, religious, political and economic conditions, are preferred to high technologies. The latter may appear to drive faster and harder toward efficiency goals, but appearances sometimes deceive. High technology tends to increase the income distributional problems between the "haves" and "have-nots."

Even appropriate technology, taken as a single means toward a single end, can have side effects. Two mechanisms through which these effects are transmitted are: forward and backward linkages from the advancing agricultural sector to the nonfarm sector; and changing opportunity costs for resources, particularly for unskilled labor. To the extent that such unintended side effects are also undesirable, a successful program to introduce appropriate agricultural technology to LDC's needs to be accompanied by companion strategies to maintain balanced growth. The companion strategies serve to increase the availability of local resources, expand markets for local products, ensure equitable regional distribution of economic gains, and build appropriate institutions.

Unskilled labor is the *resource* most likely to be in abundance and underused. Some policies emphasize birth control or migration strategies to deal with the labor surplus. The latter tends to be more a way to transfer the problem from one region to another than to solve it. Education programs which raise the skill levels of these workers and enable them to join a relatively skilled labor force, appear to show more promise. Policies to introduce large inputs of capital from abroad tend to accompany inducements for malappropriate technologies and institutional arrangements; emphasis at first should be on finding appropriate opportunities for small increments of local capital accumulated from the increasing agricultural surplus. Natural resource development policies may emphasize development of indigenous materials, including minerals, timber, and water, for use in both farm and nonagricultural industries.

Technological advance must be appropriate for nonfarm economic activity as well as on the farm. This includes finding ways for processing and distributing farm products, manufacturing and marketing purchased farm inputs, and village and urban nonagricultural industry development needed to create jobs and increase the productivity of unskilled labor. Introduction of appropriate technology requires education in the form of on-the-job training for workers and also in the form of technical assistance for entrepreneurs. The burden for conducting research and disseminating new ideas may, in the beginning, depend on nonlocal people, but implementation and further developments of appropriate technology over time should become endogenous.

Market expansion should concentrate on local village markets first. Derived demand for jobs for unemployed village residents depends on building the eco-

nomic base of the village community. The quality of life of those residents depends on their opportunities to consume what they produce. Domestic urban markets should receive attention second, and expanding markets for exports third. Value added domestically is preferred to exports of raw materials. Import substitution and domestic value added to imports of raw materials add to derived demands for domestic resources.

Regional emphasis should begin with development of a rural, nonfarm economy in the agricultural village and small town. At first, the local economy may be linked to the agricultural base, but over time nonagricultural industries need to be developed to sustain regional growth. Explicit policies need to be implemented to develop transportation and communication channels among villages and small towns and between these and the larger urban centers. Policies need to address equitable regional dispersion of economic development over the entire nation and need to be concerned with maintaining a rural-urban balance.

Institution building may emphasize economic institutions, including those which create markets for goods and services as well as money markets and those which establish goals and plans for economic development. But these must be accompanied by concern for building social, religious, and political institutions as well, which are organized to assess goals, resolve conflicts, and deal with change.

APPROPRIATE TECHNOLOGY FOR AGRICULTURAL DEVELOPMENT*

(By John S. Balis, NE/TECH, AID)

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SUMMARY

An appropriate agricultural machinery technology should include three major categories of hardware with a diversity of options in each category. The major categories are hand tools, improved animal tools and small tractors. The design options would adapt the equipment for the diversity of farming operations of the LDC's. This equipment would be designed, produced, distributed and serviced for the family farm enterprises of the LDC and should achieve measurable positive benefits in terms of both production and employment. Although it is possible to make a narrow economic and technical case for larger tractors as appropriate technology this case is weakened by the consideration of the socio-political impacts of the large tractor technology. The problems experienced by LDC's in land reform has been taken as indication that adequate political will does not exist to restructure drastically the pattern of farming enterprises. Thus the appropriate technology should be designed to raise the productivity with the broadest segment of smaller farmers using a technology that is heavily dependent on labor. This strategy contains a trade-off of production and employment factors and represents a judgment that at this stage is not well supported with field data. Some caution and continuous evaluation is suggested during the pursuit of the strategy to ensure that the benefits do in actuality conform to the expectations in an acceptable degree.

Family Farm as the Target Group.—The family farm enterprises of the LDC, like their U.S. counterpart are the most efficient users of available land. This strategy would provide these farmers with the tools and equipment to further raise production and the well-being of the farm family and their society. These farmers are not well off economically, in fact generally significantly poorer than the urban labor class. In past development programs there has been a preoccupation with production for the commercial market which resulted in the neglect of the family farm. More recently the emphasis on the "rural poor" focused upon the landless and therefore also neglected the family farm group. The family farm merits attention because it is a poor group with production potential. The family farm is not a narrow typology and the strategy has the flexibility to support the full gamut of mechanical technology required to develop the potential of this segment of the LDC economy.

A Positive Social Impact.—An increase in total food supply and an increase in income of a sizeable segment of the farm population will have broad social bene-

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*Discussion Paper Prepared for Appropriate Technology Committee of AID/W Staff, June 1976.

fits. This strategy attempts to improve equity by positively excluding a sizeable segment at the top end of the economic spectrum. However the available production parameters indicate that there are limits on the labor absorptive capacity of a production increasing technology and it is not proposed that this technology will correct all social ills although there is expected to be a net gain in well-being.

Productivity Benefits.—This technology will not produce maximum production per unit of input as this is only one of the benefits sought from the intervention. However the internal motivation of the family farm enterprise is comparatively high, perhaps higher than can be attributed to economic factors alone. Thus, the return for improving the production technology is multiplied by the factor of good management. A large portion of the production will be consumed by the farmer and by his labor force thus making measurement difficult. At the same time a lack of fertilizer, for example, may in fact limit production more seriously than will be assisted by the better tools. Realistically it is the combination of better farming methods rather than any one that produce crop yields and it will be necessary to expand all of the inputs in some coordinated manner in achieving the productivity gain.

Broad Based Economic Impact.—The industrial facilities for producing, distributing, servicing and repairing of this appropriate technology can be wholly indigenous or nearly so. This broadens the economic benefit in the society and also conforms with fiscal management objectives of many LDC's. The simplicity of the technology and its capability for immediate utilization can make it an attractive investment for local entrepreneurs. It is generally felt that previous emphasis on sophisticated technology was too lumpy to stimulate wide interest and hence resources were accumulating or being consumed unproductively. The proposed technology offers the opportunity to test that hypothesis. The caveates must be hastily added. There is an extensive set of policy and administrative adjustments that must be simultaneously instituted if the full benefits of this technology are to be realized.

Broad-Based Political Impact.—The objective is to provide a modest positive economic and/or social benefit to a broad segment of the population. The target group of farm families are minimally involved, or at the immediate fringes of, the present political processes. Strengthening of their economic status, notably their relative economic status, is expected to improve their political capability. At the same time there is no threat of a political revolution, nor is it necessary as a precondition for utilizing the technology. Thus the participating political base should broaden as the impacts of the technology are felt. This broadening will not simply be in numbers of farmers, but in numbers of industrial or urban participants as well. Some may be concerned as the political interests of agriculture are strengthened and begin to reshape the agro-industries. Yet the agro-industries interests may themselves become the political bridge that links the existing conservative rural majority and the sometimes hyper-modern urban industrial class.

Compatible With Existing Technology.—The appropriate technology concept readily assimilates existing traditional and modern technologies. It is not proposed to replace any existing technology with a technology proposed to be "right". It is proposed that existing technology will be supplemental and complemented in the course of improvement. Displacement will occur in the context of evolutionary improvement as resources are mobilized. The establishment of the new technologies will improve the productivity of the existing technologies by common reliance on the same infrastructure and other features of the economy and social structure.

Requires Minimal Facilitating Programs.—The LDC's have made significant gains in fertilizer, irrigation, etc. for HYV agriculture and in industry and infrastructure of a modern economy. These are the essential building blocks of the new technology. These blocks need to be expanded and perhaps modified to permit continued agricultural expansion, but drastic modifications are not required. There may be major problems in expanding these various elements, but the expansion of the agricultural economy should be a major resource enabling more rapid expansion.

The crucial factor is to perceive the influential nature of a set of interlinked policy and administrative policies focused at the family farm as a dynamic economic enterprise. The family farm has the capability of a high multiplier effect in utilizing development resources to yield both a production increase and an improvement in social well being. Policy reformulation and some restructuring of

the administrative set-up are necessary to achieve the target objective of the family enterprise. However the more important benefit will be the economic stimulation and reinvestment of resources when the family farmer reinvests in his enterprise and expands the productive capability. The industrial response to the farmers demand for capital goods becomes an integral element of the expansion of the total economy. Much of this expansion can be underwritten by farmers and rural businessmen as they recognize the potential returns of this kind of dynamic new business enterprise. An appropriate agriculture technology thus becomes an effective engine of economic and social development.

ATTACHMENT G

EXTRACT FROM "THE INDUCEMENT OF U.S. FIRMS TO ADAPT PRODUCTS AND PROCESSES TO MEET CONDITIONS IN LESS-DEVELOPED COUNTRIES" [1]

* * * * * * *

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Product Adaptation

Most of the products (except for the traditional ones) that one finds today in developing countries originated in developed countries, and underwent little change as manufacture eventually started in the developing countries. Most of these products manufactured locally are considered "mature" according to the product life cycle sequence. For example, one might find in a developing country a substantial market for non-leakproof batteries and inexpensive motor scooters, two products which have been declining in consumption in the U.S. and in Europe. Typically, such products are manufactured either by locally-owned companies or by investment from other developing countries. U.S. investors typically do not compete primarily on the basis of price but on the basis of product quality and brand names, so products manufactured by U.S. subsidiaries tend to be comparable with similar products manufactured in the developed countries or in developing countries by non-U.S. based multinational enterprises. The local consumer is very conscious of "Western" quality standards through imported goods, so that products manufactured locally for the same market have little scope for extensive product adaptation.

The examples of product design by U.S. investors to fit low income markets are few. An oft cited case is the development of special low cost automobiles for developing countries by Ford and General Motors—the so-called people's car. Although Ford and General Motors both are producing and marketing in developing countries a low-cost vehicle capable of different passenger/cargo configurations, the long-run competitive outlook for these vehicles vis-a-vis Italian or Japanese cars is still not clear. For example, would a car designed specifically for the varied road conditions found in Brazil compete successfully with the locally built Fiat 127, of which more than one million units have already been manufactured in Italy?

Product innovation by multinational enterprises in the development of new foods of a high nutrition content for developing countries has been less than successful. Often these foods tend to be more expensive than the nutritionally less valuable staple foods they are meant to replace. Also, the marketing of new foods has proven difficult in poor countries, where the products were not accepted by the population segment that needed them most. Furthermore, multinational companies concentrate their efforts on foods for the higher income end of the market because of the scarce profitability in producing for the lowest income levels. In this case an argument can be made for government subsidies to make the manufacture of such low-income, high-nutrition foods profitable.

Clearly the problem of product adaptation requires more investigation. Studies should focus on how much product adaptation is done through corporate research and development efforts of large multinational firms, and how much product development is done at the level of the host country. Also, studies are needed on the dissemination of new low income product technology from design centers in developed countries to developing countries. The development of simplified, but modern products, specifically designed for low income markets might prove a very fruitful ground for small engineering firms. However, the development

[1] A report to Agency for International Development by Management Analysis Center, Inc., under the direction of Robert B. Stobaugh, Professor of Business Administration, Harvard Business School, June 8, 1976.

of such products by large multinational enterprises seems much less likely, for these firms are more interested in concentrating on developing new products for high-income markets.

B. Process Adaptation

We suggested earlier that adapting to a more labor intensive manufacturing process in developing countries often is more appropriate than simply transferring capital intensive technology (adjusted for scale) from developed nations. However, at this stage of our knowledge of the problem, it would be wise not to make generalizations, but to approach each investment decision on a case-by-case basis, as is suggested by Chudson and Wells. Most foreign investors, including the U.S. multinational enterprises, have a preference to use their own technology rather than adapt it to meet local conditions. Thus, some presence or inducement is likely to be needed to achieve adaptation. And, the larger the firm, the greater an inducement must be before it will become important to the firm.

Host countries are vitally concerned with the choice of technology and are likely to play a major role in achieving adaptation to meet local conditions. Hence, we spell out some actions that would be appropriate for them. An analysis of each major investment would be desirable, albeit time-consuming. Such an analysis would involve the calculation of both the private profitability of the investment for the foreign investor and the social profitability for the host country—the latter calculation is commonly referred to as "social cost-benefit analysis." If the social profitability, calculated using shadow prices, does not meet certain criteria, then the host country should ask the prospective investor to modify his proposal in the direction of more labor intensive technologies. However, we believe that knowledge of techniques to determine social profitability and knowledge of alternate technologies are not widespread in less developed countries.

In addition to this direct influence on investors, developing countries could take a number of actions (one specific and several general in nature) that would exert indirect influence on investors to choose more appropriate techology.

First, the host government could facilitate the importation of second-hand equipment or equipment from other developing countries. Often governments of developing countries are loath to spend scarce foreign exchange on second-hand equipment since they feel they are getting "second-hand technology." Such an attitude biases investments towards a more capital intensive production because in newer equipment from the United States, Europe, or Japan, capital is substituted for labor (by increasing fixed capital per unit output, and reducing the number of operatives).

Second, developing countries could reduce factor price distortions in labor markets and capital markets. We have seen that relative factor prices have little effect on the choice of technology when investing firms are able to avoid price competition, but, if the economic environment is more competitive, relative factor costs influence the choice of technology. The elimination of subsidies to capital for investors would be a step in the right direction. This should be accompanied by the elimination of tax holidays so that the calculated return on investment by the foreign investor would be made on an after-tax basis. This would add pressure towards cost reduction, and hence toward a more appropriate production technique. Also, duty free (or preferential tariff) importation of capital equipment should be discontinued, thus making the import of expensive machinery more burdensome for the investing firm. On the other hand, subsidies for employment should be offered to offset the difference between what the firm pays for labor and what the true cost of the labor is to the economy.

Third, the business environment could be made more competitive, so that investors will need to pay more attention to costs, and therefore will feel more pressure to adapt technology towards reducing manufacturing costs. This can be done by decreasing the degree of protection from imports, and also by seeking to enlarge the market, possibly through regional integration. Furthermore, a more attractively sized market can be offered to the investing foreign firm if the number of competitors in the industry is kept low. This might seem a contradiction to the recommendation to increase competition, but it has the experience of many developing countries that a large number of producers in one industry, when the market is limited, actually results in higher prices. Effective competition could come from imports, and the degree of competitive pressure may be adjusted through the variation in import tariffs.

Fourth, a host country could take steps to facilitate foreign investment that is intended to serve export markets by taking advantage of low labor costs. These firms have a built-in competitive pressure to adapt their manufacturing process to local wages. Here the host country need not worry about increasing the competitive climate in order to bring about more adaptation, since this kind of investment seeks to reduce costs through full utilization of low wage labor.

Fifth, the host government could give very clear indications to prospective investors as to what its policy is on imports of foreign technology. Often, different ministries send out different signals to investors, which cause conflicting responses. For example, the ministry of industry might have a preference for "modern" investment, and the creation of a highly industrialized leading sector in the economy. The ministry of labor, on the other hand, might pressure the investor for maximum employment.

C. The Mode of Transfer

When technology is transferred together with equity investment, it is difficult to separate manufacturing technology from management technology. Indeed, often the host country is not aware of the alternatives. The foreign investor presents for approval to host governments a complete package, indicating few, if any, alternatives to the production process. The employees of ministries who review this project proposal are often not familiar with the industry.

But when technology is purchased via licensing agreements or in the form of equipment, this separation is made clear. Thus, technology not packaged with an equity investment may offer more alternatives to choose techniques that are more appropriate to the local environment. Unfortunately, not all technologies that a developing country might need are available through licensing or equipment purchase, because U.S. multinational enterprises tend to prefer equity investments to pure licensing arrangements.

Though licensing permits the local entrepreneur or government a wider choice, the transfer of skills is, however, more limited than with an equity. In certain developing countries, for example, there might be no local firm capable of effectively making use of licensed technology. Joint ventures offer a good means of transferring modern industrial skills, while at the same time involving a local entrepreneur who might ask pertinent questions about the manufacturing process used. Still, some review of technology by the local partner might favor capital intensive technology (since this partner shares in the benefits of non-price competition) and thereby not pressure the foreign partner for more adaptation.

To be sure, studies have pointed out that U.S. multinational firms possessing exclusive technologies, which are held only by a few firms in the industry, do not readily enter into joint ventures as do firms in industries which have more mature technologies. But this need not unduly handicap developing countries in encouraging technology transfer via equipment purchase, licensing, or joint ventures (or some combination thereof); because products and processes that are appropriate for developed countries are likely to be mature and hence are often available through licensing.

D. Detailed Recommendations

The key conclusions upon which our detailed recommendations rest are:

1. U.S. multinational enterprise—those large firms that account for most U.S. foreign direct investment—base their corporate strategies on the products and processes they develop for use in the United States and other economically advanced countries. They have preferred not to change these products and processes unless pressured to do so, either by the direct influence of a government or by indirect influences such as strong competition.

2. The host governments should be the organizations most concerned with the use of appropriate technology, and are likely to play a major role in inducing firms to adapt products and processes to meet local conditions. Yet officials of local governments lack knowledge in achieving such adaptation.

3. The transfer of technology via purchased equipment, licenses, or joint ventures rather than through arrangements in which U.S. firms have 100 percent ownership will facilitate the adaptation of technology to meet local conditions.

The two key tools upon which our recommendations rest are: (1) educational programs and (2) monetary incentives.

1. *Educational programs.*—Establish an "intermediate technology organization," perhaps a separate institute, with the primary function of providing in-depth training in the choice and evaluation of appropriate technologies. This

training would be provided for government officials and enterpreneurs from developing countries and for U.S. equipment suppliers, U.S. manufacturing companies, and U.S. consulting firms.

Although a number of viable formats could be developed, an illustrative one would be to have a "core" program in which the participants study individual cases of technology transfer to obtain better knowledge about the problems and opportunities involved, and also to learn about cost-benefit analysis so that differences between the view of the investor and the view of the nation are made explicit. The "core" program could be followed by a "practice" program, in which the participants visit U.S. firms engaged in the development of equipment, processes and products in order to insure that the U.S. entities are aware of the needs of, and exposed to opportunities in, host countries.

As an illustration of one possibility, officials in charge of the textile industry in less-developed countries and local entrepreneurs interested in textiles could visit U.S. manufacturers of textile equipment for a sufficiently long time to meet two goals: (1) the U.S. manufacturers would know local requirements; and (2) the persons from the less-developed countries would know the capabilities of the U.S. firms and become familiar with U.S.-made equipment. The net result would be greater exports of U.S. equipment, equipment that would be appropriate for the host countries.

Although the initial experience involved in starting the program would help in deciding upon future participants, we believe that it will prove important to involve officials of less-developed countries and U.S. equipment manufacturers. These two groups would have much to gain from the programs.

In addition to providing these "core" and "practice" programs, creation of a training organization would provide a permanent body of people interested in further dissemination of intermediate technologies to developing countries. Such a permanent body could:

(*a*) organize conferences on particular topics concerning the problems and opportunities offered by intermediate technologies;

(*b*) sponsor academic studies on appropriate technologies, and develop an archive of research cases drawn from various industries in several developing countries;

(*c*) act as an information clearing house for U.S. technologies that would be appropriate for developing countries, and keep extensive permanent files open to all interested parties;

(*d*) publicize its role of information dissemination, through circulars and advertisements in trade publications and by publishing a journal; and

(*e*) provide experienced consultants both to governments and industry.

