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Report of a Seminar

Office of Science and Technology
Office of Policy Development and Analysis
Agency for International Development
Washington, D.C.

MAY 1972

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Technology and Economics

in

International Development

Report of a Seminar
May 23, 1972

Office of Science and Technology
Office of Policy Development and Analysis
Agency for International Development
Washington, D. C.

PREFACE

This Report includes the papers and summaries of comments presented at a seminar held in Washington on May 23, 1972, which was designed to clarify the impact of the macro-economic framework in the developing countries on the choice of technologies introduced into these countries. A principal purpose of the seminar was to stimulate sustained interaction between economists and technologists actively engaged in developmental activities.

The seminar was a direct result of a recommendation emerging from a Workshop on Science and Technology Priorities in Development held at Airlie House in December 1971. The Workshop recognized the necessity to consider the socio-economic setting when developing specific science and technology projects and provided a point of departure for better understanding of the interaction of economics and technology.

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SEMINAR ON ECONOMICS AND TECHNOLOGY

May 23, 1972

Pan American Health Organization Building
Conference Room C

9:30 Chairman's remarks - Charles Johnson, Consultant, AID

9:35 "Some Observations on the Framework for the Optimum Use of Technologies for Less Developed Countries"

- Gustav Ranis, Yale University

Discussants: Julian Engel, NAS
Mahbub Ul Haq, IBRD

10:30 "The Use of Labor Intensive Techniques in Kenyan Industry"

- Howard Pack, Swarthmore College

Discussants: Daniel Margolies, Consultant, AID
Romulo Ferreira, OAS

11:30 "Toward a Methodology for Assessing the Impact of Technology in Developing Countries"

- Glenn Schweitzer, AID

Discussants: Peter Clark, IBRD
Ojetunji Aboyade, Economic Development Institute

12:30 Lunch

2:00 "Basic Vehicle for Southeast Asia"

- William Bourke, Ford Asia-Pacific, Inc.

2:30 Comments and General Summary

- John Lewis, Princeton University

2:50 General Discussion

3:50 Concluding remarks - Charles Johnson

4:00 Adjournment

SEMINAR ON ECONOMICS AND TECHNOLOGY

May 23, 1972

Chairman: Charles Johnson, Consultant, A.I.D.

Panelists:

Ojetunji Aboyade, Economic Development Institute

William Bourke, Ford Asia-Pacific, Inc.

Peter Clark, International Bank for Reconstruction and Development

Julian Engel, National Academy of Sciences

Romulo Ferreira, Organization of American States

Mahbub Ul Haq, International Bank for Reconstruction and Development

John Lewis, Princeton University

Daniel Margolies, Consultant, A.I.D.

Howard Pack, Swarthmore College

Gustav Ranis, Yale University

Glenn Schweitzer, A.I.D.

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Jay Davenport, National Academy of Sciences

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Gerardo Gariulo, Organization of American States

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John Rixse
Leonard Rosenberg
Edward Schiffman
Melvin Schuweiler
Edward Scoll
Peter Sellar
James Sloan
Joseph Stepanek
William Tonesk
Stephen Weed
Alfred White
David Wilson

Chairman's Remarks - Charles Johnson

A welcome was extended to the participants on behalf of the Office of Science and Technology and the Office of Policy Development and Analysis of A.I.D. The seminar was identified as one of a series of seminars and conferences sponsored by A.I.D. to provide an opportunity for a number of people to come together to develop ideas that might provide useful guidance for A.I.D. both in Washington and in the field.

The purpose of the meeting on this occasion was to explore some of the factors involved in the interaction between economics and the choice of technology, to provide a general discussion of the theoretical issues and practical problems of this interaction, with specific examples from the points of view of both the technology user and the technology donor, and to examine a methodology for assessing the technological options available to the lesser developed countries. The major stimulus for this effort was recognition of the need to make technology available to the LDC's in such a way so that it is relevant to their general development and not just to that of small, foreign dominated, economic enclaves.