Prior to the creation of a formal organization, AID should take two steps to help insure that the creation will be successful:

1. Visit organizations in other countries, especially France, Japan, and the United Kingdom, that are interested in technology transfer. Although none of these organizations are identical with the one recommended by us, something useful can be learned by visiting them. These visits should last a number of weeks in order to provide thorough knowledge.

2. Organize an international conference on the subject of appropriate technologies for developing countries. Such a conference should last for a minimum of ten days. Its purpose would be three-fold.

(*a*) educate decision-makers concerning the benefits of more labor intensive technologies for developing countries;

(*b*) make these decision-makers of the analytical tools—e.g. social cost-benefit analysis—to soundly evaluate investment proposals;

(*c*) discuss the establishment of the "intermediate technology organization."

The participants to such a conference should be:

(*a*) officials from developing countries—these officials should be employed in the ministries that evaluate foreign investment proposals, and should have themselves participated in such evaluations (AID could ask the governments of developing countries, through the American embassies, to submit suitable candidates for such a conference; the cost could be borne totally, or in part, by AID);

(*b*) entrepreneurs from developing countries or their engineering personnel—these should be persons responsible for equipment selection;

(*c*) officials from countries that have a program of attracting foreign investment for export industries—such as Indonesia, Korea, Malaysia, Taiwan, Singapore, Mexico and the Bahamas;

(*d*) U.S. equipment manufacturers—these could be attracted through appropriate advertisements of the conference plus correspondence and contacts with trade associations;

(*e*) engineers from U.S. firms involved in the design of plants for developing countries—advertisements and correspondence should be used;

(*f*) personnel from U.S. consulting firms interested in less developed countries—again, advertisements and correspondence should be used;

(*g*) managers of U.S. multinational enterprises with an interest in seeking better technologies for less developed countries;

(*h*) managers of U.S. firms in industries that suffer because of competing imports, and that would benefit from off-shore investment or procurement—e.g. textiles, garments, shoes; and

(*i*) scholars who have studied the problems of appropriate technology for developing countries.

2. *Monetary incentives.*—Although we believe that the educational programs are likely to prove the most cost-effective method of obtaining results, some experimentation with monetary incentives should be worthwhile. Some examples of actions that AID could take include:

(*a*) Ask U.S. investors about to invest in a less-developed country to develop a new design of plants that would employ more labor and use less capital than their customary plant designs. If the investor, after having developed a new design decided not to use it, AID would pay for the extra expenses incurred in making the design (a limit on the expenses provided would be set in each case) and would obtain the rights to the design so that it could be made available to other firms. If on the other hand, the new design were to be adopted by the firm that developed it, no reimbursement would be due.

(*b*) Give grants to U.S. equipment manufacturers to encourage the development of appropriate technologies for less-developed countries. The reward system might be similar to that discussed above under (a); i.e. the firm is paid for the design if it does not use it, but not paid if it does.

(*c*) Give grants to consulting firms to encourage the coupling of foreign investment opportunities with U.S. companies; for example, a U.S. consulting firm could survey one or two low-income countries for investment opportunities and then encourage U.S. firms to exploit these opportunities by using appropriate technology. To illustrate: There are opportunities for investments in food-canning facilities in some African countries such as Kenya; a U.S. consulting firm could locate these opportunities and then form a company composed of a U.S. equipment manufacturer, a U.S. food company, and local entrepreneurs to start a factory utilizing appropriate technology.

(*d*) Give special export credits for U.S. firms that export used machinery for use in less-developed countries.

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ATTACHMENT H

INTERMEDIATE TECHNOLOGY: AN INFORMAL SURVEY

(A Case Study by Peter W. Askin)

PART I

INTRODUCTION

> "The substance of man cannot be measured by Gross National Product. Perhaps it cannot be measured at all." (Schumacher, p.20)

> "Poor countries slip, and are pushed into the adoption of production methods and consumption standards which destroy the possibilities of self-reliance and self-help. The results are unintentional neocolonialism and hopelessness." (Schumacher, p. 195)

Until a few years ago, the concept of intermediate or appropriate technology was but a ripple in the backwaters of development theory and practice. Even then it was usually discussed within the context of other issues. The concept now goes well beyond these issues. Interest in intermediate technology has burgeoned, and as a concept it is now entering the mainstream of the litany and literature of development. Not a few think it should be the main focus of development activities. Terminology has become a serious problem in understanding the concept. The definitional problem will be discussed in some detail later, but at this point, it is necessary to state that the terms intermediate or appropriate technology are used interchangeably throughout the text of this paper, unless otherwise noted.

Why the sudden interest in intermediate technology? There appear to be a number of reasons. Developed and developing countries alike are becoming frustrated over the realization that aggregate-economic growth theories and foreign aid programs with massive transfers of capital since the end of World War II have done little for the masses of people who constitute the world's poor. World levels of food production are not adequate to remove the specter of mass hunger; unemployment exceeds thirty percent in many of the poorer countries and threatens to go higher; the tide of rural to urban migration has not been turned; and population growth threatens to wipe out the advances that have been made.

The second set of factors that have contributed to the relatively sudden popularity of intermediate or appropriate technology flowafrom an increasing disillusionment with some of the results of large-scale industrialization and modernization. The concept of intermediate or appropriate technology has great appeal in the industrialized countries to those who long romantically for the simplicities of a bygone era they never knew, or who are alarmed by the ramifications of the limits of growth theories, the rapid depletion of nonrenewable resources and the threats of environmental destruction. In the developing countries, the concept converges with the resurgence of nationalism, ethnicity and the desire to preserve traditional cultural values, as well as a frustration with the results of Western-inspired development programs.

There is yet a third set of factors which is probably more germane. From disappointment with the results of conventional development wisdom has come the growing belief that (1) economic progress in many of the poorer countries has been frustrated or retarded by attempts to transfer and utilize inappropriate "Western" technologies and (2) that more appropriate alternatives can and must be found.

Dr. E. F. Schumacher, in his book Small is Beautiful....perhaps was more responsible than anyone in capturing most of the above factors at their confluence, channeling them into a concept and popularizing that concept into a movement. Ralph Nader reportedly carries a dog-eared copy of Schumacher's book wherever he goes. A 1976 U.S. Presidential Candidate, Governor Brown of California, is also a Schumacher fan and has established an intermediate technology position on his staff.

The literature on the subject is vast, groping and growing; yet there is a dearth of well-documented experience concerning applications of the concept. The principles, even the definitions, underlying the concept are unclear and unestablished. It is not clear from any level of analysis exactly how intermediate technology is to be universally employed as a development strategy in solving the problems of the world's poor. A few disclaimers, therefore, are in order. This paper attempts only a limited and informal survey of the subject. It describes some of the major definitional and conceptual problems that have emerged. It addresses but does not attempt to resolve the more controversial issues surrounding intermediate technology. Mainly the paper attempts to assess on the basis of a limited field survey, how the concept of intermediate technology is viewed by policy makers, planners, practioners, innovators, etc. in some developing countries and to describe the major applications of intermediate technology activities in the countries surveyed. Lastly, the paper attempts to arrive at some conclusions concerning the role of international agencies in assisting the development and dissemination of intermediate technology.

The latter is relevant to all United States agencies involved in external assistance. In the Secretary of State's address (delivered by Ambassador Moynihan) to the Seventh Special Session of the United Nations General Assembly last September, he stated:

> "Developing countries need not only new funds but also new technology. Yet the mechanisms for the transfer of new technology and for its local development are limited, and are seldom at the sole command of national governments, and the technologies of industrial countries must often be adapted to local economic and social conditions. New institutions and new approaches are therefore required."

It is particularly relevant for the Agency for International Development (A.I.D.) in that last year the U.S. Congress amended the Foreign Assistance Act to include a section on "Intermediate Technology" and to require A.I.D. to greatly expand its efforts in this field.

Intermediate or appropriate technology is an exciting idea which, theoretically, holds out a great deal of promise to the poorer nations of the world. It is also a rebellion--a rebellion against neo-classicial economics and against much of the conventional development wisdom of the last twenty-five years. As such, it has provided to date far more questions than answers. It also runs the risk of becoming a development fad or a panacea. It is definitely in danger of being over-attended, over-conceptualized by the development experts of the West and under-attended by some developing countries. Nevertheless, the concept of intermediate or appropriate technology has focussed attention on some important questions. It has made technology a major development issue and has served to sharpen the debate on the larger issues of employment versus production and growth versus equity. It points up how little is known about the relationship of technology to growth and of the development process itself.

PART II

THE CONCEPT

> "There is nothing in the experience of the last twenty-five years to suggest that modern technology, as we know it, can really help us to alleviate world poverty, not to mention the problem of unemployment which already reaches levels like thirty per cent in many so-called developing countries, and now threatens to become endemic also in many of the rich countries." (Schumacher, Small is Beautiful, p. 148).

> "We know that labor is there, waiting to be applied. The brains are there. It is possible that the motivation is there also. What is needed is the technology. Not sophisticated technology emobdied in heavy capital; not primitive technology, but something in-between -- tools and machines -- appropriate to the situation in the particular country at that time." (Hon. Clarence D. Long, Representative of the State of Maryland, Hearings before Committee on International Relations, 94th Congress, First Session on the Foreign Assistance Act. p. 336)

A. Some Definitional Problems

Terminology is definitely a stumbling block to the analysis and understanding of the concept of intermediate or appropriate technology. It has been alternately referred to as appropriate technology, low-cost technology, labor-intensive technology, capital-savings technology, alternate technology, self-help technology, village-level technology, progressive technology, indigenous technology, peoples' technology, light-engineering technology, adaptive technology, light-capital technology and soft technology. There are probably more, and more to come.

For the most part these terms are used interchangeably in the literature, but at times they become almost slogans, deliberately chosen it would appear to connote a particular bias or ideology or to emphasize a particular set of economic or social variables. For example, the terms labor-intensive or capital-savings technology (regardless of country origin) emphasize the employment factor in technological choice. Indigenous, peoples', or village-level technology focus on the local development, modification and adaptation of technology--normally technology that derives directly from traditional tools and methods. Alternate and soft technology tend (but not always) to embrace more ecological and environmental considerations such as alternate and renewable sources of energy and the environmental impact of technologies. Adaptive technology generally means the modification of an existing technology--normally the scaling down of large, sophisticated machines and processes to smaller, cheaper and simpler products and methods.

Intermediate Technology (a term that is falling out of favor) on the other hand refers, at least in the Schumacher sense, to new products and processes which in scale, simplicity, accessibility and productivity lie somewhere between existing primitive and advanced

technologies but which are closer to the former than the latter on the spectrum of possibilities. The term intermediate technology has fallen from grace because it is thought to convey images of a static and "second-best" technology. Actually there is little evidence in the literature to support this belief and almost none was found in a survey of three developing countries.

Appropriate technology has been defined somewhat differently. One author (Morawetz) defines it "as the set of technologies which make optimum use of available resources in a given environment. For each process or project, it is the technology which maximizes social welfare if factors and products are shadow priced." A.I.D. has adopted a tentative definition which states it simply as "technology which enables developing countries to provide goods and services for their people in a manner which is compatible with LDC conditions." One definition that seems to make as much sense as any comes from Indonesia in which technology in general was looked upon as falling into three distinct categories--traditional, intermediate, and advanced Western technology. Appropriate technology was then defined as that which uses a combination of these three.

It will serve no major purpose to prolong this semantical ping-pong. Most authors have settled on the use of the term appropriate technology, or the simultaneous use of both appropriate and intermediate, but no one seems entirely comfortable with this compromise, probably because it begs so many questions. One can only speculate that some of the uncertainty and debate over concept and application flow directly from the lack of precision in terms and definition.

B. Towards A Conceptual Framework

It would be nice at this point to lay out clearly and briefly the conceptual framework for intermediate or appropriate technology as background to a discussion of some of its applications. Unfortunately, one doesn't seem to exist in any ready and recognizable form. Part of the problem of course is the potential scope of the subject. Conceivably, few forms of economic and social activity are excluded. Theoretically, the concept can be applied to the productive as well as to the non-productive sectors, to consumption patterns and to social services as well as to the production of goods, to health delivery systems as well as to the mechanization of agriculture. Another part of the problem is that the subject is so closely related to other major issues and processes. In one sense, it goes to the heart of the development process itself and challenges current theories of development and economic growth. The concept flows directly from the major development problems of unemployment, regional imbalances, income distribution inequities and the relation of technology to growth. On a more philosophic plane, it represents a search for a more rational lifestyle, a modus vivendi for man with his environment.

In an attempt to provide some further insights into the concept, the author has chosen to approach the conceptual framework problem from five different but related angles--first, a somewhat philosophic view; second, the economic issues; thirdly, the question of technological choice; fourth, some application issues; and last, by an attempt to extract some conclusions concerning characteristics and criteria.

1. The "Schumacher School"

On a broad plane, the concept of intermediate technology with Dr. Schumacher as its chief prophet, is in a sense a rebellion against

neo-classical economics. A recent Newsweek review of Schumacher's book stated: "Schumacher's message is deceptively simple:

> the economic system should serve man, man should not serve the system. Modern economists, he maintains, have established material growth--in the form of the gross national product--as the chief measure of social progress. As a result, economics has become a psuedo-science in the service of a pseudo-philosophy--materialism--in which greed and envy are justified through the uncritical worship of continuous and unlimited growth." (Newsweek, March 22, 1976, "Thinking Small", p. 14)

Schumacher advocates the Buddhists' "Middle Way" and contends that man can better meet his needs by scaling down his wants. This must happen, he notes, because man cannot continue to use up nonrenewable resources at the present rate and survive. In economic and technological terms then, the "Middle Way" is finding the right development path "between materialist heedlessness and traditional immobility". In the search for the right development path, finding the "appropriate scale" of things becomes all important. He applies this to the scale of organizations as well as to the scale of machines, to consumption patterns as well as to production methods. He admits that this concept cannot be universally applied, but argues that it is ideal for fulfilling the needs of the poor. To Schumacher, it does not mean going back to outdated methods, but rather forward into new technological territories. The task, he states is to develop appropriate technologies which will create literally millions of new workplaces. In short, he is advocating Ghandhi's principle of production by the masses, not mass production.

Schumacher elaborates on this in a hypothetical example. He speaks of a $100 technology (actually he used pounds sterling) in terms of investment per workplace. The hypothetical cost of a workplace using traditional technology would be about $1.00 while the workplace investment in utilizing Western technology would be about $1,000. The gap is enormous and the latter technology crowds out the former. What is needed, Schumacher contends, is a $100 technology (or $100 investment per workplace); one that is "immensely more productive than the indigenous technology, but immensely...cheaper than the sophisticated, highly capital-intensive technology of modern industry." These technologies, Schumacher states "must be cheap enough for jobs to be provided in very large numbers and simple enough to be used and maintained by rural and small town populations without sophisticated technical or organizational skills and with very low incomes. It follows that equipment of this kind will have to be provided largely from indigenous resources and employed largely to meet local needs". (Stewart, p. 108)

Following are two brief case examples which illustrate this approach to intermediate or appropriate technology:

Example One: Metal Bending Machine (AFRICA)

The problem posed to the Intermediate Technology Development GROUP (I.T.D.G.) in London was to find a simple tool by which African village craftsmen (blacksmiths and metal workers) could bend metal around the wooden wheels of new ox-carts. The least expensive modern piece of machinery to do this cost in the neighborhood of 700 British pounds and required an electric drive. The I.T.D.G. knew that European forefathers had a simple machine to do this which had fallen

into obscurity. They finally found such a machine in a French village. They redesigned and upgraded it. It is simple and can be made and used by any village blacksmith. It costs seven British pounds to produce and is all hand-powered.

Example Two: The Egg-Tray (ZAMBIA)

The I.T.D.G. found a situation in Zambia where egg producers were in despair because the supply of imported egg crates had given out. No one in Zambia knew how to make them. The need was for a million trays a year. A multinational company reported that the smallest egg-tray making machine turns out one million trays per month. The company also reported that it would be uneconomic to make a smaller machine. The I.T.D.G., working with the Royal School of Arts and a small manufacturer in Scotland, redesigned the egg-tray (into a much better one) and designed a prototype machine to produce it. The machine is now being used in a number of African countries.

This kind of intermediate technological generation is going on in a number of countries in Africa and Asia, more examples of which will be discussed later. These above examples illustrate several different aspects of the concept: One is that it was stimulated by outsiders. The target group was small-scale, low-income craftsmen and farmers. In one case an older, discarded technology was rediscovered and through modern sector knowledge was redesigned, upgraded and put into effective use at low cost. In the other case, the same result was achieved by developing a completely new (in scale) technology.

The Schumacher School, while not ignoring the economic questions, refuses to be imprisoned by the rigors of quantitative economic analysis; most of which Schumacher dismisses as pre-conceived notions translated into foregone conclusions. This School also tends to limit the concept of intermediate technology to the non-modern or traditional sector and with the belief that unless this sector begins to grow, any hope in the modern sector is illusory. At the heart of this conceptualization is the belief that the right path is the dynamic approach to development which treats technology as the central issue. This in turn will open up avenues of constructive action which the static, econometric approach fails to recognize.

2. The Economic Debate

The Schumacher level of conceptualization does not satisfy most economists. However, they are often badly split in their own attempts at conceptualization and analysis of appropriate technology. Space does not permit a full discussion of the economic debate but the following (largely drawn from Sarah Jackson's work) represents a useful summary of the main arguments:

a) The Arguments in Favor

- Capital is scarce relative to labor which is in direct contrast to the countries developing and exporting the technology. Therefore, the capital requirements for providing full employment via these technologies is simply beyond the reach of the poor countries; also they cannot afford the corollary levels of investment in infrastructure, market and market support systems demanded by higher technologies.

- Labor, for the poor countries is the abundant resource. Therefore, appropriate technologies would use more of the abundant resources for each unit of output.

- The large-scale nature of production of capital-intensive technologies cannot be achieved or fully utilized in poorer countries because of the small size of their markets.

- Appropriate technologies can better take advantage of traditional economic activities and make fullest use of existing organizational, management and entrepreneurial talents.

- Smaller-scale permits more geographic dispersion and wider links with the rest of the economy.

- More appropriate technologies will permit more jobs from the limited capital available. This in turn will spread the benefits more quickly and will spark more demand for marketable products.

- Appropriate technologies are more likely to stimulate the traditional sectors by developing backward linkages with agriculture and other feeder industries. Large-scale production using capital-intensive technology, on the other hand, tends to displace traditional sector economic activities.

- Western technologies tend to ignore the raw materials of the ountries in which they are introduced, because they have been developed for a different climate and environment. This not only adds to their cost but may make them totally inappropriate for local conditions.

- Technologies which make maximum use of poor countries' resources would produce higher rather than lower rates of growth and better distribution of income, and would permit them to compete (under laws of comparative advantage) more equally in world markets.

The counter-arguments are based mainly on the rapid growth through accelerated industrialization theory of development. In other words, in order to raise their rate of growth over time, poor countries must create their own industrial sector as soon as possible.

b. <u>The Arguments Against</u>:

- Capital-intensive investments maximize total output in the shortest time. Returns on capital are usually greatest when capital is combined with the most efficient Western technologies. Therefore, they generate the greatest savings for necessary future investment and thus continued economic growth.

- Labor-intensive industries take longer to produce a given output and tie up scarce working capital longer.

- Labor is not as abundant or as cheap as it looks and entrepreneurial talent is not as abundant as it seems in developing countries. Wage rates are often artifically high. This is generally the labor required for industry. Cheap labor, where it exists, may not be suitable for efficient production even with small-scale technologies. Labor-intensive industries require more complex management skills which are in short supply. Therefore, available entrepreneurial talent should be used where it will yield the greatest return.

- Capital-intensive industries generate downstream employment generation which more than offset the fewer workplaces of the industry in question.

- Many industries are not economically divisible because they must produce for an compete in wide domestic and international markets. Quality

control and precision in production become critical and cannot be achieved in smaller-scale, labor-intensive and geographically-dispersed production processes.

- Decentralized, small-scale industries are not conducive to creating the necessary environment to form a critical mass of competitive innovation.

- Western technology can be transferred more easily to poorer countries than developing brand new, and possibly more appropriate techniques.

- The prestige value of developing a modern capital-intensive industrial sector cannot be underestimated. It also provides labor and management with skills that eventually will be needed in a modern economy and exposes them to modern work values of precision and efficiency.

The economic debate seems to center on one basic question--whether maximum production through the use of Western technologies or the fullest utilization of available resources is the best path to economic growth? The question is in some respects a challenge to basic economic theory at both the macro and micro levels. The quick-growth theory has not solved the problems of massive unemployment and inequitable income distribution. On the other hand, increasing labor-intensive activities may reduce overall output which many countries cannot afford to have happen. Thus the developing countries are confronted with a production versus employment dilemma.

At the micro-level, the theory goes, variations in capital-labor ratios are the standard responses to variations in factor prices. Output is always maximized when the productivity of the one scarce factor (capital) is maximized (by technology and other efficiences). Further, as long as the marginal productivity of labor (the abundant factor) is positive, every increase in employment will increase the productivity of capital. Therefore, increasing employment will increase output. The trouble is practice has not followed theory. Case after case has been cited of labor-rich countries following capital intensive methods. Why haven't these countries,or particular businesses, selected mixes of production factors more consistent with their factor endowments and comparative advantage? Is it because the productivity of labor is negative? Is it due to the absence of labor-intensive alternatives? Is it due to inappropriate conditions of choice, e.g., lack of information, distorted factor prices (and thereby wrong-headed government economic policies), tied-aid, etc.? Or can it be attributed to planners' and entrepreneurs' irrational preferences for sophisticated technology and methods of production? There are few conclusive answers to these questions. Some evidence has been found to support the conclusion that all these factors have an adverse influence on technological choice at various times. Certainly, in terms of the theory, developing countries operate in an imperfect world of competition. Information does not flow freely so available choices are not always known. The factors of production are not mobile. Entrepreneurs and other decision makers may become enamoured with the more sophisticated equipment or processes. Import policies, licensing practices, etc., may indeed make capital goods irresistably cheap.

Factor price distortions are believed by many economists to play the largest role in bringing about production mixes contrary to a country's factor endowment. In fact, some contend that unless factor price distortions are removed, appropriate technologies will not and cannot emerge.

What causes factor price distortions? If government economic policies are wrong in terms of a country's factor endowment, this will create a gap between market prices and the real or social costs of production factors. For example, if through government policies interest rates are kept artificially low, if capital imports are encouraged by low import tariffs, if foreign exchange is overvalued, and if foreign aid and investment are plentiful, the price of capital becomes cheap relative to its inherent scarcity. Also government policies regarding wage laws can distort factor prices. Labor may become overpriced relative to its abundance by artifically high minimum wages, fringe benefits, hiring and firing policies, etc., or wages may not distinguish sufficiently between skilled and unskilled, or between skills in high and low demand. These distortions, therefore, give the wrong signals to the planner and the entrepreneur and lead them into the wrong factor mixes and technological choices.

What are the solutions? The standard responses of course are: (1) reform government policies, or (2) shadow price the factors of production to determine their real or "social" costs and make the technological decisions on that basis. Neither solution seems that easy or terribly realistic. It takes massive persuasion and political will to carry out a full package of policy reforms. The government's development planner can shadow price production factors and make recommendations accordingly. This may or may not influence the technology chosen for government-financed or government-controlled projects. It is difficult, however, to see how this technique will influence or affect the private entrepreneur who, regardless of the shadow price argument, must still pay the market price for his production inputs. Conceivably, shadow prices could be used as indicators that government policies are wrong, e.g., they could be used to establish more rational import policies. They could also be used in a situation where government has established a centralized mechanism for screening or improving the import of capital goods. In the final analysis, the tradeoffs will be made on the basis of how a country perceives its development priorities and carries out its development strategy.

3. The Question of Technological Choice

By this time, it is apparent that in one sense there is nothing basically new in the philosophy underlying intermediate or appropriate technology or in the arguments against it. The industrial and agricultural development of Europe and the United States were based on innovative and incremental approaches to technology--largely in response to factor (labor) scarcities. China, Japan, and even India are to some degree more recent examples. The basic difference is that today there is, theoretically, a more pronounced choice among three basic alternatives: (1) utilization or transfer of existing technologies (ranging from traditional to the more advanced Western technologies), (2) adaptation and modification of these existing technologies, and (3) invention of new ones. Each choice has its own set of issues and problems.

Staying with existing traditional technology may mean continued low levels of output without the generation of additional employment. On the other hand, the international transfer of existing Western technology to developing countries is made difficult in many cases by what has been referred to as a "communications gap" and a "suitability gap". Contributing to the "communications gap" are such factors as the high costs of transfer, international restrictions and the exercise of monopoly power. Even if these obstacles are overcome, most "Western" technology has been developed to suit developed country factor endowments, and seldom will be "appropriate" in all respects.

Generation of new technology can be stimulated in at least two ways. One is simply to cut the country off from imports--a la the Chinese model--thus forcing entrepreneurs and engineers to be inventive and innovative. Another is an extensive local research and development effort, for example, through the establishment of Appropriate Technology Centers (ATC's). In the first case, it is thought that if factor prices are not right, there will be little incentive to innovate unless it is forced or done for reasons of challenge or patriotism. In the second case, research tends to be isolated from producers and the problems areas. As will be shown later, this becomes a key issue at the application stage. There is, however, a surprising number of national and international appropriate technolgoy centers already established and functioning.

The third general alternative is of course technological adaptation. To many, this offers the most promising area for the development of more appropriate technological choices. It would seem to follow that a country must be semi-industrialized in order to fully exploit this process. In other words, it would require a cadre of entrepreneurs and trained engineers to identify the potential for adaptation and at least a light engineering or small capital goods production capacity to follow through. It is possible that other factors such as production costs relative to sales price, absence of factor distortions, the existence of competiton, high tariffs on imports, are also important incentives in the adaptation process.

The element of choice is basic to the concept of appropriate technology. Opinions differ on how much choice actually exists for developing countries. Some feel there is a fairly wide shelf from which to choose and therefore they favor the alternatives of transfer and adaptation. Others are convinced that the shelf of choices for a particular product in a particular country situation is in reality quite narrow or even non-existent. They emphasize the generation of new technologies. The Schumacher School certainly backs the latter view. The problem, as has been suggested, is that very little is known about the processes of generating new technologies, and therefore, the adaptation alternative seems to have the best track record.

4. Some Theoretical Applications

Earlier it was stated that the concept of intermediate or appropriate technology could embrace almost any form of economic and social activity. Theoretically, this is true, but it is by no means proved by practical experience. The literature suggests a wide variety of current and possible applications, the full impact of which remains to be documented and assessed. Space does not permit even a partial listing but they include almost every sector. Following are just a few examples.

In agriculture: improved hand tools and equipment such as hoes, weeders, shellers, wheel barrows. Small-scale animal-drawn or motor-driven equipment such as--steel-tipped plows, harrows, power tillers, harvesters and threshers, irrigation pumps, which increase productivity over traditional tools and methods.

In rural industry: improved small-scale equipment and methods for making small-scale metal products such as farm implements, spare parts, cooking utensils and other home products. Simple food processing equipment and methods such as vegetable oil pressing, processing of food grains and vegetable fibres. Cottage industries such as spinning, pottery making, paper making, wood working, leather working, etc.

In urban industry: simplifying modern technology or redesigning traditional technology in such manufacturing activities as farm equipment, metal products, chemicals, sugar refining, cement and brick making, shoes and leather goods production, glassware production, pharmaceuticals, food processing, food preserving, wood and paper products, ceramics, even in oil refining and car manufacturing (e.g. the Jeepney and the Fiera).

In transportation, water-works and construction: more efficient but labor-intensive methods of road building, ship-building, irrigation systems, water filtration (home and city), low-cost house construction, etc.

In the service sectors: low-cost health delivery systems, educational methods, and water purification and sanitation systems; also, developing simple and low-cost information dissemination systems, as well as simplified marketing and distribution systems for a range of commercial goods.

In the energy sector: developing wind and solar-powered equipment for home and farm water use and small-scale irrigation systems, grain drying, etc. Developing methane gas converters (powered by animal dung) for home cooking, lighting and refrigeration.

Even a summary list like the above points up a major application issue--is intermediate or appropriate technology applicable primarily to the traditional or non-modern sector? The question is important in fashioning criteria for appropriateness and determining research and other allocations in the development and dissemination of appropriate technology. As conceptualized by the "Schumacher School", it seems to pertain almost exclusively to the traditional sector. Under the economic debate, the concept is widened and, in fact, the debate strongly suggests a bias for the modern sector. For example, the factor price issue pertains much more to the modern than to the traditional sector. The problem is compounded by the fact that the line between the traditional and modern sectors is not that clearly marked, and to the extent that it is, it is constantly changing.

The question also can be looked at in terms of where the greatest need exists. As we have seen, appropriate technology springs from the need to increase employment and to decrease income disparities. Between the two sectors, these needs are much greater in the traditional sector and the type of response to the need is likely to be different than in the modern sector. The problem in the modern sector is often that the production processes have been organized on too sophisticated and large a scale, thus leading to idle capacity and wastage of capital. The response then is to lower productive capacity, save capital and where possible increase the labor inputs. This is generally accomplished by modifying downward Western technology rather than creating new technologies. Modification, however, does not necessarily increase employment. The problem in the traditional sector is somewhat opposite, i.e., the production is organized around technologies that are too primitive and too inefficient to increase incomes, stimulate business and industrial activity and generate employment. Depending on the product, this calls for either major adaptation of Western technologies or more likely, the need to generate completely new ones.

There are other points at issue. Assuming limited financial resources, there will be competition between the two sectors in the allocation of resources for the development and dissemination of appropriate technology. Whether an adaptive or new technology approach is taken, the process is expensive. Innovation and inventors are present in all countries but the supply is limited. Therefore, it will be

important to decide which sector (or products) should receive the emphasis. Another point is that if income is increased in the traditional sector, it is likely to be at the expense of the modern sector. Or conversely, and perhaps more importantly, care must be taken that in developing more appropriate modern sector technologies, it does not further destroy jobs and markets in the traditional sector.

There is no simple answer to the question of whether intermediate or appropriate technology is primarily applicable to the traditional sector. The usual answer of course is that it is applicable to both sectors. It is also clear that most of the conceptualization and application efforts to date do in fact give primary emphasis to the traditional sector, partly because it is easier to work in this sector and also because the needs are more obvious. It could be that much more is known about the "tinkering" process to make primitive products more efficient than the process of scaling down and simplifying larger and more sophisticated techniques. This suggests that perhaps one of the greatest weaknesses in current approaches to appropriate technology questions is the attempt to apply the concept uniformly to both sectors. It is possible that each sector requires a substantially different approach beginning with the objectives and on through the conceptualization and application stages.

5. Characteristics and Criteria

It goes without saying that the foregoing discussion falls far short of a clear and consistent conceptual framework for intermediate or appropriate technology. From it, however, one can draw a few conclusions regarding the nature, characteristics and criteria of appropriate technology.

It seems relatively clear that the overall objective of appropriate technology for the developing countries is to achieve a state of technological independence. This does not imply a state of scientific self-sufficiency or technological isolation. More correctly it implies the development of local resources (labor, entrepreneurs, materials, research capacities, supporting systems etc.) to the point that developing countries can make their own technological choices consistent with local resource availabilities and national goals such as increasing income, output, employment and basic services. In this context, the major characteristics and criteria by which appropriate technology seems to be recognized and applied include the following:

a. Low cost inputs:

- low capital cost per work place
- low capital costs per unit of output

b. Intensive use of the abundant factors of production:

- labor
- local materials
- entrepreneurs

c. Simplicity of inputs and outputs in their:

- manufacture
- operation

- maintenance and repair
- organization and need for support systems.

d. Low cost outputs that:

- are accessible and affordable by low income groups, and
- fulfill basic needs.

e. Small in scale relative to capital-intensive and advanced technological activities.

f. Economically efficient and commercially viable.

g. Compatible with local political, economic, social, cultural and physical environment.

h. Encourages indigenous innovation, self-help and participation in the process (i.e., growth from below).

i. Geographically dispersed.

j. Dynamic, progressive and adaptable to changing conditions and requirements.

Most of these factors have been discussed in some detail earlier. A few points, however, need to be stressed. First, the above characteristics and criteria represent an optimum. In practice, they may not all be present in every type of appropriate technology. The second point, not often brought out in the literature, is that in most cases, appropriate technology is highly location-specific. This characteristic immensely complicates the task of drawing a conceptual framework and mounting any broad projects or programs to develop and disseminate appropriate technology. It particuarly complicates the task of organizing realistic and effective international assistance. The final point is that, despite the heavy emphasis on traditional sector needs, the response to these needs requires the use of modern scientific and engineering knowledge and skills, as well as innovation and imagination. The challenge is whether technicians trained in the modern sector can adjust their thinking and skills to extract the best from the new and the best from the old in developing something in-between which is more appropriate for the utilization of local resources and conditions.

PART III

LDC ATTITUDES AND APPLICATIONS

"When bulldozers were sent to Asian nations to replace shovels, we turned their values and their culture upside down," says Carl Madden, a top economist at the U.S. Chamber of Commerce. "I agree with Schumacher that the rich nations must walk softly through the rice fields." ("Thinking Small", Newsweek, p. 14)

Most of the theorizing about appropriate technology has occurred in the industrialized countries and among international development experts, although a few of the more worthwhile contributions to the literature have been made by practitioners in the developing countries. Very little attention has been paid to date, however, on how the concept of intermediate or appropriate technology is viewed by the developing countries themselves, e.g., by planners, policy makers, industrialists, small entrepreneurs, inventors, educators, as well as by the target of this technology--the low income groups. In other words, how do these groups look at appropriate technology as a development strategy? Is it responsive to their national, sector and local priorities? What are the problems and conflicts associated with it? How is appropriate technology stimulated and supported? Where are the nuclei of ongoing intermediate and appropriate technology activities? How do developing country officials and innovators view the role of international assistance in developing and disseminating appropriate technology?

These and related questions were the subject of a very limited survey conducted by the author in three developing countries. The purpose here is to describe the results of this survey and to relate these results to the concept and later to the role of international assistance. But first, a couple of caveats are in order.

The countries surveyed were the Philippines, Indonesia and Sri Lanka--also a brief visit was made to the Technology Development Institute (TDI) of the East-West Center in Honolulu to discuss its activities in the field of appropriate technology. The survey focussed on the rural sector in each of these countries. This was the result of time limitations and the author's conviction that in terms of need this is the sector most relevant to the general concept and to the role of international assistance. It excludes, therefore, most activities pertaining to small and medium-scale urban-based industries and to the service sectors, as well as to alternate sources of energy.

A. The Philippines

1. Some Background Notes

The Philippines have made great economic strides since their break with the colonial pattern of trade and investment of thirty years ago. Since that time industry has been built up through a process of import substitution of primary and consumer goods. The process was fuelled and financed to a large extent by a lively market for traditional agricultural exports. Industrial growth slowed down in the 1960's, however, as easy export markets ran out and the country attempted to shift into the secondary phase of import substitution, i.e., capital and producer goods. Additional growth from this point was purchased at the price of increased inefficiency and was accompanied by rising numbers of un and underemployed and

worsening family and regional income distribution. The economic causes appear to be the constraining effect of continued import substitution programs and the slow growth of the rural sector.

The rural sector in particular has not been able to provide sufficient productive employment opportunities, despite the agricultural productivity improvements that have occurred since 1965. This has led to "premature" rural-to-urban migration and aggravation of the urban unemployment problem. The situation in the rural sector can be summarized as follows:

- considerably higher infant mortality and lower literacy rates than the urban areas.
- paucity of hospital beds and care outside of Manila.
- adequate water supply in only one-half of rural homes.
- electricity available in only 10 percent of rural homes.
- rural incomes are one-third those of Manila and about one-half those of other urban areas.
- low agricultural yields.
- extensive unemployment, especially in the non-agricultural parts of the rural sector.
- widespread malnutrition.

The task, it seems, is to mobilize and energize the rural sector to increase output, income, employment and basic services, while at the same time orienting the industrial sector away from import substitution (to keep it from feeding off the rural sector) and towards exports. The geographic dispersal and ruralizing of industry as well as technological choices will play important roles in this two-sector strategy.

2. Attitudes Towards Appropriate Technology

In general, a surprising degree of awareness and understanding of the basic elements and issues of appropriate technology were found in discussions with officials, practitioners, farmers and small businessmen in the Philippines. Part of this is attributed to the influence of the International Rice Research Institute (I.R.R.I.) located at Los Banos, which has been one of the pioneers of appropriate technology for rice cultivation in Asia. Also the history and evolution of the Jeepney industry has given Filipinos another concrete example of how appropriate technology can work. The survey also revealed a lack of any real sensitivity to some of the terminology or conceptual issues discussed earlier. Under any number of terms and definitions, the "2nd best issue" seems to be a non-issue in the Philippines. At the same time, there is a very narrow base of appropriate technology research and applications. With the exception of the Jeepney industry, current applications seem to be confined largely to agricultural mechanization and isolated research and development efforts in the urban-based industrial sector which have not yet been translated into action programs.

Perhaps a more accurate observation would be that the Philippines is in a state of transition with respect to intermediate and appropriate technology. There are several indicators of this. Recently the concept of "appropriately-scaled technology" was injected into the mid-term appraisal of the Four-Year Development Plan, with the idea that the next steps would be to initiate research and formulate programs. Some research is already in progress at several branches of the University of the Philippines, particularly at Los Banos and at the Small-Scale Industries Institute located in Quezon City and at Mindinao University.

In addition, the GOP has created a Farm Systems Development Corporation with responsibility for researching, testing and evaluating various farm systems and technologies. To date, the emphasis has been placed on small-scale irrigation systems and on small-scale farm machinery. The recently initiated cooperative movement is in many ways an application of appropriate technology concepts. Organized vertically down to the "barrio" level, the "coop" movement is designed to provide, farmers, among other things, small-scale irrigation systems, small-scale machinery and rice processing equipment and a "technology package". Some of the equipment, in time, will be produced by the cooperatives themselves.

Another example of changing emphasis on the part of the Government is the increase in government-sponsored credit programs for the purchase of small-scale farm machinery, particularly the small power tillers and threshers. The GOP, with World Bank and other loans, has extended low-cost credit for the purchase of farm machinery in order to increase production. Most of this machinery has tended to be large Western four-wheel tractors and similar equipment imported from the West and from Japan. Recently, however, emphasis has shifted to the small two-wheel tractors manufactured locally or imported from Japan. This shift was given an added push last year when hoof and mouth disease began to deplete the Carabao (water buffalo) population. This decrease of the Carabao population had serious economic and political ramifications. It left many farmers at the mercy of the "custom cultivators" or with the alternative of using human-power to pull ploughs and other animal-drawn equipment through the rice fields. This occurred in several areas and was unacceptable politically and socially. Most farmers, when credit is available, seem to prefer the small power tiller to the Carabao, even though the tiller may provide more power and capacity than are needed for two-to-five hectare farms. When several farmers were asked why they aspire to own the power tiller, the usual response was "because the Carabao is too much work. It requires one person at least five hours per day to provide the necessary care and feeding." This raises an important point. Farmers, in addition to wanting to increase output, also want some of the drudgery taken out of their primitive farming methods. This is a factor not always taken into account by the theorists, engineers and economists in the debate over intermediate and appropriate technology issues.