In view of the importance of the subject and the complexity of the issues, it was regrettable that the time constraints of a one-day seminar required that the principal speakers try to limit the presentation of their papers to twenty minutes and the discussants restrict their comments to ten minutes.

SOME OBSERVATIONS ON THE ECONOMIC FRAMEWORK FOR OPTIMUM LDC UTILIZATION OF TECHNOLOGY

by

Gustav Ranis
Professor of Economics and Director
Economic Growth Center
Yale University

The "proper" use of technology is, of course, not an end in itself. The growing concern with the subject emanates, instead, from its possible relevance to the increasingly serious problems of rising unemployment and worsening income distribution in the less developed world. There is no need to dwell at length on the facts before us: even reasonably "successful" countries, i.e., growing at 5 to 6 percent annually in real terms during the 50s and 60s, have been experiencing increasing rates of unemployment and underemployment, along with growing disparities in the regional and personal distribution of income. Non-agricultural sector labor absorption rates, i.e. the ability of the commercialized portions of non-agricultural activity to provide efficient employment, has been low and falling -- to the 2 or 3 percent level annually -- increasingly unable consequently to even keep up with the growth in the labor force. For manufacturing alone, the developing world as a whole experienced annual rates of growth of output in excess of 7 percent between '55 and '65, while the rate of labor absorption was just about 4 percent.[1] When we view this record of the past along with the existing backlog of underemployment in agriculture, the likely incapacity of agriculture to be able to "hold" its own increments of population efficiently, plus the overall labor force explosion we can safely anticipate over the next decade and a half -- regardless of the extent of success in curbing fertility -- the dimensions of the mounting pressures for labor absorption on the part of the non-agricultural sector are painfully clear.

The part of that same historical record we would like to concentrate on in the context of this paper is the apparently ever-increasing capital intensity of LDC's industrial sectors, taken as a whole, both in terms of output mixes and the technology employed for given mixes.[2] What is more, unlike in

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[1] David Turnham, The Employment Problem in Less Developed Countries, O.E.C.D. Development Center, Paris, 1971.

[2] Though there exists an intimate relationship between what is happening in agriculture and industry in the typical LDC, in terms of the supply of wage goods, industrial real wage levels, and migration patterns, considerations of space force us to concentrate only on the industrial sector here. We are thus also slighting the customarily large LDC services sector.

agriculture where most people have increasingly come to accept the realism of alternative optimum scale and input combination, depending on varying endowment conditions, the belief continues to be widely held that LDC industry is subject, in nature, to more or less fixed proportions statically, and to the march of ever-increasing capital intensity dynamically. All of which, of course, seems to support the notion of the inevitability of a conflict between output and employment objectives as we look into the future.

Fortunately, however, a little thought leads us to the conclusion that this conclusion is unrealistically pessimistic, at a minimum because we know that there exist a number of mature technology exporting countries which differ from each other in the capital intensity of their latest technology -- not to speak of the possible choice of alternative vintages and of the possibilities of substituting and adapting "on top of" any given set of borrowed technology. Moreover, there exists evidence, mainly from a "deviant" subset of developing economies, which indicates that the aforementioned generally dismal LDC record on output versus employment generation may be misleading if not interpreted in its proper historical perspective. Such evidence of markedly differentiated performance extends to the nature of the role of industrial technology change, including at the micro level, and strongly indicates that that role is not fixed in nature but is subject to policy actions, both within and outside of the developing world.

Section II briefly explores the technology transfer mechanism, first in the abstract, then in the context of post-war LDC development experience. Section III presents empirical evidence, from the "deviant" subset of LDC's -- both at the macro and micro levels -- concerning the potentially different roles technology transfer can play under different historical and environmental conditions. Section IV is concerned with the policy conclusions which may be derived from our analysis.

II. The Technology Transfer Mechanism

It must be remembered, first of all, that, unlike in the rich countries, technology change in the developing world is not an internal quasi-automatic and routinized process generated through R&D expenditures allocated according to some public or private rules of cost-benefit analysis. Rather, it is, at least in the first instance, an act of borrowing from someone else who has already incurred the costs of trial and error, from conception to laboratory invention to commercial innovation. While the Pearson

Commission and others referred to the fact that "only" 2 or 3 percent of the world's R&D is today spent by the LDC's, I think there is no one who would really recommend that the poor countries could afford to shut themselves off from the accumulated knowledge of existing industrial technology and start inventing and innovating de novo. LDC expenditures on R&D are, of course, positively correlated with technology change but this does not by itself prove causation nor that they ought to spend more in this direction. Katz,[1] for example, found that, for Argentina, the rate of growth of industrial output (a proxy for "learning by doing") explained 84 percent of the so-called "residual," R&D only 6 percent. It is thus, in the absence of contrary evidence, quite natural and appropriate that LDC's spend only .01 to .05 percent of their GNP on R&D, as contrasted to 5 percent in the case of the developed countries. As we shall see below, it is much more relevant to inquire into the composition of LDC expenditures on R&D, as between so-called "basic" and "applied" research.

One thing is amply clear, i.e. the very co-existence of rich and poor on the same shrinking globe presents many interdependencies, advantages as well as disadvantages, to the poor countries. Among these, the existence of an international technology shelf which incorporates all versions and vintages of human productive experience to date -- both on "how to make" a given commodity, as well as on "what to make" -- probably represents the single most dominant phenomenon, at least as far as the LDC's current use of technology is concerned.[2]

In examining the nature of the technology flows from rich to poor and in assessing the contribution of these flows to the problem of LDC performance with respect to output, employment, and income distribution, it is helpful, moreover, to differentiate clearly between the initial act of borrowing from the shelf and the subsequent act of domestic adaptation.

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[1] Jorge M. Katz, "Industrial Growth Royalties Paid Abroad And Local Expenditures on Research and Development," Paper presented to IEA Conference on Latin American Development, Mexico City, December 1971.

[2] Theoretically, such a shelf is composed of all possible ways in which a unit of X can be produced by different countries and at different times. The most capital-intensive choice might, for example, be U.S. 1972 machinery,-an intermediate choice, Japanese 1972 machinery,-and a yet less capital-intensive choice, Japanese 1950 machinery, etc., with virtually an infinite number of theoretical possibilities available. In the real world, as we shall see below, only a portion of such a shelf may, in fact, be illuminated and an even smaller portion feasible for borrowing.

Borrowing implies taking something off the shelf and attempting to replicate it more or less as is in the recipient country, using essentially the same processes and combinations of factors. Theoretically, of course, as we have already mentioned, there exists considerable choice as to what is borrowed in terms of from which country and what vintage, but such choices may, in fact, be severely circumscribed either because only a subset is known or because the LDC is otherwise constrained by its own economic environment and non-economic preferences or those of the technology lender. Thus the 1950 vintage U.S. technology may not be considered "shiny" enough by the recipient; moreover, it may not be physically available for export, even if the blueprints could be found and dusted off; on the other hand, the 1972 vintage Japanese technology may not be importable if the recipient's main trade and/or aid relations are with another advanced country, etc. Regardless of how large the visible shelf and how constrained or unconstrained the choice, it is this act of technological borrowing which people usually have in mind when discussing the technology gap and technology transfer -- and which is usually blamed by those who object to the use of "inappropriate" industrial technology.[1]

There is, however, a second important dimension to the technology transfer mechanism which is usually given much less attention, namely technological adaptation or assimilation. Such assimilation basically means the ability to adjust borrowed technology to the often radically different factor endowment situation by means of a secondary innovational response. Since we are discussing a process of borrowing from capital rich to capital poor countries, this adaptation process, if it takes place at all, can be expected to be in a labor-using or capital-saving direction.[2] The borrowing and the adaptation may, of course, be going on together, i.e. as part of one entrepreneurial act; in fact, there is likely to be significant interaction between <u>where</u> the LDC borrows