It should also be mentioned that part (10 - 15%) of a World Bank loan is dedicated to providing investment and working capital to small rural entrepreneurs who wish to manufacture small-scale farm equipment. Thus far, the program has been limited to lending for the manufacture of power tillers, power threshers and batch rice dryers. This appears to be a good, if very limited, beginning in the stimulation of small rural industries.

One final note on attitudes. Most officials surveyed were well-disposed towards the concept of appropriate technology as a development strategy for the Philippines. Not all, however, were satisfied with the current approaches. The most controversial issues concerned farm mechanization. Many felt that more efforts should be made to

develop improved animal-drawn equipment rather than small mechanized equipment. The main reasons given were that better animal-drawn equipment would be more economically accessible to small farmers, more attuned to the scale of small farm operations and more in concert with existing infrastructure and the existing social/cultural environment. To some extent, this official attitude seemed to mask a deep sympathy for the small farmer and traditional culture, and a fear that the small farmer would not be able to resist the prestige of buying new equipment, whether he needed it or not. A deeper insight into Philippine attitudes can be gained from looking closely at some of the current applications. In general, however, the Philippines appear ready for a wider application of the concept. No marked sensitivities or general resistance were found. What is needed is a sharper focus at the planning and operational levels and a more coordinated push by Government institutions.

3. Major Activities and Applications

Despite the lack of planning and programs, there are several significant on-going appropriate technology activities in progress in the Philippines. Some are purely research and experimental, others have a rather long history of application. The following are some representative examples.

a. The "Jeepney" Industry.

No survey of appropriate technology in the Philippines would be complete without at least mentioning the "Jeepney" industry, as the history of this industry embodies most of the essentials of the appropriate or intermediate technology concept. It is purely indigenous and was a going concern long before the terms intermediate or appropriate technology became popular.

The Jeepney industry was born of the great need for public transportation and an abundance of cheap, locally available war surplus materials that existed after World War II. After the war, millions of dollars of excess army property was available in and to the Philippines, including Jeeps and Jeep spare parts. It was almost natural then that a local adaptation of the army Jeep vehicle evolved. It started in small shops with crude versions. It is now a $20 million a year business. Jeepneys are made in over 100 shops, large and small, throughout the country. It is estimated that Jeepneys comprise almost 50% of the vehicles in the Philippines. Now various models, sizes and shapes are available, many brightly painted, decorated and with titles or names. They have become an intimate and colorful part of the Philippine culture and they provide much of the country's public and private conveyance system, particularly in the rural areas.

The complete body and all sheet metal parts are made locally in small and medium-sized shops. The engines and gears are generally imported as surplus or excess property items, but increasingly engine and transmission parts are produced locally by the larger shops. A large automotive component industry has sprung up around Jeepney production. The sheet metal work is done by presses in the larger shops and by simple metal bending and metal-forming machines in the shops of smaller producers. The entire industry is highly labor intensive. Some producers have modernized their production methods but most are still using essentially the same simple tools and techniques of twenty years ago. Current costs vary depending on the model and whether new or reconditioned surplus engines are used. Average retail costs range between $1500 and $2500.

The success of the Jeepney industry in the Philippines can be traced to three main factors:

- the low-cost of surplus engines and suspension systems.
- the widespread availability of local materials and spare parts.
- it fits the requirement, i.e., the demand for a low-cost, durable vehicle that will survive the rugged country roads and terrain of the Philippines. The evolution of the Jeepney industry provides some valuable lessons for the proponents of intermediate or appropriate technology. For example, it illustrates that:

  a) the product must be demand-oriented, simple, functional and durable.

  b) local materials must be in abundance and their supply assured.

  c) the product must be something that local, small town artisans can copy, i.e., a sample or prototype is generally needed in the beginning.

  d) some standardization of spare parts must be achieved.

b. The I.R.R.I. Machinery Development Program

The work of the Agricultural Engineering Department, under the leadership of Dr. Amir Kahn, and as part of the International Rice Research Institute (I.R.R.I.) at Los Banos, is based on a rather simple theory. Most modern imported mechanization technologies are inappropriate for application to tropical agriculture. There are essentially only two categories of modern farm machinery - Western farm machinery which has been developed primarily for dry land farming and the agricultural machinery that has been developed in Japan which, while smaller in scale and suitable for wetland rice production, has become highly sophisticated and too complex and uneconomic for most tropical rice farmers in other Asian countries. The introduction of new rice varieties has brought on the need for technologies that are simple and inexpensive, yet much faster and more efficient than the traditional technologies. In other words, double and triple cropping has increased the need for faster and more efficient land preparation, fertilization and post-harvest processing.

The second premise is that traditional, primitive technologies, including animal-drawn equipment have evolved over hundreds even thousands of years and that there is not a sufficient margin of improvement left in most of this equipment to make a significant enough impact on increased productivity and output to influence most farmers to adopt the improvements. Therefore, the decision was made to concentrate, for the most part, on the lower scales of mechanization. This decision also embodies another basic conviction, which is that the farmer in addition to looking for ways to increase his capital/labor-output ratio is also looking for ways to remove some of the drudgery of farm work. Experience with the adaptation of imported machines to fit these needs has not worked out. What has been lacking is demand-oriented product designs which can take advantage of and stimulate locally available metal-working technology. Therefore, the emphasis was placed on simple mechanized tillers and threshers. However, the development of new designs and prototypes is expensive and often outside the engineering expertise available in any quantity in most developing countries. In the developed countries this market identification and design role is played by industry. In the developing countries, the small to medium-sized metal working firms and manufacturers are the logical producers of small-scale

equipment but they lack the design knowhow. Therefore, the design role, for a time, must devolve on national and international institutions such as the Farm-Machinery Development Program at I.R.R.I.

Based upon this theory and with A.I.D. as its largest sponsor, I.R.R.I. has designed or adapted thirty-five to forty pieces of small-scale hardware considered suitable for various small-farm applications in the rice growing regions of the world. Following is a partial listing:

- rotary harrow for small tractors
- four-wheel 15 hp riding tractor
- 8 - 14 hp tiller
- single and multi hopper seeders
- anhydrous ammonia applicator
- rotary power weeder
- contact herbicide applicator
- drum-type paddy thresher
- axial flow thresher
- manually operated grain cleaner
- test tube miller
- grain moisture meter
- heated sand parboiler
- batch rice dryer with oil burner
- low lift bellow pump
- solar energy collector
- differential slip tiller
- four-wheel 15 hp riding tractor
- deep placement granular and liquid fertilizer applicators
- stripper harvester
- table-type paddy thresher
- rotary power grain cleaner
- oscillating screen-air cleaner
- adaptation of Engleberg rice milling machine
- rice hull furnace for drying paddy
- vertical axis windmill

The above projects are in various stages of development. The manual grain cleaner, the windmill and the solar collector are still experimental. However, six designs have been put into commercial production in the Philippines and in a few other countries. These are worthy of further note.

The 5 - 7 hp tiller is probably the most popular and successful of the I.R.R.I.-developed small-scale machines. It is not an original technology but a simpler model of the two-wheel tractors developed in the U.S., Japan and elsewhere over the last several years. Its engine, chains, sprockets, bearings and seals must be imported. The remainder was designed to be produced by small metal working shops in most Asian countries. It comes with an array of attachments (e.g., lowland cage wheels, upland wheels, rubber lug wheels, comb harrow, trailer, plow, slasher blades, ridging blades, rotary grass cutter and a centrifugal pump). Twenty companies are now producing this tiller in the Philippines. Over 7000 units have been produced throughout Asia. I.R.R.I. is now working on a slightly larger version with steering clutches, which was a drawback of the smaller machine.

The axial flow thresher has become moderately popular after two earlier versions failed miserably. It weighs approximately 1000 pounds and requires a 7 hp engine to power it. Its main advantages are: mobility (pulled to the field by carabao, small hand tractor or jeep or truck), multi-crop capability (rice paddy, sorghum, soy beans, etc.) and flexibility and efficiency (threshes one ton of paddy per hour). It requires a three to four man crew to operate. Its main disadvantages seem to be that it is expensive (about $US 2000), and its capacity is quite a bit beyond the needs of the average 2 - 5 hectare rice farmer. It is estimated that it requires at least 15 hectares to make it pay. If a farmer can afford to buy it, however, he can amortize the cost fairly quickly by doing custom threshing. It is also potentially ideal for "coop" ownership.

The rotary power weeder is a three-row, engine-powered machine of light-weight construction for easy turning at the end of the rows. The weeder was designed at I.R.R.I. but it is produced almost exclusively in Japan. It has a lightweight, high-speed one hp engine that is difficult to duplicate in other countries. It is also not too economical for operations under 6 hectares. The development of a good manually-operated rotary weeder would work best. Thus far, one has not been developed at I.R.R.I.

The tractor extendible lug wheel is an I.R.R.I.-designed set of steel lugs attached to the rear wheels of a four-wheel tractor to prevent it from becoming bogged down in wet rice fields. The lugs can be extended easily to give more traction and mobility. It has become popular with custom tractor operators.

The batch dryer is another of I.R.R.I.'s post-harvest processing innovations. Drying of paddy is a serious problem in most Asian countries and the cause of considerable lost production as it directly affects spoilage or results in a high level of "brokens" during the milling process due to improper hardening and moisture content. Farm-level dryers are popular in Japan but are too expensive to import and too difficult to fabricate in most developing countries. The I.R.R.I. dryer is more simple, consisting of a grain bin with a perforated floor, a blow, fan and a kerosene burner. It can dry one ton of paddy (16% to 26% wet) in five or six hours. The dryer is being produced by six companies in the Philippines and production has also started in Taiwan. I.R.R.I., however, has developed two modifications of the original prototype--a wooden grain bin which can be built by farmers and a furnace to heat the dryer which uses rice hulls as furnace fuel. All these items are being produced and sold by small metal working shops in the Philippines.

While the results of the I.R.R.I. Machinery Development Program are somewhat controversial in appropriate technology circles, its general approach to the problem is interesting and somewhat unique. The approach consists of the following distinct elements and steps.

a) Study the economics of mechanization, identify the major areas of potential new designs and identify the reasons why commercialization of small-scale machinery had not taken place earlier.

b) Design new small-scale equipment or improvements in existing equipment.

c) Interest local small firms in manufacturing the equipment from I.R.R.I. - furnished designs. This proved to be a major problem. Poor response was received to general advertisements in local newspapers. It was discovered that small firms were not familiar with working from engineering designs and were reluctant to invest in the prototype unless they had assured orders. This bottleneck was broken by giving the designs to the manufacturer in return for the production of a few demonstration machines.

d) Field test the first manufactured prototype and suggest manufacturing improvements and modifications before authorizing the manufacture of the rest of the initial prototypes.

e) Encourage and assist the manufacturer in selling the first prototypes to farmers by furnishing technical assistance, test results, promotion leaflets, and instruction manuals, as a further means of stimulating interest in commercial production and obtaining additional field test data.

f. Encourage manufacturers to incorporate their own ideas for design changes and adapt the machines to their own production facilities to give them competitive advantage.

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I.R.R.I. has extended this basic approach to nine other Asian countries, namely Pakistan, Thailand, Indonesia and Sri Lanka, Malaysia, Taiwan, Korea and Vietnam (before April, 1975). This "outreach" program is basically done through sub-contract arrangements with public and private institutions or firms in these countries and by furnishing designs, prototypes and a limited amount of financial assistance. Production of initial prototypes apparently has taken place in all of these countries, but has not yet developed into any significant commercialization, except in Taiwan.

The I.R.R.I. machines are not without their critics. The major criticism and opposition to date centers around the following contentions:

a) the I.R.R.I. machines, especially the power tiller and axial flow thresher, provide more power and capacity than the average farmer needs and are, therefore, uneconomical. They should be made to a smaller scale or some of them abandoned in favor of hand-powered or animal drawn equipment.

c) The I.R.R.I. machines displace labor in labor-abundant countries.

d) The I.R.R.I. program is not an indigenous enterprise since it depended heavily on outsiders to initiate and sustain it.

e) The I.R.R.I. machines are not commercially viable without an initial subsidy.

f) The I.R.R.I. machines have not made a significant impact on increased output or increased net farm income.

In summary, a serious shortcoming of the I.R.R.I. experience has been the lack of impact studies built into the design, development and commercialization stages. Without these the validity of the above arguments and counter-arguments cannot be evaluated intelligently.

3. The Kaunlaran Industrial Shop

The survey included a visit to a small rural manufacturer of the I.R.R.I.-designed machines, the Kaunlaran Industrial Shop (K.I.S.) located at Calamba, Laguna, R.P. The owner - manager of KIS was formerly a skilled craftsman in I.R.R.I.'s Agricultural Engineering Department. In 1973, he started his own machine shop, under a shade tree, with three employees and a limited amount of "scrounged capital". His original capitalization was the Philippine peso equivalent of about $500. He now has paid-in capital in excess of $25,000 equivalent and subscribed-capital of almost $100,000. KIS now employs eighty-three workers in three locations. Plans call for an expansion in 1976, provided Government-sponsored loans are available. It is interesting to note that about 50% of KIS's skilled employees were recruited from "Jeepney" shops. KIS has produced and sold most of the major and more popular I.R.R.I.-designed equipment (about 60 units in 1975), but up to now it has emphasized the axial-flow power thresher. In 1976, KIS plans to increase its production of power tillers and batch dryers.

The Kaunlaran Thresher has undergone several modifications over the original I.R.R.I. design, e.g., a fifth louver has been added to the axial flow to make it more efficient. It has been modified in some models to enable it to be moved about the field by animal power. The thresher sells for the equivalent of about U.S. $2,000, while the tiller and dryer will sell in the $800-$1000 (U.S.) range. These prices are competitive with larger dealers and,KIS believes, are affordable by small farmers with access to Government-sponsored credit. All three machines contain roughly 15% to 20% of imported components, while the remaining components are made in the KIS shop from locally available raw materials.

The KIS owner and manager regards the following as the main reasons for his success. One is the fact that the I.R.R.I. engineers and technicians worked closely with him and his employees during the initial development and expansion stages. Second, that he personally supervises the quality control aspects of production, and third, that he has chosen demand-oriented products which he is willing to back up with guarantees and post-sale service. Working closely with the farmers has increased their confidence in him and also has led to several useful in-the-shop modifications and improvements.

4. The Zero Tillage Concept

A small experiment is underway in the Central Luzon area of the Philippines which could be considered a unique application of intermediate technology. It combines the most advanced seed technology available, water control and intensive use of farm management and farm labor, while using almost exclusively hand-powered equipment.

In brief, the system involves taking a small acreage of from one to two hectares and sub-dividing it into from 70 to 100 small plots. Each plot is then farmed intensively and separately. High yielding varieties are used but the cultural practices differ from the norm. For example, seeds are presoaked and then germinated in the dark. The seedlings are treated with a zinc oxide solution to increase their absorption of nutrients. In transplanting, the seedlings are spaced less intensely than normal and in east-to-west rows to increase exposure to solar radiation. In addition, fertilizer and pesticide applications are made weekly (7 times during the growing season compared to 2 or 3 applications under normal practices). Harvesting occurs earlier to avoid losses from field shattering. The rice is harvested close to the ground and removed from the field the same day. The next day a new crop is planted between the rows of the old crop. The harvested rice is dried by electric lamps one day and milled by a hand-powered rice mill the next day. The rice produced brings premium prices in the Japanese restaurant trade in Manila.

Four crops are produced on each plot each year (compared to two previously) with a labor input four times that of traditional crops. From land preparation through harvest, no mechanical or animal-powered equipment is used. Equipment includes a hand-pulled plow, hand-pushed rotary weeder, backpack sprayer, a harvesting scythe, foot pedal thresher and hand winnnower. The concept has caused considerable excitement in the Philippines. The system depends heavily on two things--discipline or intensive farm management almost 365 days a year and precise water control. The question is whether the majority of Philippine farmers are willing to subject themselves to more work rather than less? Most agree that the answer is "probably not" but other experiments are underway which, while using the same principles, attempt to reduce the man-days of farm management down to a more realistic level, e.g. around 320-330 man-days. It will take several crop cycles to determine to what extent these efforts will prove successful and attractive to other farmers. The experiment illustrates another facet of intermediate technology, the best of the new and the best of the old, and it has caused some of the small-scale mechanization proponents to do some serious rethinking.

5. The Institute of Small Scale Industries.

At the academic level, one of the major research efforts is occurring at the University of the Philippines' Institute of Small Scale Industries (I.S.S.I.), located at Quezon City, I.S.S.I. has been in operation for almost ten years. It has been assisted over the years by the Royal Dutch Government and is dedicated to upgrading small industry in the Philippines through training, research and extension services. It

is now engaged in a "state-of-the-arts" survey of ten selected industries as a preliminary step to establishing transfer of technology programs. These programs are being assisted financially by Canada's International Development Research Centre (I.D.R.C.). The surveys are aimed at determining the level of technology in use in each of the ten industries, including recommendations for the most profitable technology for a given industry. This along with training of entrepreneurs, managers and foremen of small industry, is combined with the identification and design of more appropriate adaptive technology for each industry. The purpose is to increase the income of the small entrepreneur and to prepare him for making the technological choice most appropriate for his industry, and also to stimulate local innovation. Foreign experts are brought in to assist with the training and to advise selected industries. I.S.S.I. has made several "laboratory" innovations. For example, three presses have been adapted or newly designed: an old drill press has been adapted for modern small shop uses, a new design for a pneumatic press has been put into operation, and an impact press has been newly designed. The purpose of these is to demonstrate to entrepreneurs what can be done by innovation.

The biggest problem facing small industry in the Philippines is the erratic flow of raw materials and financing. In I.S.S.I.'s view, this is a more serious problem than the lack of more appropriate technologies. Cooperatives are one way to help alleviate these problems, but stronger Government policies are also needed in the marketing and distribution of the raw materials on which small industries depend. Sufficient credit at reasonable interest rates has not been available to small entrepreneurs in the Philippines. More is being allocated than before but the amount is quite limited and the process is slow.

6. Regional Adaptive Technology Centers (RATC's).

Mindanao State University is one of four non-metropolitan Asian Universities participating with the East-West Center of Honolulu in a program designed to develop Regional Adaptive Technology Centers. The other universities are Yeungnam University, Korea; Hasanuddin University, Indonesia and Khon Kaen University in Thailand. The purpose of these centers is to provide community-related research, consulting, training, technological adaptation, and industrial extension for small industries within the community served by the Center. Mindanao State University first concentrated on the local brassware industry. These programs began in 1974. Some have advanced more than others, but in concept they represent an important development in the field of intermediate technology. Previous international assistance has tended to concentrate on upgrading national and international-level institutes without upgrading and developing linkages with local and regional institutions. The latter are in the best position to identify problem areas, carryout adaptation and disseminate information to rural target groups. India, apparently, has carried this concept to a relatively advanced stage. The RATC concept is one that merits more attention by international assistance agencies and national governments if they are serious about developing and disseminating intermediate or appropriate technology. RATC's will be discussed in more detail at a later point in this paper.

7. Problems and Research Priorities

Following are some of the major problem areas observed in the Philippines where research and application seem most needed. The list is restricted primarily to the rural sector.

a) Small-Scale Farm Machinery: The results of the I.R.R.I.-designed farm Machinery Development Program are impressive but not conclusive. More research is needed to determine better responses to a number of questions and problems. There is some doubt as to whether

I.R.R.I. has hit the right scale of some of its equipment. The tendency in second generation development will be to go for a slightly larger scale, where the real requirement may be in the other direction. A closer look also needs to be taken at a mix of hand, animal and gas-powered equipment. In terms of rice production, perhaps the biggest payoff will be in the post-harvest handling and processing of rice. Losses at these stages due to inefficient methods and technologies can vary from 15-30% due to improper harvesting, drying, cleaning and milling. Past responses to the drying, cleaning and milling problems have tended towards importation of large rice processing complexes. Many of these have not worked out because the technology has not been appropriate. Continue research needs to be done on the batch dryer and on solar drying, w. h is the subject of a current experiment at the University of the : ippines at Los Banos.