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[1]It should, moreover, be noted that "picking something off the shelf" may not be quite as simple as it sounds. A so-called turnkey project, an extreme version of technological borrowing, may try to duplicate all the inputs in their familiar combinations yet, finding itself in a totally different environment, be forced to operate much more inefficiently. The more capital intensive the import, i.e. the further removed from the total cultural and economic experience of the recipient, the larger the gap between shelf efficiency and the efficiency of the initial transplant. Such X-inefficiency is likely to diminish quasi-automatically with time.

[2]Some of this may be what textbooks call "substitution," i.e. relatively more labor and relatively less capital for essentially the same production process, in response to different relative prices. Some may involve reorganizations, which are more in the nature of innovations. We are not concerned here with the theoretical niceties of such distinctions and will call anything which achieves a lower capital-output ratio (or a higher productivity of capital) without sacrifice of a labor productivity, a capital-saving innovation.

from the shelf and the potential for further reductions in the capital-output ratio "on top of" the import. We will, however, find it useful to maintain a distinction between these two important types of innovational activity when analyzing optimum LDC utilization of technology.

The reason for this, in short, is that the two component processes of technology transfer are likely to play a substantially different role, absolutely and relative to each other, depending on where a particular developing economy finds itself at a particular point in its own historical development. Most LDC's entered what has been called the import substitution phase of development after World War II.[1] This period is characterized by the attempt to restructure pre-independence or colonial resource flows in the direction of national development. Given the customary absence initially of a strong indigenous entrepreneurial class, as well as some of the necessary economic and social overheads, the import substitution regime has typically concentrated on capturing traditional export earnings, through exchange controls, and redirecting them to the construction of overheads in the public sector and the expansion of import-replacing consumer goods industries, either in the public sector or, via import licensing and tariffs, in the private sector. At the same time, domestic resources, given the inflationary pressures caused by deficit financing, increasingly overvalued exchange rates, the tight rationing of credit (as well possibly of such other scarce inputs as cement, steel, etc.), were being redirected to the same growing industrial sector. The well-known distortions of relative prices resulting from such government intervention in a number of crucial markets help pull resources into the hands of the public sector for social capital construction, on the one hand, and provide larger than normal profits to offset larger than normal risks for the country's fledgling private sector entrepreneurs, on the other.

Specifically, import substitution policies bias both the initial borrowing choice (in a capital-intensive direction) and reduce to a minimum the volume of labor-using assimilation carried on in connection with that borrowing. The price of (scarce) capital is kept artificially low by a combination of over-valued exchange rates, a differential tariff structure, low interest rates, accelerated depreciation allowances, etc.; the price of (abundant) labor is kept artificially high by minimum wage legislation, pressure in behalf of fringe benefits and higher pay for night work and against differentials by age and sex, social security taxes levied on a number of workers basis, job security, plus large

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[1]Some, e.g. in Latin America, substantially earlier.

severance payment provisions, etc. With economic signals thus severely distorted in favor of the use of capital, most private sector technology borrowing takes place at the most capital-intensive or modern end of the shelf. The public sector is even more likely to select the latest technology since costs normally play a smaller and prestige and other institutional constraints a larger role here.

Secondly, since where one does one's technology borrowing, i.e. at what "distance" from the social-cultural inheritance and experience of the borrower, undoubtedly affects one's ability to adapt, the technological assimilation process is normally held to a minimum during the import substitution phase of development.[1]

Finally, and most importantly, as long as the policy of heavy protection from both foreign and domestic competition provides entrepreneurs with assured and large windfall profits, there is little reason for them to exercise their technological ingenuity in any particular direction. It is well known that businessmen are prone to "satisficing" rather than "maximizing" profits; the difference between 50 and 60 percent annual profit rates just looms much smaller than the difference between 10 and 20 percent in a more competitive environment. Under import substitution the large established firms are able to sit back and relax once they have gotten their licenses, loans, or permits, while small or new entrepreneurs have difficulty in achieving access to resources at any price. Given the aforementioned relative price distortions plus normal expectations of a continuation of the present environment with, if anything, rising relative wages, there is little reason to bias technology in a labor-using direction.

In short, with borrowing capital-intensive and adaptation virtually absent, LDC industrial technology is likely to be heavily labor-saving, and increasingly so over time, during the import substitution phase -- in spite of a large and growing overhang of idle labor. Similarly, the economy's output mix will, if anything, be shifting in a more capital-intensive direction as new industries are built and overheads constructed -- usually financed by the continuing export of traditional raw materials and primary products. The aforementioned heavy veil between market and shadow prices of both factors and products, moreover, permits little change in the output mix via trade. The major

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[1]Even in India, a large relatively domestically oriented economy, with a substantial domestic engineering and machinery producing capacity, only 12 percent of industrial technology has been of the indigenous variety during the import substitution phase.

change in such mix can take place only through domestic demand pattern changes, as per capita incomes increase with continuing consumer goods import substitution -- all of which makes a further contribution to the increasing capital intensity over time of the industrial sector. In short, when the end of primary, i.e. non-durable consumer goods, import substitution has been reached, we can expect the industrial sector to be more capital intensive than it was at the beginning, both in terms of output mix and technology.

Small wonder, therefore, that our first look across the LDC's during the 1950's and 60's yielded such pessimistic conclusions with respect to the problem before us; for it is a fact that most of the developing world, especially Asia and Africa, has been engaged in a more or less typical import substitution pattern during that period. This pattern, moreover, while it has become fashionable to be critical of it, may well constitute a necessary response to the initial shortage of domestic entrepreneurship and overhead capital. The real issue is "how much" and for "how long."[1] Once the end of "primary" import substitution has been reached, LDC's usually have at least two choices: one, with the help of their now mature entrepreneurial capacity, to move into a more market and labor-intensive industrial export phase, via a gradual reduction of the temperature in the industrial "hothouse;" two, to try to avoid the (inevitable) pains of such a transition[2] by continuing to import substitute in "secondary," more capital-intensive areas, e.g. durable consumer goods, capital goods and the processing of intermediate goods -- the entire process continuing to be fuelled by traditional, as well as newly searched out primary product exports. Much of Latin America moved from primary directly to secondary import substitution after the 30s; Africa is largely still in the primary phase; and Asia presents a mixed picture, as we shall see shortly.

The main conclusion we wish to reach here then, and as emphatically as possible, is that the generally pessimistic overall

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[1]To the extent that import substitution is likely to be a necessary historical phase--especially in countries which don't have a very strong and diversified natural resources base to count on--one could, of course, distinguish between "good" and "bad" forms, e.g. the use of tariffs versus quotas. But such a discussion would take us too far afield here. (See the author's "Relative Prices in Planning for Economic Development," in International Comparisons of Prices and Output, D.J. Daly, editor, NBER, Columbia University Press, 1972.

[2]For the groups favored by the direct controls regime, i.e. large scale industrialists, importers and civil servants whose windfall profits and power (as well as supplementary incomes) respectively would be threatened thereby.

historical record of LDC's with respect to employment and income distribution versus output performance, including the apparent inability to use labor intensive technology and output mixes in an efficient fashion, is heavily conditioned by the fact that the vast majority of the countries under observation has been (and today still is) engaged either in primary or secondary import substitution. On the other hand, there are a few countries which, at the end of their primary import substitution phase, moved on to export substitution, i.e. the fusion of maturing entrepreneurs with large supplies of unskilled labor to effect a shift of the country's production and export structure from an essentially land to a labor fuelled basis.