One of the chief problems with the I.R.R.I. equipment is that there are no thorough impact studies available. In other words, after almost ten years of development, experiment and application, precious little is known about the impact of some of this equipment on employment, farm income and production. Secondly, I.R.R.I. bases its product development program on the principle of "commercial viability". The principle has merit, yet the process appears to be heavily subsidized from inception on through the purchase of equipment by the farmer and subsidized credit for the small manufacturer. Some subsidization is inevitable and probably desirable but the question of how much should be looked at more closely.

b) Irrigation is an area where innovation in small-scale methods could pay enormous benefits. In the Philippines there is a need for many more small dams and reservoirs in the rain-fed areas in order to convert these to areas of constant water supply. Within the irrigated areas, there is a requirement for an efficient, inexpensive variable-depth immersion pump for small-scale irrigation systems. Also, it would appear that for provinces such as Nueva Ecija wind-powered pumps could be utilized. Preliminary research indicates that chemically treated membranes derived from fibrous vegetable matter could make excellent and inexpensive water proof liners for irrigation ditches and small canals.

c) Fish farming. In previous years, fish raised in the rice paddys were the source of additional subsistence or cash-crops. In the Philippines, fish have disappeared from the paddys. Many believe that this has been caused by the use of fertilizers and pesticides. Research is needed to more precisely determine the causes and find a solution.

B. Indonesia

1. Some Background Notes

With a population of about 140 million people, Indonesia is the fifth largest country in the world. A per capita income of about $100 (measured in 1973 prices) also makes it one of the world's poorest countries. Open and disguised unemployment and a continuation of massive rural-to-urban migration are some of its most serious problems. Yet, Indonesia is rich in oil and natural resources with vast unexploited lands. It has shown a steady growth rate over the last few years in both the agricultural and industrial sectors but it is not yet self-sufficient in rice production, which is a rather alarming fact given the estimates that its total population will increase by 100 million people over the next twenty-five years. This also has great significance in terms of political/social balances and its dual development goals of growth and equity.

The Government of Indonesia (GOI) has not been unaware of these problems. Agricultural development, employment, improved income distribution and population control have been primary development objectives for the past several years. However, there seems to be an excessive capital-intensive bias in the economy which may have contributed to some of these distortions. Several factors have contributed to this bias. Its rich natural resource bases has attracted foreign investment and with its capital-intensive technology. Oil and other primary product exports have also brought in the foreign exchange earnings by which Indonesia could afford to import capital goods. Substantial foreign aid, with its own orientation towards advanced Western technology, also may have contributed to a capital-intensive economy. There is evidence that Indonesia is now "rethinking" some of its development strategy and is beginning to question the wholesale importation of Western technology. In fact the labor displacement issue has become so sensitive, there is danger that policy decisions may shift to the other extreme. Indonesia has not yet found a comfortable path to the dual goals of growth and equity and has not yet come to grips with the question of technological choice and its impact on employment.

2. Attitudes Towards Appropriate Technology

In a country as diverse as Indonesia, it would be unrealistic to think that a complete and totally accurate picture of attitudes towards something as far ranging as appropriate technology could be gathered with limited time and travel. At best, this approach can only yield a few indicators and sketches, which in this survey are confined largely to the rural sector.

In the rural areas, particularly on Java, it is important to understand that farm holdings are very small, with the majority less than one hectare and many as small as one-half hectare. This will not support a family even on a subsistence level. Thus, a farmer's income comes from many sources. The farmer and his wife and his children are also laborers in other farmers' fields much of the time. It is estimated that as much as seventy percent (70%) of rice production is done by hired labor. Java probably has the most intensive rice production in the world. As many as 950 women are involved in one way or another in the harvesting and post-harvesting of one hectare of rice. Hundreds of harvesters thus share in the rice crop. This process has been referred to as "shared poverty". While it is a way to distribute wealth (or poverty), it causes many problems for the farmer whose crop is being harvested. Large losses in production are incurred because of trampling, droppage, shattering, and stealing. Farmers have resorted to various ways to cut these losses such as selling the rice crop to middlemen before the harvest. The middlemen then control the harvest and do not have the same degree of social pressure to use so many harvesters.

Small-scale technology could and has reduced these losses but at a price. A dramatic example of the impact of new technology on employment in rural Indonesia concerns the introduction of rice hullers as opposed to the traditional handpounding of rice by women. It is estimated that the rice huller, while increasing output (some estimate 5 or 6%) has displaced about 125 million woman days of labor annually, which represents $50 million dollars in wages a year. Another illustration concerns the introduction of the new high yielding rice varieties of the Green Revolution. These varieties shatter more easily than the traditional crops, which are harvested by women using the "ani-ani" knife. The knife is hand-held and used to cut one stalk (panacle) at a time. The stalks are bundled together and carried from the field. The villagers know that a sickle should be used on the new varieties but many are reluctant to do so for fear of the economic and social consequences. Those that do, automatically displace a great deal of rural labor.

These are but a few examples of how even simple technology can affect the economic and social relationship of a country like Indonesia. The labor displacement issue is highly sensitive and affects most attitudes towards any kind of rural technology that departs significantly from the traditional. It particularly affects attitudes towards the introduction of small-scale I.R.R.I.-type farm machinery. Unfortunately, the I.R.R.I. equipment has become synonomous with appropriate technology among many Indonesians. For this reason, Indonesia recently declined to participate formally and fully in I.R.R.I.'s "outreach" program. This represents a setback in terms of understanding its concept and application. As will be seen later, however, Indonesia is now participating in this program on a "semi-formal" basis. Also for the same reasons, most of the imported small-scale Japanese tractors and other farm equipment have failed commerclally in Indonesia. Many officials flatly predict that the I.R.R.I. and similar Japanese machines will have no future in Java. This is not a unanimous or universal attitude, however. The chief reason for the debate is that, despite the abundance of labor in rural areas, there appear to be labor shortages during the peak periods of land preparation and harvest. This has been caused in part by the new seed varieties and increased uses of fertilizer which permit double-cropping but require quick land preparation between harvest of the first crop and the planting of the second. It is also caused by a declining water buffalo (kerbau) population.

In this debate, one sees the constant dilemma between growth and equity, employment and output, and the lack of any research that would put the issue to rest one way or another. From studies that have been done, however, there seems to be little doubt that the use on Java of such small-scale equipment as the power tiller and the power thresher is definitely labor displacing. One study indicated that without commensurate increases in production, employment losses for each 5-7 hp. power tiller used at a three-fourths utilization rate were 128 man-days per year when displacing a water buffalo, and 688 man-days per year when displacing manual methods (contrary to the Philippines, manual labor has been used as extensively as animals in land preparation). When is it efficient for a farmer to own a small tractor? One study estimates that in rice farming a farmer with a "padi tractor" should own about seven hectares and have effective control over 20 hectares, i.e., by leasing additional land or leasing the use of the tractor. This amount of hectarage does not fit the pattern of average holdings on Java. It also gives weight to the argument that the newer technology, even small-scale equipment, may impact adversely on the lowest income groups.

Attitudes towards small-scale equipment change drastically when related to the trans-migration areas. These area will be settled by Javanese families. The average-sized holdings will be from three to five hectares. Considering the amount of clearing that will be necessary, plus the harder soil and the problem with alang alang, (a pernicious jungle growth) this is more than a farm family can handle with hand labor and traditional tools. It is probably more than can be handled with animal-powered equipment. Hence, the interest in appropriate technology and small-scale mechanized equipment for these areas.

In summary, the general attitudes in Indonesia towards technology are somewhat confused and diverse. The country is only now beginning to correct what has been a strong capital-intensive bias. Attitudes towards intermediate or appropriate technology vary from apathy to misunderstanding to a high degree of awareness. Those most knowledgeable believe that the problem is not one involving concept but rather confusion in how to go about making the right technological choices. There is a favorable disposition towards international assistance but few ideas

exist as to specifically how this assistance should be directed. It is clear that the labor displacement issue is ultra-sensitive and for this reason appropriate technology efforts must be approached with great care. There is also a concern for the conflict between technology and the environment and a strong feeling that appropriate technology activities must be indigenized to the extent possible in order to avoid conflict with cultural traditions.

3. Major Activities and Applications

A productive survey of appropriate technology activities and needs in Indonesia would take many weeks if not months. The following represents at best the barest of samples.

a) The Institute of Technology at Bandung

On a conceptual level, the Development Technology Center (DTC) at the Institute of Technology at Bandung (ITB) is probably the major catalyst for intermediate or appropriate technology efforts in Indonesia. The DTC is three years old. It has an able Director and is staffed by highly trained and motivated people. As part of a national institution, the DTC looks at appropriate technology in a broad sense, as an avenue for "better living" for rural peoples and is, therefore, interested in a broad range of technological improvements and adaptations. The DTC has laid out three stages for its appropriate technology activities. The first stage which DTC refers to as "software" is the identification, training and motivation of select groups of rural entrepreneurs. In addition, the DTC attempts to provide technical assistance to rural entrepreneurs to complement a fairly sizeable and accessible Government-sponsored credit program for small-scale enterprise. To date, over one hundred entrepreneurs have been assisted, mostly from the Bandung area. The DTC is attempting to involve the entire banking community as well as several Government ministries in this effort.

The next stage will be to set up an information center, or a clearing house system to get at the dissemination side of appropriate technology which the DTC sees as the priority problem. Assisted by international experts, the DTC hopes to establish important links with most of the international institutions and to establish downward linkages with regional institutions in Indonesia. As a further stage, the DTC also plans to get into the development, testing and adaptation of appropriate hardware in such areas as food processing, food preservation and storage, clean water systems and pumping equipment, waste utilization, energy generation (solar, wind, hydro, bio-gas), and low-cost construction of bridges, housing and irrigation works. Some specific projects either active or contemplated are a coconut dryer, more hygenic processing of "tempe" (fermented soybean cake), a solar water distillation unit (adapted from a Brace Institute design), adaptation of the "Sofretes" water pump, a bio-gas digester (at Lembang), solar water heaters, dryers and refrigerators, and a windmill pump. Also as part of the hardware development stage, the DTC hopes to set up three experimental field stations--one will be in a fishing village, the second will be in an isolated agricultural village (accessible only by boat) and the other will be in a village that is in transition from agriculture to handicrafts and small industry. Mobile shops will be available to serve these stations. In this way, the DTC hopes to accomplish realistic testing, development and demonstration, but more importantly, to involve the villagers in each of these locations as participants in the process.

The ITB-DTC has made a valiant start in the appropriate technology field. It has established good linkages with the Government and with international institutions but is under-staffed and under-funded for the goals it has set. While it is in a good position to influence Government

policy, its greatest challenge will be to serve as a model and catalyst for the several regional centers of technology in Indonesia. This network will not be easy to establish given the tremendous distances and communication problems of Indonesia.

2. Farm Machinery Testing Program

The Sub-Directorate of Mechanization of the Food Crops Division of the Department of Agriculture located at Pasar Minggu (a few miles from Jakarta) is practically the only Government agency involved in testing small-scale farm equipment. It is serving as a sub-contractors for I.R.R.I. but not as part of a full and formal I.R.R.I. "outreach" program. It takes the basic approach that agricultural production, particularly in rice, soybeans and peanuts, must be increased substantially. This, therefore, calls for an intensification program in terms of irrigation, land preparation, fertilizers, insecticides and improved seed varieties, which in turn requires selective mechanization in carefully determined areas. The program is very sensitive to the labor displacement problem and for the most part it selects areas where the average holdings are five hectares or above, where the animal population is small, and near big cities where farm labor tends to be scarce. In addition to the increased production objective, the program also is dedicated to taking some of the drudgery out of farming.

Tests are conducted by the Extension Service on farmers' land. This includes big machines for plantation production and small-scale equipment (up to 15 horse-power) for smaller holdings. The program also tests some hand-powered equipment such as hand-held sprayers but this does not seem to be a major emphasis of the program. The tests are also coordinated with the Ministry of Industry to determine if spare parts can be manufactured in Indonesia. The small-scale farm equipment tested thus far has involved I.R.R.I.-designed machines and imported Japanese equipment. The Food Crops Division has no equipment design capability similar to that of I.R.R.I., although it has experimented with the local manufacture of these machines with one or two small entrepreneurs on a sub-contract basis. Apparently this has failed to generate much commercialization because the small manufacturer in Indonesia lacks the kind of credit that allows him flexibility in taking risks.

The results thus far of the Farm Machinery test have been limited. The staff is convinced that there is a large demand for small-scale farm equipment due to peak period labor shortages and a decline in the water buffalo population. One small roto-tiller of the type imported from Japan has been adapted, improved and is being marketed in Indonesia. A locally-adapted irrigation pump has proved successful and has contributed to an increase in production in the test areas. Unfortunately, not much testing and adaptation seems to be in progress in the transmigration areas, which offer the best potential for small-scale equipment and are relatively free of the labor displacement issue. It also appears to be missing the great mass of low income farmers with holdings of one hectare or less.

3. The Institute of Agriculture at Bogor (IPB)

The IPB is one of the main agricultural experiment stations of Indonesia at which there is a small Institute of Technology and Mechanization. The Institute has conducted some limited experiments in design and adaptation of both traditional and modern farm equipment. The basic concept is somewhat unique and interesting. Intermediate technology is seen as improved versions of traditional technology while appropriate technology is one that combines traditional, intermediate and advanced technologies. Earlier efforts to concentrate solely on intermediate technology failed and were abandoned in favor of a more

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mixed approach. Experiments thus far have included testing and adaptation of a soybean extruder, tractors of various sizes, a seed planter, and a coconut cleaner. Like the Sub-Directorate of Farm Mechanization, the emphasis is on selective and gradual mechanization.

The IPB has established arrangements with the Tool Foundation (Netherlands). IPB also wished to establish an arrangement with the East-West Center at Honolulu but lacked the necessary funds. Very few working relationships with the Institute of Technology at Bandung or other Indonesian institutions were apparent.

4. Other Activities and Applications

The balance of the appropriate technology effort in Indonesia appears to be relatively minor and scattered. In all fairness, this may be the fault of the time and geographic limitations of the survey. In any event, the following are the other major activities that came to the author's attention:

a) British Assisted Renovation of Irrigation Works

Two British teams have organized a village-level program for the renovation of irrigation works in East and Central Java. Many of the tertiary and lesser irrigation canals and headgates in these areas have fallen into disrepair. The British teams have devised a system for cleaning and restoring these canals using local materials and village labor. The headgates are being made by village blacksmiths and metal workers using simple tools and methods. It is expected that this kind of a project will have a significant impact on agricultural production at a relatively low cost.

b) Bio-Gas Conversion

There is a small Ford Foundation project at the Gajah Mada Institute in Jogjakarta. A similar program is underway on Bali, and as mentioned earlier, at Lembang. Like most of these projects, they are still experimental and have not been advanced to the point that they can be commercialized successfully.

c) The "Butsi" Program

"Butsi" is the Indonesian equivalent of a domestic peace corps which like VITA of the United States operates a village technology unit. Its main purpose is to demonstrate to villagers how they can make simple low-cost improvements in their daily lives through better water and sanitary facilities, better agricultural methods, etc.

d) Small-Scale Rural Industrial Credit Program

The Bank of Indonesia has approved the equivalent of $120 million in GOI funds to assist small-scale rural entrepreneurs with working and investment capital. Almost any kind of small-scale industry is eligible, and up to 10,000 rupiahs can be loaned for working capital. The sector breakdown of loans approved to date is: Agriculture-19%; Industry-28%; Trades-32% and transportation-14%. In terms of appropriate technology, the missing ingredients in this credit program have been technical assistance and supervised technological transfer to accompany the financial assistance. This may be partially remedied by a proposed complementary World Bank technical assistance loan under which cadres of foreign experts could be financed.

5. Major Research Priorities

The range of possible applied research activities in the area of

appropriate technology in Indonesia is extensive, given a continuation of the Government's current development objectives concerning income distribution and employment generation. The following are only a few of these possibilities--

a) better hoe - the locally produced hoe tends to last only a few months. Those imported from Europe last a couple of years. A better hoe could be produced by small manufacturers if shown a better technology.

b) cold box - for keeping fish for fish farming in the wetland rich areas.

c) better extruder for soybeans and other nutritional products--something in between the large inefficient machine now being used and the more primitive methods.

d) locally produced low-lift irrigation pump. Also there is a need for small turbines to produce hydroelectric power on a small scale. It is reported that there is not one Indonesian irrigation economist in the country.

e) machine-developed building materials, e.g., bamboo designs or wood and cement mixtures.

f) shipbuilding. There is a large demand and need for more small to medium-sized water craft for transportation of cargo and people between the islands. A better technology is needed to increase the production, efficiency and safety of water-craft without inordinate displacement of labor. Labor displacement apparently is already occurring among the fishing fleets where motor-powered trawlers are replacing sail-powered vessels. There has been a decline in the number of fishermen, a decline in the income of sail-boat fishermen and an overall increase in the annual catch. There is also a need for a simple ship-to-shore communications system.

g) revival of the blacksmiths trade which is dying out due to competition by large foundries and metal working firms. Previous outside help in this area has been unsuccessful.

h) small-scale post-harvest rice and grain processing equipment, especially equipment for threshing, drying and storing. It is not clear if the I.R.R.I.-designed equipment would be appropriate without significant adaptation. The pedal or hand thresher would seem ideal for parts of Indonesia but even this simple technology may displace too much labor. Better village-level storage is a must.

i) development of a trans-migration research and application package. Some ad hoc research and application has been done for the trans-migration areas but a more integrated "package" approach should be considered. This could include everything from hand tools to bio-gas converters. It is especially true of the proper mix among hand-powered, animal-powered and engine-powered equipment. One suggestion is that cattle be furnished the trans-migration settlers as a source of food, animal power and one way to control alang-alang. It is certainly clear that much of the small-to-medium-scale agricultural equipment is more suitable to the trans-migration areas than to densely-settled Java. Research could also be done on an all-purpose vehicle for these areas, similar to the Jeepney and the Fiera of the Philippines.

j) "zero-tillage" or intense cropping concept of rice cultivation now under observation in the Philippines, may have great utility for the rice growing regions of Java where land holdings are so small.

k) Regional adaptive training centers offer one of the best areas in which to expand. The development and diffussion of appropriate technology in Indonesia is one of the areas in which international assistance could be most effective. In addition to increased financial support, an information network needs to be established among these institutions, and between them and national and international-level organizations. Some of the more specific needs expressed to the author were:

- a country inventory of on-going appropriate technology activities.
- an in-country information and "clearing house" system to promote the concept and diffuse existing information.
- a fund to finance high risk starts among innovators and small-rural entrepreneurs.
- outside assistance with designs and systems to develop a critical mass of understanding and awareness of the possibilities and potential of appropriate technology.

C. Sri Lanka

1. Background Notes

Sri Lanka is currently faced with a stagnant declining economy and high levels of unemployment. This has come about over a period of years and is principally due to declining markets and prices for its primary export products (tea, rubber, coconuts), increased costs of imports and population growth caused basically by decreased infant mortality and death rates. During better years in which exports were booming, Sri Lanka established a high level of social welfare services which allows most of the population wide access to medical services, education and even subsidized food allowances. The problem is that the country has attempted to maintain this standard of living in the face of declining national income. For the past several years per capita income growth has not quite kept up with the annual birth rate of approximately 2.5%, foreign exchange reserves have fallen, imports have been curtailed and unemployment has risen over 20% and Sri Lanka is now heavily dependent on foreign assistance.

Food accounts for almost half of Sri Lanka's annual imports but agriculture is clearly Sri Lanka's most important sector. It accounts for more than one-third of the Gross Domestic Product and well over half of the national employment (as much as 80% when calculating agriculture's indirect impact on employment). Tea, rubber and coconuts are the country's chief foreign exchange earners and are raised under plantation conditions. These plantations recently have been taken over by the State. Rice is the principal domestic food crop followed by manioc, kurakkan, corn, sorghum and soybeans. The country is rather sharply divided into a northern dry zone and the southern wet zone. Three-fifths of the area under cultivation is family farms that range from one-half to two and one-half acres in size. The rural areas are served by comparatively good roads and toehr communications and social services. Sri Lanka has been spared the massive rural to urban migration problems of other countries. Yet unemployment is highest in the rural areas.

The industrial sector is divided basically into four categories: large private factory industries producing mostly consumer goods; medium to large public industries producing intermediate goods (iron, steel, refined petroleum products, chemicals, etc); small private industrial activities such as power looms, coir and coir products, handicrafts and cottage industries; and small to medium-scale public industries and industrial cooperatives producing a wide range

of products such as paper, leather, ceramics, oils and fats, plywood, cement, sugar, textiles, tires, tubes, hardware, small-scale machinery, rice milling and so on. There has been an increase in public industrial activity over the past few years as these enterprises have had the most access to scarce foreign exchange.

Sri Lanka, historically, has been heavily oriented towards imports. As the foreign exchange squeeze developed, import substitution was encouraged but without regard to efficiency, comparative advantage or employment effects. This encouraged capital-intensive industries that required large imports of raw materials, components and Western technology, thus placing an increased strain on foreign exchange reserves in the face of declining exports and mounting unemployment.

Government policy for the past few years has been directed towards restructuring this industrial pattern by emphasizing low capital-intensity products located to the extent possible in rural areas; by the establishment of public industries in order to produce domestically basic inputs for other industries; and by orienting the rest of the industrial sector towards exports that reflect Sri Lanka's comparative advantage. Sri Lanka has moved slowly in these directions over the past few years. Imports are controlled centrally under a licensing arrangement. It also provides a point for "screening" technological choices. Several light engineering cooperatives have been established. A State Hardware Corporation has been put into operation. Incentives have been established for increased exports, e.g., import licenses are granted more quickly to those industries that have potential for earning foreign exchange. It will take several years, however, for Sri Lanka to overcome its most serious economic problems.

2. Attitudes Towards Appropriate Technology

Sri Lanka's development planning efforts are well oriented in the direction of appropriate technology. Much of the national planning documentation could be chapters in an appropriate technology textbook. In fact, it appears that intermediate or appropriate technology was in progress in Ceylon long before anyone invented the current terminology. The author was told that early versions of the two wheel tractor had been developed on a small scale in Ceylon some twenty years ago. The point is that there is by and large a high degree of understanding and awareness of appropriate technology concepts among a large number of public and private sector Ceylonese, many of whom are able to intellectualize the concept as well or better than Western theorists and practitioners.

Appropriate technology, import substitution, conservation of foreign exchange, indigenization of technology, employment generation self-help and national pride are almost synonomous in the minds of many Ceylonese. Opinion is divided, however, on how to go about implementing the concept. There is a definite sensitivity to the "foreign expert" who along with Western-oriented Ceylonese planners and entrepreneurs are sometimes blamed for overselling and importing Western-technology in the past and for not looking inward at Sri Lanka's own resources and factor endowments. Aid agencies are chastised for not being more flexible in their aid-giving approaches (e.g., program versus project aid) and for insisting that "foreign experts" must do the studies, etc. It would appear that this generally widespread orientation towards appropriate or intermediate technology is the product of several factors. One, it seems to come naturally to many Ceylonese, almost as an extension of the culture. Second, the high literacy, access to education facilities and relative ease of communications undoubtedly have also helped in the spread of technological

information. Lastly, the foreign exchange crisis and drastic reduction of imports, and alarming levels of unemployment have all been catlysts in developing a "let's make it ourselves" attitude. A major shortcoming to date, however, appears to have been the time necessary to translate attitudes and plans into actual output-oriented programs. Part of the problem lies in interagency communication and policy coordination.

Dr. Schumacher has visited Ceylon many times and has developed a rather large group of supporters and admirers. Several Ceylonese are internationally recognized authorities in the field of appropriate technology and are frequent participants in appropriate technology symposia. Most of the attitudinal and conceptual approaches to appropriate technology in Sri Lanka conform closely to the Schumacher model. One wonders which came first--the Schumacher school or the Ceylonese model. One difference is that the Ceylonese model is more heavily flavored with ideology (anti-imperialist, anti-materialist, anti-foreign-expert and anti-Western technology rhetoric). This is not a critical statement. It simply emphasizes some of the sensitivities and the fact that many Ceylonese look at the concept of intermediate or appropriate technology not in simple economic terms, or solely in terms of the conflict between employment and output but rather in humanistic terms and as a practical extension and application of Buddhist teachings.

3. Major Activities and Applications

The majority of appropriate technology activities observed pertained to the rural sector but were representative of what appear to be a wider range of experimentation and application going on in other sectors. Following are the major applications of which some first hand knowledge was gained.

a) The Ministry of Planning and Employment

This Ministry is a major nucleus for conceptualizing, planning, organizing and to some extent operating several kinds of appropriate technology activities, or "peoples technology" as they were referred to in the Ministry. These activities are briefly described below.

1) Blacksmiths

The Ministry's first program was to organize village blacksmiths into light industrial cooperatives. At least 45 of these were claimed to have been established in 14 districts involving over 12,000 blacksmiths. The main features of the program are that the worker is not separated from his workplace, that he has the prospect of owning his own business in his lifetime, and that he is initially provided with inputs (raw materials, tools, etc) and market outlets "without the intervention of middlemen". Technical assistance was furnished by Government and volunteer university graduates. These cooperatives are turning out simple tools and implements which were previously imported. It has also revived a craft which was slowly dying because of imports and larger-scale domestic competition.

2) Medium-Scale Industrial Cooperatives

Medium-Scale Industrial Cooperatives were the next type of cooperative to be organized beyond the blacksmiths and small-scale metal workers. The fundamental reason for organizing these two levels of cooperatives is to achieve import substitution in the agricultural sector, where even simple tools and implements are being imported. The Medium-Scale Industrial Cooperatives are cooperatives of small machine shops, welding shops, and foundries in various

districts. The Cooperative is provided with a technical center for quality control and systematic production of small-scale agricultural equipment. Each technical center is equipped with a heat treatment plant, metrication center, an assembly area, and a central stores and sales area. It was reported that eight of these Medium-Scale Industrial Cooperatives are operating in Sri Lanka.

One such cooperative was visited near Colombo in the small town of Nugegoda. This Cooperative employed about thirty people and was concentrating on the manufacture of a small two-wheel tractor. The target is to produce 20 tractor units per month in each location. The first units were sold in late 1975 and since then production has been averaging about 10 to 15 units per month at each center at a cost of about 4,500 rupiahs each (about U.S. $600). The engine, wheel belt, bearings, sheet metal and drive chain are all imported. The remainder of the machine is made in Sri Lanka. There is little quality control but thus far there have been few complaints and the farmers have access to the regional technical centers for major repairs and adjustments.

The demand for two-wheel tractors was estimated at 4000 to 6000 per year. Yet the full production of these cooperatives would only be a little over 1000 per year. There appear to be several reasons for this discrepancy. As mentioned earlier, there is a national controversy over the two-wheel tractor. One faction, the Ministry of Planning and Employment and others, favor the local production of the I.R.R.I.-type tractor to fill the entire demand. Another faction, mainly in the Ministry of Agriculture, favors the more sophisticated Japanese two-wheel tractor of which about 1200 are imported annually. Their argument is that the imported model is better, more maneuverable in the field, and is what most farmers want. A second factor in the low production of the local version is the flow of raw materials due to foreign exchange shortages and import restrictions. However, a shortage of steel imports and scrap metal resulted in a novel and innovative project a short time ago. A small group of skilled metal workers broke up two ships anchored in Sri Lankan harbors for scrap. Plans are to buy obsolete ships and do more of this in place of importing the steel.

3) Pottery and Pharmaceuticals

The Ministry has established other programs to organize the country's pottery, ceramic and pharmaceutical industries. Clay pots were actually being imported while this ancient craft was dying in Sri Lanka. These potterers cooperatives were furnished up-dated tools and kilns and were given technical and financial assistance. Likewise an effort is being made to organize the "native doctors" and pharmacists. The latter is part of a multi-agency effort to establish in Sri Lanka intermediate processing of herbs into pharmaceuticals and teach "native doctors" and pharmacists how to administer these medicines. This is an interesting scheme, apparently based somewhat on the Chinese "barefoot doctor" model and some basic economics. Sri Lanka grows many herbs and roots that are used in the pharmaceutical industry in the West. Herb medicine has been practiced by "native doctors" in Sri Lanka for centuries. Up until recently these herbs were exported to Europe where they were processed into modern pharmaceuticals, some of which were shipped back to Sri Lanka at high prices for consumption in the modern sector. Herbs are still exported in order to earn foreign exchange but increasingly intermediate-level pharmaceuticals are made in Sri Lanka for domestic consumption. The author observed one herb that native doctors prescribe in raw form for sore throats. These same herbs are now processed in Sri Lanka into a liquid cough medicine called Valmelix.

b) The Industrial Development Board

The Industrial Development Board (IDB) is part of the Ministry of Industries and Scientific Affairs. It's function is the promotion and development of small-scale industries. One of its major functions is the development of machinery and organization of the local manufacture of machinery for the small-scale sector. It also conducts several experimental projects. Under the latter category, projects of interest include--the development of a high quality banana fiberboard, coir dust board, bricks made from rice husks and fuel briquettes from peat, and quality hand-made paper. The IDB also will give further technical assistance to the fledgling small-scale straw board co-operative industries that have been started in eight locations, to small manioc starch plants, eight small safety match plants, coconut and palmyra jaggery, and roofing tile plants.

The machinery development program has concentrated on such things as the two wheel tractor and tractor trailer, a single roller cotton gin, a bench lathe and a methane gas generator. The bench lathe has been fully developed as has the methane gas converter. Special credit programs are planned to demonstrate and popularize the gas converter for use by private individuals. The IDB is also involved in the manufacture of small engine-driven and bullock-driven sugar cane crushers. For the future, the IDB will initiate research and experimentation on a hand-operated sugar crusher, dipping machine for leather goods, wood turning lathe, fretsaw and a hand corn sheller.

Another important part of IDB's programs is its small-scale across-the-board industrial credit program. The IDB can now make loans to small entrepreneurs of up to 250,000 rupees.

c) The Farm Machinery Research Center (FMRC)

The FMRC is located at Maha Illuppallama in the North Central province. This is part of the Engineering Research and Development Division of the Department of Agriculture and is the only organization in Sri Lanka that does farm machinery research. This includes machinery design, testing and evaluation, including field trials and evaluation of the effects of mechanization. The FMRC was set up in 1968 to evaluate the large and varied amounts of farm machinery that had been imported into the country since the end of World War II without regard to its suitability for local agricultural conditions. The FMRC's work is done in conjunction with the Agricultural Implements Factory located at Welsira, which will be discussed later.

The FMRC has conducted research on a wide range of farm implements but has given preference to seeding and threshing equipment. More emphasis has been put on adaptation of foreign equipment than on new design. Results thus far among mechanized equipment evaluated seem to favor engine-powered threshers and adaptation of imported Japanese two-wheel engine-powered tractors. The FMRC has tested a pedal thresher and two or three versions of wetland and upland hand seeders. They appear to be the most suitable for Sri Lanka's agriculture. A simple hand weeder has been modified and put into mass production.

d) The Agricultural Implements Factor

The Agricultural Implements factory at Welsira (a short distance from Colombo) is the production side of the Ministry of Agriculture's farm machinery development program. If FMRC tests and adaptations prove favorable, the Implements Factory then produces

the equipment according to estimated demand. This factory has turned out an impressive array of small-scale equipment, but in relatively small quantities. Following is a partial listing of items being produced at Welsira: tractor cage wheels, ridger points, chick feeders, winnowers, galvinized water tanks (400 gallon capacity), galvinized buckets, egg trays, poultry feeders, wheel barrows, ploughs and plough shares, animal cages, bee boxes, incubators, paddy bins, grass cutting knives, axial flow threshers, hand-pushed seeders (four types) and weeders, and a hand-operated centrifuge pump for extracting honey.

The Welsira factory is also building prototypes of the I.R.R.I.-type coaxial thresher and a simple grain cleaner. One of the more interesting adaptations is the development of a foot pedal thresher modeled after the Chinese and Indian models. It is also building a modified I.R.R.I. axial flow thresher which, it is claimed, represents several improvements over the I.R.R.I. design. It is estimated that there is a potential demand for about 12,000 power threshers in Ceylon. There is also a high demand for several thousand foot pedal threshers which can be adapted to an engine power source, e.g., by a pulley off the two-wheel tractor. The Welsira factory has given equal attention to hand-powered equipment. It is now producing second and third generation hand-powered weeders and seeders. In each of these the greatest attention was given to simplifying the design and substituting local materials for those that must be imported, e.g., wood for steel. When demand for these items reaches a certain level, production is turned over to the private sector.

Even in hand tools, however, there are difficulties in achieving import substitution. One of the best examples is the mammoty, a large, rather heavy, short-handled hoe, which many small farmers use for a variety of tasks including tillage. The size and shapes vary within the country, depending on customs and soil conditions. At one time these were all imported from Europe. Now none are imported and the farmers are unhappy with th local versions. It doesn't last as long and doesn't have the same feel and balance. The same thing is occurring with the two-wheel power tiller. The local versions (I.R.R.I. design and Landmaster varieties) are not as popular as two or three models of Japanese tractors. The main reason seems to be maneuverability. The Japanese models have steering clutches; the I.R.R.I. type does not. There may be a prestige factor at work also. There is pride in owning the fancier model and farmers like the chance to show it off when hauling produce and family to market.

e. <u>The Farm Mechanization Training Center (FMTC)</u>

The FMTC, which also is part of the Ministry of Agriculture, was established in 1971 near Anuradhapura under a cooperative agreement between Sri Lanka and the Federal Republic of Germany. The German assistance has involved the complete equipping of the Center with modern tools, machinery and training materials, as well as furnishing a team of German experts for technical training, advisory and extension services. The Center is surrounded by a hundred acres which are used for field trials and crop production. The main purpose of the Center is to offer technical training at a variety of levels on farm mechanization. Training programs of varying lengths are conducted for farmers, agricultural students, public and private repair shops on farm machinery functions, maintenance, repair and the economics of farm machinery. Depending on the group, special training is offered on two-wheel tractors, four-wheel tractors, water and irrigation pumps, pesticide and fertilizer sprayers, welding, forging, lathe operations, diesel engine repair, transmission repair, etc. In this manner, the FMTC complements the work of The Farm Machinery Research Center and the Agricultural Implements Factory in the area of small-scale farm mechanization. The agricultural extension agent plays an

important role in tying these activities together at the farm level. An additional spin-off of the FMTC is the creation of semi-skilled craftsmen and mechanics for the rural area.

f) The Somisiri Huller Manufactory

The Somisiri Rice Huller Manufactory is one of twenty or more small-to-medium-sized manufacturers of small-scale farm equipment. Somisiri began in 1942 with the manufacture of a rice huller. The original huller has gone through several modifications since that time and the company now produces other farm equipment, including the small two-wheel tractor. It also makes parts and components on a sub-contract basis for one or more of the Medium-Scale Industrial Co-operatives which are making and assembling small-scale farm equipment.

If Somisiri is typical of other small-to-medium shops in Sri Lanka, the country has an excellent base from which to build a dynamic and innovative small-scale industrial sector. Typical of the Somisiri operation is the fact that it is currently working on a technology by which a small diesel engine could be manufactured in Sri Lanka. Somisiri is now the only manufacturer of gear wheels in the country. Several years ago, after a long search, the owner of Somisiri discovered the gear wheel technology he had been looking for. It was found in a small two-man shop in a remote rural area of the British Isles. It was easily adapted to the Somisiri operation in Sri Lanka and the company has been producing quality gear wheels since. This same innovative drive is what has prompted the search and experimentation for a locally-produced small gas combustion engine. Somisiri is convinced that it can be done and that Sri Lanka cannot develop its full potential in appropriate technology until it can produce its own gasoline power source since all adaption of mechanized equipment now must be built around imported engines and other difficult to make components. In addition to profit, and the thrill of innovation and discovery, there is an obvious national pride at work among innovators like those at Somisiri.

g) Summary

The foregoing represents only the barest sketch of what is going on in Sri Lanka in the fields of intermediate or appropriate technology. If a complete inventory could be made of all on-going research and applications efforts, it is the author's belief that it would add up to a surprisingly full and comprehensive picture. Despite its previous history of mindless importation of inappropriate technology up to 1968, there is now a relatively wide-spread sensitivity to the concept of appropriate technology and its importance for Sri Lanka. There appear to be several reasons for this. First is the foreign exchange squeeze which has developed an import substitution consciousness. This attitude even pervades larger-scale and more capital intensive activities. For example, a modern rice milling complex is being built in Anaradhapura with the help of the UN's Foreign Agricultural Organization (FAO). Although it is being built of largely imported materials, plans are already underway to substitute local materials and to interest local manufacturers in making as many components as possible before replicating this rice milling complex in twelve other locations. The second major reason is that Sri Lanka is blessed with what appears to be a great number of highly trained, gifted and innovative planners, technicians, and entrepreneurs who understand the concept of appropriate technology thoroughly and who are attempting to do something about it. A major problem may be the lack of coordination in policy formulation and execution. With so much of the organization and operation of the economy in the hands of Government institutions, there is room for conflict and duplication.

The case of the two-wheel tractor (i.e., produce locally or import) is a good example of this. The author was told this policy conflict between import licensing on the one hand and the stimulation of local small scale industry on the other exists in other product areas.

Sri Lanka offers a productive area for further research and study. This is not to suggest that it become a laboratory for the world, but considerable further research needs to be conducted in the area of appropriate technology for application in Sri Lanka and for possible application elsewhere. One of the areas in which further research is required in Sri Lanka is in the agricultural areas scheduled for irrigation. With the diversion of the Mahaweli River, thousands of acres of dry land will come under irrigation. This will make it possible to use an ancient "tank" system of irrigation and restore rice and other production to bottom lands. In order to diversify agriculture and increase production, the Ministry of Agriculture is attempting to introduce "hillside" farming into several mountainous and semi-mountainous areas. This is a form of farming that does not belong to Sri Lanka's ancient past and, therefore, an entire new and "appropriate" technology must be developed for it. This includes water control, equipment, land preparation as well as the appropriate seed and soil technology.

In the farm sector, the Government seems committed to mechanization as a means of increasing production. Current research emphasizes the smallest scale of mechanization. This is a reaction against the inappropriate equipment that was imported into Sri Lanka between 1944 and 1968. It also stems from a conviction, fairly pervasive, that improvements in animal-powered equipment are not the answer. To the extent that Sri Lanka cannot produce its own appropriately-scaled equipment, the dilemma is often seen as a choice between "shiploads of rice or shiploads of two-wheel tractors". More than once the author heard statements such as "the person who objects most to mechanization comes from the West." Also, among innovators and practitioners, there is a feeling, like some in the Philippines, that animal-powered equipment is about as good as it can be made and that if one tinkers with it too much, its technological balance will be upset and it will become even less efficient.

In Sri Lanka, like several other countries, there is a trend toward greater mechanization without a solid data base concerning the impact of small-scale equipment on increased production, farm income and employment in the rural sector. This, along with rural industrialization and information dissemination, is probably one of the most urgent research priorities in the field of intermediate or appropriate technology. Within this context, land preparation and post-harvesting appear to be the most important areas to which more attention should be devoted. Another area for research and possible international assistance is in the area of organizing production systems. Many Ceylonese believe that a sufficient design and innovative capability exists but that help is needed in organizing production more efficiently. This includes assistance with small plant layout, organizing production and assembly systems, and sources of supply.

PART IV

ON THE ROLE OF INTERNATIONAL ASSISTANCE

> "Appropriate or Relevant or Intermediate Technology with Dr. E. F. Schumacher as its prophet may draw many disciples from among the privileged both in the rich and the poor world. There is nothing surprising in this trend as it is the way things do happen. However, if Appropriate Technology becomes a preserve of the few and if it turns out to be another elitist exercise to which the poor have no access, all your endeavours will end in disappointment and frustration. Therefore, I strongly believe that all Appropriate Technology programmes should be directly related to concrete development actions. The beneficiaries should have direct access from the problem-identification stage to problem-solving experience so that the programme becomes their own." (H. Ariyaratne, "Appropriate Technology", The Ceylon Daily News, March 24, 1976, p. 4).

1. The AID Mandate

In 1973 Congress, by amending the Foreign Assistance Act of 1961, radically changed the directions of United States economic development assistance and concentrated it in three principal areas--food and nutrition, population and health and education and human resources development. Congress also intended that to the extent possible assistance in these areas be directed at reaching the poor majority of the populations of the developing countries. This mandate is contained in Sections 102 through 106 of the Foreign Assistance Act. In 1975 Congress added Section 107 which provides that:

> "Of the funds made available to carry out this Chapter for the fiscal years 1976, 1977 and 1978, a total of $20,000,000 may be used for activities in the field of intermediate technology, through grants in support of ... expanded and coordinated private effort to promote the development and dissemination of technologies appropriate for developing countries. AID shall prepare a detailed proposal to carry out this section and shall keep the Senate Foreign Relations Committee and the House International Relations Committee fully and currently informed concerning the development of the proposal...".

From a review of Congressional Hearings, it is clear that Congress expects AID to go far beyond the language of Section 107. In particular, Congress would like to see established an International Institute of Intermediate Technology. The implication is that this Institute would be in the U.S. private sector with authority to influence AID policies and programs concerning intermediate technology. It is also clear that Congress expects AID to support national institutes of intermediate technology within the developing countries, some of which already exist. Congress is concerned that if intermediate technology is not rapidly institutionalized in the developing countries, the concept will not gain momemtum.

AID is both a newcomer and an oldtimer in the field of appropriate technology. AID and its predecessors have fostered intermediate and appropriate technology kinds of activities around the world since at least the days of Point IV. Small demonstration projects, self-help school construction, small business development, village technology, labor-intensive activities, and popular participation all have been and still are integral parts of AID policies and programs. The small-scale farm machinery development program at I.R.R.I. is sponsored by AID. AID has not, up to this point, focused these activities under the banner of intermediate or appropriate technology, and, in this respect, AID is a newcomer.

Over the past ten years, a surprising number of public and private Appropriate Technology Centers (ATC's) have been established in the industralized and developing countries. These ATC's generally fall into three categories: governmental and government-related agencies, universities and non-profit institutions. Following is a list of some of the main technology centers established to date:

* Intermediate Technology Development Group Ltd. (London);
* Brace Research Institute (Ste Anne de Bellevue, Canada);
* Appropriate Technology Cell (New Delhi);
* Planning Research and Action Division (Lucknow, India);
* Appropriate Technology Development Unit (Varanasi, India);
* Industrial Development Division, Engineering Experiment Station (Georgia Tech, Atlanta, Georgia, USA);
* Volunteers in Technical Assistance (Mt. Rainier, United States);
* Division of Microprojects (Eindohoven, Netherlands);
* Appropriate Technology Centre (Islamabad, Pakistan); and
* Technology Consultancy Centre, University of Science and Technology (Kumasi, Ghana).

This rapid proliferation of national and international institutions dedicated to the development and dissemination of intermediate or appropriate technology is encouraging but it does raise questions concerning duplication of effort and investment. At present there is no division of labor or information or other networks that can tie these institutional efforts together so that research results and other information can be widely shared.

AID is now conducting a comprehensive "state of the art" survey of the entire field of appropriate technology, including discussions with the U.S. private sector in preparation for responding to Cohgress. Although AID has a clear mandate and ample financing authority for an action program, its task is not an easy one. The field of possibilities is immense but there are as many unanswered questions. Opinions vary considerably as to how, at what levels, and in which sectors, appropriate technology should be developed. Therefore, AID must choose its course carefully, least appropriate technology becomes a development cliche, a superficial or redundant effort, or even disruptive to the developing countries.

B. A Few Reminders

It is not the purpose of this paper to present a detailed outline of an appropriate technology assistance strategy for AID or other international assistance agencies. This is left to others who are far more able and knowledgeable. It might be helpful, however, to summarize a few basic insights--call them reminders--developed in the course of preparing this paper which do seem to limit, constrain or otherwise influence, the role of international assistance in the development and dissemination of appropriate technology. They have been prepared with the AID Mandate in mind but could be equally applicable to other assistance programs. The points are by no means inclusive, and some may appear to hammer unnecessarily on the obvious. They are covered in some detail in order to illustrate and support the basic thrust of this paper which is that the nature and characteristics of the concept of appropriate technology severely limit and constrain the role of international assistance. This is not to state that this role is unimportant; it does imply that it must be approached with a degree of caution, and more modestly, imaginatively, and differently than traditional forms of assistance.

1. The Objectives. It is well recognized that conventional development theory has not delivered for over one-half of the world's population..." the poor majority". The theory that rapid industrialization and expansion of the modern sector, utilizing capital-intensive technologies, would cause the traditional sector to shrink and become absorbed by the modern sector has not come about for most of the developing countries. In fact, the disparities between the two sectors have increased in most cases. If technology is not the central issue in this dilemma, it certainly plays an important role. Traditional sector technology has not been able to provide an increase in production orincomes. Much of the modern sector technology has been imported without modification and has been unusable or inappropriate. In other words, there has been a lack of suitable alternatives to these extremes. The result, due only in part to the lack of suitable alternatives, has been low production, low income, rural-to-urban migration and lack of basic services, particularly in the rural areas.

The short-term objective of appropriate technology, therefore, is to fill this technological gap in carefully selected key problem areas. The longer run objective should be the technological independence of the developing countries to the degree that they can make their own technological choices based on their resource endowment and perceived priorities. In terms of international assistance, this means at the outset a progressive passing of initiative and decision making to the developing countries.

2. "We all need humility in the face of what we do not understand." This statement, taken from the dictionary definition of humility, seems to be a particularly apt reminder for those concerned with appropriate technology. Perhaps it should end there out of risk of sermonizing or constructing platitudes. It might be well to be reminded, however, that past development assistance programs have had something to do with the transfer of inappropriate technologies to the developing countries. Developing country planners and international development experts, for the most part, have been trained in the industrialized countries. They have been strongly steeped in and oriented towards advanced Western technology. This has injected a capital-intensive bias into many development assistance strategies, programs and projects.

A basic premise of appropriate technology is that modern sector knowledge can be applied to develop technologies which are infinitely better than primitive methods but which are greatly reduced in cost, scale and sophistication compared to that existing in the

advanced Western societies. It is rather sobering and humbling to ask if Western-trained and Western-oriented economists. engineers and other technicians can suddenly do an about face and apply their knowledge and skills to the small and the simple? The answer is not self-evident. A positivo answer begins to form when we are willing to learn from the past and face the future with a certain modesty and a great deal of imagination.

3. Technology is not neutral. Technology has been compared to tourism in that it carries its own culture with it whereever it goes. This may be a slight overstatement but it illustrates an important point which is that technology is often biased. For example, the Green Revolution, while achieving some dramatic results on the production side, was biased in its technology. Success for the farmer depended on access to water, fertilizers and pesticides; for those without them there was no Green Revolution. Moreover, the Green Revolution has created an increased demand for mechanization, both on and off the farm. This too requires access to credit and often displaces labor. Mechanization in turn tends to create consolidation of land holdings, which can further skew the income distribution pattern in the absence of alternatives. Appropriate technology introduced into the modern sector can have the effect of displacing markets and jobs in the traditional sector. In fairness, it should also be stated that enrichment of the traditional sector probably has to be at the expense of the modern sector. Technology also introduces its own requirements for different support systems. It changes the infrastructure requirements, training requirements and marketing systems, just to mention a few.

The basic point is that technology, at any level, can create second and third generation problems that were not foreseen, not thought of and not desired, some of which wipe out the initial gains or compound the original problem. There will always be trade-offs but a better job could be done in forecasting second and third generation problems so that, to the extent possible, these trade-offs can be made deliberately before the fact rather than forced by unplanned, unforeseen results after the fact. There is no guarantee that appropriate technology is immune from these risks and dangers. After all, inappropriate technologies were probably once thought to be appropriate. The trade-off dilemma of course must be sorted out by the developing countries themselves. International assistance agencies can contribute to sound decisions in this respect by more thorough research and analysis of new ideas and by assisting with developing better information gathering and distribution systems.

4. Appropriate technology is highly location specific. There is no such thing as an intermediate or appropriate technology for the third world, or the fourth world, or perhaps even for one country. This sounds like a truism. Yet this element seems to be overlooked or down-played in the literature and in some current applications. It has great significance for how international assistance is structured and how effective it can and will be.

There are at least three major reasons for the location specificity of appropriate technology, some of which are more obvious than others. The first and most obvious reason is found in the differences that exist in conditions from one country to another or from one region to another. The basic problems may be very similar but the solutions required are often very different. These differences include political, economic, social and cultural patterns, resource bases, agricultural practices, topography, soil conditions, population densities, infrastructure, level of development, etc. The two-wheel tractor may be appropriate for the five-hectare Central Luzon rice farmer but completely inappropriate for the one-half hectare Javanese rice cultivator.

Less obvious is the factor of national or local pride among appropriate technology innovators and entrepreneurs. While it is difficult to document, there seems to be a tendency to make some modification, however minor, in technology developed elsewhere. This tendency was observed in all three countries visited. Part of this is due to a cautious attitude or the desire to do exhaustive tests and trials before introducing a foreign technology. There is also a bureaucratic desire to justify the effort. Entrepreneurs like to make some modifications in order to identify the product with their enterprise. Whatever the other reasons, one of the purposes behind much of the tinkering and modifying seems to be finding ways to impart a national or indigenous character to the technology. This means that in addition to being technically appropriate, the technology must also reflect the sociocultural setting. The Jeepney industry in the Philippines is the best example that comes to mind.

The location-specific nature of appropriate technology vastly complicates, limits, and perhaps alters the traditional forms of international assistance. Except in products involving solar energy, wind power, bio-gas conversion and development of combustion engines, the location-specific nature of appropriate technology forces the fragmentation of activities particularly at the product design and commercialization stages into a series of "micro-projects" for a region or a country. This means that the research, planning, participation and decision making must take place in or near the problem area. It may also mean that this type of effort does not lend itself easily to the familiar forms of program and project assistance. The emphasis on use of local resources certainly changes the nature of the inputs and the way projects are designed and managed. It places a much greater reliance on local institutions in the developing countries, many of which are ill-prepared for the task. To the extent that outside assistance is required, it calls for a greater number and variety of technical specialists working for extended periods of time at grass roots levels. Therefore, while appropriate technology may lower the foreign exchange requirements for international assistance, it could raise and change considerably the foreign personnel requirements. In other words, labor-intensive programs may require labor-intensive international assistance. If this is true, the question is whether AID, and similar agencies, are willing to reverse past and current trends towards fewer rather than greater numbers of direct-hire and contract technicians? The alternative is for AID to be simply the conduit for financing this work through other institutions. Regardless of the option chosen, the real payoff is not likely to come from a United States university laboratory. It will come from imaginative and innovative people, indigenous and foreign, working in the developing countries, close to the problem.

5. Commercial Viability. Another important consideration for developing countries and international assistance agencies involved in appropriate technology efforts is the question of commercial viability. There are those that argue that many of the "village level" intermediate technology activities in progress are a waste of time and money because they are not "commercially viable." This is a question closely related to the above discussion of location-specificity and the process of "indigenization" which is discussed later.

The question of commerical viability is central to the economics of appropriate technology. There are those (see Kahn) that argue that the commercialization of appropriate technology, simultaneous with its design and development, is a prerequisite to its success and favorable impact on such problems as unemployment, low production and rural-to-urban migration. In other words, these socioeconomic benefits will accrue only when technology caters to the demands of the local population. Appropriate technology, therefore, must be demand-oriented and capable of local (mostly rural) manufacture and marketing: Proponents contend that in the rural areas of developing countries there is an effective demand for modern

sector products. The problem is that these products, which are now made in the modern sector or are imported, are too expensive and too sophisticated for rural inhabitants. What needs to be done is to redesign a whole series of high demand, high utility products such as flashlights, sewing machines, cooking utensils, tools, appliances, farm implements, gas lanterns, simple vehicles and conveyances, etc., into simpler and lower-cost products capable of being made and manufactured in rural centers by small entrepreneurs for purchase by rural inhabitants. In this way, rural employment is increased, rural income goes up, rural-to-urban migration decreases and living standards are bettered. This is seen as a far more effective means of developing and promoting appropriate technology than tinkering with improvements in traditional technology, which must be subsidized and are probably not commercially viable over a long period. The commercial viability approach assumes that the original design, development and commercialization stages also must be subsidized by the public sector. In industrialized countries, this function is carried out by the R & D elements of industry. No such capability exists among small to medium-sized rural manufacturers and, therefore, this must be done by international or national institutions. This would be accompanied by industrial extension services until the product is established commercially.

The commercial viability criterion has one principal advantage. Within a rural context, it provides a relatively simple means of determining priorities, geographic dispersal of small industry and allocations of resources for the development and dissemination of appropriate technologies. In other words, it allows market forces to make most of the determinations and builds a dynamic and progressive element into the introduction of new technologies. The major disadvantage may be that the technologies involved will become biased towards those with means and bypass in terms of benefits the lowest income groups. Also it is not clear what this approach would do to traditional or marginally-improved traditional technologies and those that make their meager income from them.

Except for the last issue, it does appear on balance that the commercial viability principle must be an inescapable and indispensable element in the formulation of appropriate technology strategies and programs. It is somewhat inconceivable that it could be otherwise in countries operating under some form and degree of a "free market" system. Where possible, close examination should be made to determine if this same principle can be applied to upgrading traditional methods of production and the commercialization of traditional products. In any event, there will have to be a relatively heavy investment of time and patience, if not money, in which international assistance agencies must be prepared for some frustration and failures on the road to successes.

6. Technology is Only Part of the Picture. The literature and the litany of appropriate technology is becoming so vast and popularized that there is a danger it will become a science unto itself and isolated from many other related factors that bear on the development process. Developing countries and international agencies need to guard against falling into this trap. While it is true that not enough is yet known of appropriate technology *per se*, even less is known of its relationship to other development issues.

The first level of relationship is that of appropriate technology to national development goals, policies and priorities. These goals and the trade-offs implied will have a strong influence on the success of appropriate technology efforts. For example, increased agricultural production, increased employment in the rural areas, energy conservation, import substitution, and reduced income inequities are all goals that can be served, theoretically, by appropriate technology. Each, however, requires a different response and produces a different effect. The concept of

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appropriate technology also is inextricably linked to economic policies, entrepreneurial attitudes and business practices. The factor price issue, foreign exchange and interest rates, tax policies, labor legislation, licensing regulations and import policies are only a few illustrations of this interaction and interdependence.

But appropriate technology cannot exist by economics alone. This is perhaps more true of the traditional sector than the modern sector but it applies to both. Cultural values, traditional practices and social customs are important variables in the equation. There are at least two reasons why more Javanese farmers do not harvest rice with a simple sickle rather than the slower ani-ani knife. One is related to myth, and the other is related to strong social pressures to maintain a traditional, labor-intensive, crop-sharing method of harvest. Somewhat conversely, many Ceylonese farmers prefer a more expensive Japanese two-wheel tractor to the less expensive locally-made model because the imported model has more features on it which not only make it easier to handle in the field but make it more prestigious to drive around the village.

Several more such examples could be found or cited to illustrate the interdependence of appropriate technology with a host of other issues and factors. Like most other development approaches and concepts, appropriate technology involves a series of linkages that must be understood and accounted for before putting it into practice. This truth casts some doubt over Schumacher's statement that "technology should be treated as the central development issue." If there was ever a development concept that required a multi-dimensional, multi-disciplinary approach, it is appropriate technology.

7. The Process of "Indigenization". The dictionary defines indigenous as "born, developing, growing, or produced naturally in a region or a country." In a sense, this expresses both the essence and the challenge of intermediate or appropriate technology. In other words, how can new and more appropriate technology be introduced from the outside in a manner that allows it to take root and grow naturally within a local environment? How can international assistance be structured so as to stimulate local initiative and innovation without stifling or destroying it? To these questions there are no facile answers. It is a delicate and fragile process calling for the utmost sensitivity, imagination and patience. Without presuming to write a prescription, it would seem that the process of indigenizing technology must include or at least take into consideration many of the following factors:

a. The concept and practice of intermediate or appropriate technology must be accepted and expressed as an important part of national policy and national develoment goals.

b. There must be a demand or felt need for the technology and the products produced by it. In other words, it must be able to stimulate commercially viable enterprises leading to sought after socioeconomic benefits.

c. The basic research concerning the relationship of the technology to the local and national environment must be completed. To the extent possible, this research should be done by indigenous personnel in the locale in which the technology will be used.

d. The technology must be based on the maximum use of local resources (manpower and materials). Import requirements should be kept to a minimum and constitute a small percentage of the inputs required.

e. The inputs to and the outputs from the technology (production process) should be relatively low cost and accessible by a large share of the local population.

f. The organizational and support requirements should be commensurate in scale, simplicity, cost and maintenance requirements with the technology.

g. The technology should stimulate other local enterprises, e.g. retail outlets, the manufacture of spare parts and accessories, agri-business, etc.

h. There should be opportunity for involvement by the users and beneficiaries of the technology from the inception of the activity. To the extent that outside expertise is needed at the research, design, development, production and marketing stages, strong provision should be made to train indigenous personnel at each stage. This would include technical skill training as well as management training for entrepreneurs.

i. Also provision should be made for continuing access to backstop and problem-solving services, e.g., industrial extension services, associations, small-scale industry institutes, regional technology centers, etc.

j. The technology introduced should not have an adverse impact on existing traditional enterprises or labor markets. Preliminary researoh should identify the number of workplaces the new technology will create and/or displace.

k. Factor price distortions should be identified and removed if possible as well as similar disincentives and obstacles to the viability of the technology. The marketing system should be adequate to assure a steady flow of production inputs and delivery of the production outputs. This may also call for the establishment of standardization policies and mechanisms to assure adequate quality control and avoid second and third generation problems.

l. The technology must be allowed to grow and develop at its own "natural" pace.

m. Its successes or failures should be judged by indigenous standards, not those of outsiders. In most cases, however, market forces and commercial viability will provide the yardstick.

n. The technology introduced should be flexible enough to accommodate further innovations and adaptations to allow for progressive improvements and transition to better alternatives.

It is recognized that the foregoing is but a crude and superficial treatment of a complex process. It is a process about which a good deal more can be written and about which a great deal more needs to be learned. It is hoped, however, that it serves to illustrate several key points concerning the concept of intermediate or appropriate technology: (1) that it is a fragile and delicate concept that can be shattered easily by over-attention and clumsy, presumptive approaches, (2) that the role of international assistance is limited and constrained by this factor and the increased dependence on local participation at several levels and linkages, and (3) that the process involves substantial and long-term investments of time, patience and restraint, elements which international assistance programs often have had much less of than capital.

8. The Need for Impact Studies. Perhaps one of the greatest obstacles to better understanding and acceptance of the concept of appropriate technology as a development strategy is the lack of data concerning the impact it has had or is having on production, income patterns and employment. For example, part of the controversy surrounding the suitability of the IRRI-designed equipment stems from the fact that sufficient methods

for measuring impact were not built into the activity from the design and development stages. This evaluation is absolutely vital for intelligent decision making and dissemination of the technology as well as for minimizing second generation problems. It was not clear in any of the three countries visited exactly what impact the two-wheel tractor is having on these three important problem areas. One good study has been done in Indonesia on the labor requirements for hand-powered, animal-powered and engine-powered tillage (see Morris). Although this study is limited to a few geographic areas, it does give a relatively clear picture of the labor-using and labor-displacing qualities of these three common types of rice cultivation. More such studies need to be made. This would be a fruitful area for international assistance and international agencies should insist that methods of measurement be built into any appropriate technology research and application activities in which they cooperate.

C. Some Thoughts on Priorities

The field of appropriate technology is so vast and the range of possibilities is so extensive there is a danger that international efforts will become anarchical, redundant, or reduced to scattered and feckless tinkering unless some sense of focus and priorities is introduced into the process. Despite previous discussion concerning the limited role of international assistance, there are several ways in which the international agencies can assist in organizing and focusing the appropriate technology movement. A few of the major ones will be touched on briefly.

1. International coordination is perhaps the first order of business. As was seen earlier, there are already a surprising number of appropriate technology activities sponsored by developed as well as developing countries already underway. Those described earlier represent only a fraction of the total. With only a few exceptions, each is doing its own thing. While this is consistent with the location-specific nature of appropriate technology, it could lead to unnecessary duplication and reinvention of wheels. Some better mechanisms are needed to establish an international appropriate technology center or network, to which other international, regional, national and sub-national institutions would not only have access, but from which these institutions would receive information on a regular basis. This would serve to encourage and stimulate national efforts and provide a basis for assessing impact and progress, as well as identifying problems. This international appropriate technology center would not necessarily conduct research for international application. This is probably better left to private and public specialized international institutes, and national and sub-national centers in the developing countries, as well as to universities and foundations.

2. Traditional versus modern sector is another issue involving priorities. Several facets of the issue have been pointed out earlier. International agencies probably need to decide whether they are going to support appropriate technology activities in both the modern and the traditional sectors or confine their efforts to just one. There has been an unconcealed bias in this paper in favor of concentrating appropriate technology primarily, if not exclusively, in the traditional sector, with emphasis on the rural areas. There are basically three reasons for this bias. They are: (a) not enough is known about appropriate technology and there are not enough resources available to mount full-scale efforts in both sectors, (b) appropriate technology is aimed at helping the lowest income groups and while they are to be found in both sectors, in urban as well as rural areas, the greatest need exists in the traditional sector, and (c) appropriate technology appears more suitable for application in the traditional sector, especially when new technologies are required rather than just adaptations. This focus seems especially suited to

agencies like AID where development assistance programs are aimed almost exclusively at the lowest income groups.

The above discussion clearly suggests that in terms of appropriate technology the two sectors cannot be approached similarly. Much of the appropriate technology literature does not make this distinction. The author would like to carry the point even further and suggest that completely separate appropriate technology assistance strategies need to be developed for each sector. If nothing else, this might help to clarify some of the confusion that now exists.

3. Inventories and profiles are especially urgent facets of the informational issue. As one of the first steps in constructing an international informational network, inventories, or at least profiles, could be constructed of the on-going or contemplated appropriate technology activities in each developing country. This would also include key innovators and institutions. This is an area in which international assistance could be very helpful but it would have to be approached carefully and with the full knowledge and cooperation of the developing countries involved. Depending on how each country sees its own priorities, this could be done on a more limited basis, e.g., for only one sector, or the energy area, irrigation, or the construction field, etc. In any event, some such information gathering seems absolutely vital in mounting appropriate technology programs.

4. International Regional Institutes play an important role in the appropriate technology sphere. There are now several of these international centers in Asia, Latin America and Africa. These institutions have been devoted primarily to developing better seed technologies and cropping practices. Some have added "hardware" or farm equipment development programs to the basic seed research. The I.R.R.I. Farm Machinery Development Program, described earlier, is one of the better examples. Similar efforts are in progress at the Tropical International Institute of Agriculture (IITA) in Nigeria. The author had the opportunity to discuss the program at IITA with one of the Institute's engineers. IITA takes a "farming systems" approach to appropriate technology. They have titled the farm systems approach "minimum toilage" to complement the crop work which is built on a "maximum cropping" concept. Most of the equipment is hand-powered with a few small engine-powered two-wheel tractors for the heavier work.

More of these kinds of efforts are needed, especially when joined with specialized crop research. These Institutes have the advantage of being oriented to a specific crop or crops and of being located in the areas in which the crops are grown. They can provide a locus of basic research and the training of indigenous personnel. Their role, while important, is limited by two factors: (a) in terms of the basic research, design and development of appropriate technology, they are restricted to the conditions existing within the immediate area of the research station; not all of the research, therefore, is applicable and transferable to other regions and countries, and (b) design and innovative personnel are usually expatriates which limits to some extent their ability to participate effectively in the "indigenization" process. Nevertheless, these international institutes are an extremely important link in the chain.

5. National Technology Institutes and the Regional Adaptive Training Centers are the next key links in the chain as they form the important interfaces with international assistance agencies and international research institutes on the one hand, and developing country activities and policies on the other. The national technology institutes are in a good position to promote, stimulate, evaluate, guide and coordinate research and application. These institutions are among those closest to the problem areas and target populations. India has already established a

separate complex of national and regional appropriate technology centers. Indonesia has a national technology institute which functions at both the national and regional levels. In Sri Lanka, these functions are performed by the university and several research centers within the Ministries of Industry and Agriculture.

In many countries, past development efforts have been focused on the establishment and strengthening of national institutes of technology and have neglected the parallel development of the provincial and regional centers. Consequently, the latter lag far behind in their ability to make a contribution to the development and dissemination of appropriate technology. Linkages have not been formed between national and regional centers in terms of information and personnel exchange. The regional centers have not been sufficiently mandated or equipped to perform community-related research and application. Yet, in terms of the location specific principle and the process of indigenization they could play the most vital role. The East-West Center in Honolulu, has been engaged for the past few years in assisting the development of four regional adaptive training centers located in the non-metropolitan areas of four Asian countries. The concept is sound but needs far more support than it has enjoyed in most countries.

6. AID priorities in appropriate technology is a question with which the Agency is now faced. Should it concentrate its resources on support of general level efforts, e.g., across-the-board research, or should it limit its activities to selected areas in order to achieve more immediate impact? These are not easy questions to answer. A full and complete answer to this question will not be attempted in this paper, but since this paper was motivated primarily by the Agency's new congressional mandate on intermediate technology, it is only appropriate that it end with a few general thoughts on how AID might structure some of its priorities in this field, keeping in mind the foregoing discussion and the general set of reminders put forth in the preceding section.

-- AID should probably take the lead in establishing an international appropriate technology information center and network to provide, in effect, a clearing house for and dissemination point for the vast amount of appropriate technology information that has been developed and that will be developed over the next few years.

-- With the above as the exception, AID should probably opt for a concentrated focus on appropriate technology. This focus should be limited to the traditional sector, and within that context, assistance should be focused primarily, if not exclusively in the rural areas. Narrowing the focus a bit further, it should be directed at the farm, village and rural market town levels in terms of food production, food processing, basic crafts and skills, and, in sum, the rural manufacture of a selective range of high demand, high utility products that could be made by rural industry for the primary consumption of rural inhabitants. This has the advantage of trying to raise food production on the one hand and absorb more surplus rural labor on the other. It is also recognized that it is far more complex than it looks, which is probably one of the reasons it has been so neglected.

-- AID can support this focus in several ways and at several levels, for example:

- institution building in establishing and strengthening the policy, technical and administrative capability of national technology institutes and regional adaptive training centers.

- support of specific research at the international, national and regional levels. The following are only a few possibilities:

- the process by which innovation and inventive activity is stimulated;

- methods of technological information dissemination in the developing countries;

- methods of training rural entrepreneurs;

- market assessments, i.e., estimating the demand for new technologies and new products for the rural areas;

- the pros and cons of small-scale mechanization;

- small-scale food processing;

- specific design development and commercialization of low-cost, high demand, high utility products and the technologies (the entire production process) to produce them;

- the construction of national inventories and/or profiles of current appropriate technology activities, the key institutions and innovators involved in order to get a comprehensive picture, country-by-country of the state of the art and also to establish some baseline data against which future progress can be measured.

As a final thought, AID should consider a review of its current project activities to determine the "appropriateness" of the technologies and techniques called for by these activities, either directly or indirectly. If no other purpose is served, it would provide a useful way to involve a good share of the Agency in understanding the concept of appropriate technology, and it may even lead to some useful insights, if not discoveries.

INTERVIEWS

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Wickremamayeke, Teddy, Director, Rice Processing Development Center, Paddy Marketing Board, Anuradhapura,Sri Lanka.

Wimberly, James, Advisor to the Paddy Marketing Board and IRRI Representative, Colombo, Sri Lanka.

Wijewardene, Ray, Engineer, International Institute of Tropical Agriculture, Ibadan, Nigeria. (Interviewed in Colombo, Sri Lanka).

Zimmerly, Garnett, Director, USAID/Philippines, Manila.

BIBLIOGRAPHY

Adelman, Irma, and Morris, Cynthia T., Economic Growth and Equity in Developing Countries, Stanford University Press, Stanford, 1973.

AID - Appropriate Technologies for International Development--Preliminary Survey of Research Activities, Office of Science and Technology, AID, Washington, D.C., 1972. 60 pp. TA/OST 72-11 (PB 212 288).

AID - "Implementation of 'New Directions' In Development Assistance." Report to the Committee on International Relations on Implementation of Legislative Reforms in the Foreign Assistance Act of 1973, Washington, D.C., U.S. Government Printing Office, 1975.

AID - Technology and Economics in International Development, Washington, D.C., Office of Science and Technology, Agency for International Development, May 1972.

Anonymous, "Thinking Small", Newsweek, March 22, 1976, pp. 14.

Ariyaratne, H., "Appropriate Technology," The Ceylon Daily News, March 24, 1976, pp. 4.

Bautista, F., and Wickham, T.H., The Tractor and the Carabao: A Socio-economic Study of Power Source for Land Preparation in Nueva Ecija International Rice Research Institue, Los Banos, Laguna,Philippines, 1974.

Bell, Cline, "The Acquisition of Agricultural Technology: Its Determinants and Effects," The Journal of Development Studies, No. 9, October 1972, pp. 123-160.

Brown, Lester R., Seeds of Change, Praeger Publishers, New York, 1970.

Bruton, Henry J., "Economic Development and Labor Use: A Review," in E.O. Edwards (ed.), Employment in Developing Nations, Colombia University Press, New York, 1974, pp. 49-67.

Cabanos, Phil, "Jeepney Manufacturing in the Philippines: A Model for Developing the Agricultural Machinery Industry", Agricultural Mechanization in Asia, Autumn 1975.

Cooper, Charles, "Science, Technology and Production in the Underdeveloped Countries: An Introduction", The Journal of Development Studies, No. 9, October 1972, pp. 1-18.

Duff, B., Output, Employment and Mechanization in Philippine Agriculture, International Rice Research Institute, Los Banos, Laguna, Philippines, December 1974.

Eckhaus, R.S., "Making the Optimal Choice of Technology", in Gerald M. Meier (ed.), Leading Issues in Economic Development: Studies in International Poverty, 2nd Edition, Oxford University Press, New York, 1970, pp. 345-348.

Edwards, Edgar O. (ed.), Employment in Developing Nations, Colombia University Press, New York, 1974, pp. 428.

------, "Employment in Developing Countries", Employment in Developing Nations, Columbia University Press, New York, 1974, pp.1-44.

Fei, J.C.H., and Ranis, Gustav, "A Model of Growth and Employment in the Open Dualistic Economy: The Cases of Korea and Taiwan", Yale University, New Haven, 1974, (draft).

Gamble, Alton F., An Accelerated Cooperatives Development Program for Nueva Ecija, Office of Agricultural Development, U.S. Agency for International Development, December 1975.

German Foundation for Developing Countries - Development and Dissemination of Appropriate Technologies in Rural Areas, International Workshop, July 17-28, 1972, Kumasi, Ghana, Seminar Centre for Economic and Social Development, German Foundation for Developing Countries, 1972, pp. 211.

Gotsch, Carl - "Economics, Institutions and Employment Generation in Rural Areas", in E.O. Edwards (ed.), Employment in Developing Nations, Colombia University Press, New York, 1974, pp. 133-160.

------, "Technical Change and Distribution of Income in Rural Areas", American Journal of Agricultural Economics, No. 54, May 1972, pp. 326.

International Rice Research Institute, Agricultural Machinery Development Program, Terminal Report, Laguna, Philippines, May 21, 1975.

Inkeles, Alex, and Smith, David H., Becoming Modern: Industrial Change in Six Developing Countries, Harvard University Press, Cambridge, 1974.

I.L.O., The Work of the Intermediate Technology Development Group in Africa, by E.F. Schumacher, Geneva, pp. 20. ALSO: International Labor Review, Vol. 106, No. 1, July 1972.

------, Sharing In Development: A Program of Employment, Equity and Growth for the Philippines, Geneva International Labor Office, 1974.

------, Matching Employment Opportunities and Expectations: A Programme of Action for Ceylon, (a WEB Report), Geneva International Labor Office, 1971.

------, Appropriate Technology, Employment and Income Growth, Prepared by the ILO at the invitation of UN ACAST, 15th Session, Geneva, November 15-26, 1971, pp. 34.

Jackson, Sarah, Economically Appropriate Technologies for Developing Countries, Overseas Development Council, Washington, D.C., 1972, pp.38.

Kahn, Amir U., "Appropriate Technology and Development Assistance", Unpublished Manuscript, Los Banos, Philippines, January 1975.

------, "Appropriate Technologies: Do We Transfer, Adapt, or Develop?", in E.O. Edwards (ed.), Employment in Developing Nations, Colombia University Press, New York, 1974, pp. 223-233.

------, Mechanization Technology For Tropical Agriculture, Paper No. 74-01, International Rice Research Institute, Los Banos, Laguna, Philippines, Paper presented at OECD Seminar, September, 1974.

Kelley, Alan C.; Williamson, Jeffrey; and Chatham, Russell J., Dualistic Economic Development, University of Chicago, Chicago, 1972.

Kissinger, Henry A., "Global Consensus and Economic Development", The Secretary of State, Department of State, Washington, D.C., September 1, 1975.

MacPherson, George, and Jackson, Dudley, "Village Technology for Rural Development: Agricultural Innovation in Tanzania", Reprint Series No. 413, University of Cambridge, Department of Applied Economics,. Reprinted in International Labour Review, No. 3, February 1975, pp. 105-126.

Marsden, Keith, "Progressive Technologies for Developing Countries", International Labor Review, Vol. 101, No. 5, May 1970, pp. 475-502. ALSO: W. Galenson (ed.), Essays on Employment, ILO, Geneva, 1971, pp. 113-140.

McRobie, George, and Carr, Marilyn, "Mass Production or Production By The Masses: Technology a Critical Choice for Developing Countries", Manuscript, Intermediate Technology Development Group, Ltd., Parnell House, London, November 1975.

Mendis, D.L.O., "Appropriate Technology: Underdevelopment and Over-Development", Economic Review, I, Peoples Bank, Sri Lanka, May 1975.

------, "Planning the Industrial Revolution in Sri Lanka", Occasional Paper, No. 4, O.E.C.D. Development Centre, January 1975.

Merrill, William C., "The Impact of Agricultural Mechanization on Employment and Food Production", Occasional Paper, No. 1, Technical Assistance Bureau, U.S. Agency for International Development, Washington, D.C., September 1975.

Mishan, E.J., Technology and Growth: The Price We Pay, Praeger Publishers, New York, 1970.

Morawetz, David, "Employment Implications of Industrialization in Developing Countries: A Survey", The Economic Journal, September 1974, pp. 491-530.

Morris, Richard, The Potential Impact of Mechanical Land Preparation in the Indonesian Small-Holder Rice Producing Sector, (unpublished manuscript), International Rice Research Institute, Bogar, Indonesia, September, 1975.

O.E.C.D., Choice and Adaptation of Technology in Developing Countries: An Overview of Major Policy Issues, Paris, O.E.C.D., 1974.

O.E.C.D. Development Centre, "Low-Cost Technology--An Inquiry Into Outstanding Policy Issues", Interim Report of the study sessions held in Paris, September 17-20, 1974, Paris: O.E.C.D. Development Centre, January 1975.

------, "Research and Related Activities of the Development Centre in 1975", Paris: O.E.C.D. Development Centre, May 15, 1975.

Owens, Edgar, and Shaw, Robert, Development Reconsidered, D.C. Heath and Company, Lexington, Massachusetts, 1972.

Pickett, James; D.J.C. Forsyth and N.S. McBain, "The Choice of Technology, Economic Efficiency and Employment in Developing Countries", in E.O. Edwards (ed.) Employment in Developing Nations, Columbia University Press, New York, 1974, pp. 209-221.

Ranis, Gustav, Technology Choice, Employment and Growth, Economic Growth Center, Center Discussion Paper No. 97, Yale University, New Haven, Connecticut, 1970, pp. 23.

Sen, Amartya, Employment,Technology and Development, Clarendon Press, Oxford, England, 1975.

Schumacher, E.F., Small is Beautiful: Economics as if People Mattered, Harper and Row, New York, 1973.

Sinaga, Rudolph, and Collier, William, Social and Regional Implications of Agricultural Development Policy, Paper presented at the South East Asian Agricultural Economics Association Meeting at Balihpapan, Indonesia, November 3-4, 1975.

Stewart, Frances, "Choice of Techniques in Developing Countries", The Journal of Development Studies, Vol. 9, No. 1, October 1972, pp. 99-121.

------, Technology and Employment in Less Developed Countries, Prepared for the Ford Foundation Seminar on Technology and Employment, March 21-24, 1973, pp. 119.

------, "Technology and Employment in LDCs", in E.O. Edwards (ed.), Employment in Developing Nations, Columbia University Press, New York, 1974, pp. 83-129

Timmer, C. Peter; Thomas, John Woodward; Wells, Louis T., Jr.; and Morawetz, David, The Choice of Technology in Developing Countries: Some Cautionary Tales, Center for International Affairs, Harvard University, Cambridge, Massachusetts, 1975.

United States House of Representatives, 94th Congress, 1st Session, Hearings of the Committee on International Relations on the International Development and Food Assistance Act of 1975, U.S. Government Printing Office, Washington, D.C., July 21, 1975, pp. 329-340.

United States Senate, 94th Congress, 1st Session, Hearings Before the Sub-Committee on Foreign Relations... to Amend the Foreign Assistance Act of 1961, U.S. Government Printing Office, Washington, D.C., 1975.

Usui, M., Choice and Adaptation of Technology in Developing Countries: An Overview of Major Policy Issues, Review of the Discussions held at the Study Sessions organized by the OECD Development Centre, Paris, November 7-9, 1972, OECD, Paris, 1974, pp. 240.

Wells, Louis T., Jr., "Economic Man and Engineering Man: Choice of Technology in a Low-Wage Country", in Timmer, C. Peter et al., The Choice of Technology in Developing Countries. Some Cautionary Tales. Center for International Affairs, Harvard University, Cambridge, Massachusetts, 1975.

White, Lawrence J., (ed.), Technology, Employment, and Development, Princeton University Press, Princeton, New Jersey, 1974.

Winston, Gordon C., "Factor Substitution, ex ante and ex post", Journal of Development Economics, Vol. 1, No. 2, September 1974, pp. 145-163.