The achievement of this transition permitting the economy to function more flexibly in response to a changing endowment picture, could, of course, be materially assisted by a change in the predominant public policy package, as we shall see, and the role of technology, both in terms of the borrowing and adaptation processes, be made to change rather drastically. Our aim here is not to "praise" the choice some countries made at the end of their primary import substitution phase and to "condemn" that of others. No two countries are ever alike in terms of their initial structural conditions, and we recognize that the socio-political situation is customarily much too complicated for any simple judgments or prescriptions. We nevertheless do believe that, in order to properly assess the significance of the rather negative overall LDC record on technology choice, an examination of the experience of some "deviant" cases, both at the macro and micro levels, is likely to prove instructive. We turn to this now and hope at the same time to be able to be responsive to at least some of the "special case" or non-transferability arguments which are often raised in this context.

III. The Empirical Evidence

We intend to deal only with the contemporary Korean and Taiwanese cases (along with some attention to historical Japan) in any detail -- and that mostly at the micro level. This is both because macro economic changes in these economies over time are by now pretty well known and because the relationship between the overall economic environment and changes in the role of technology can best be documented at the micro level -- at least at this stage of our understanding.

The beginning of export substitution signalling the end of the primary import substitution phase occurred in Taiwan about 1959 and in Korea about four years later. With industrial entre-

preneurs now sufficiently mature, both societies shifted to a new policy package, entailing substantial readjustments in the major, previously distorted, relative prices at about that time.[1] In both countries the curbing of government deficits and inflationary pressures permitted markets hypothetically to resume their normal functions; and devaluation (accompanied by liberalization of the import regime) plus interest rate reform (i.e. higher, more uniform, official rates) -- as well as other displacements of direct by indirect controls -- permitted such markets to function again in practice.[2]

Agriculture and exports were no longer discriminated against. The veil between the economy's resource endowments and their use was gradually being lifted and a substantial broadening of the development base achieved by harnessing a much larger proportion of previously disenfranchised peasants and medium and small scale entrepreneurs to the effort. Consequently, the generation of output could be accelerated because of -- rather than in spite of -- a shift to a more labor-intensive production and export pattern, both in terms of changes in technology and output mix. These, of course, naturally go together in a more competitive environment. Successful sales in the international markets for industrial goods requires the use of a more appropriate, i.e. endowment-sensitive technology and, in turn, makes it possible to alter the structure of a rapidly growing total export volume.

Taking the Taiwan case first, the major policy changes, including devaluation and interest rate reform, followed the end of primary import substitution in 1959. The results: in 1952 traditional rice and sugar constituted 78 percent of export earnings; by 1969 this had shrunk to less than 5 percent; labor-intensive industrial exports, including textiles, wood products and electronics grew from 5 percent to nearly 70 percent of total exports (themselves growing at an excess of 30 percent annually) over the same period. Industrial labor absorption rates of 3 percent annually during the 1952-59 (import substitution) period accelerated to more than 8 percent annually in the (export substitution) 1960s -- so that both the relative (from 56 percent in 1953 to 40 percent in 1968), and even the absolute number of workers in agriculture could be reduced, and the pool of the underemployed "mopped up" -- in spite of substantial population and labor force growth. We should, moreover, note that the distribution of income (as measured by the ratio between the percentage of total income received by the bottom 20 percent relative to that received by the

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[1] Any change in direction of an economy, and in the facilitating policy package, does not, of course, ever occur from one year to the next, but is the result of a rather gradual evolution.

[2] This time, however, in contrast to the colonial period, subject to the government's national development-oriented guidance.

top 20 percent) also improved substantially as between 1953 and 1964 -- undoubtedly as a consequence of a substantial increase in the labor share.[1] Taiwan's domestic saving rate, a respectable 10 percent in '52-'54 shot up to 35 percent by '67-'69 and her growth rate -- with much less foreign capital contributing -- rose from 2-3 percent to 7-8 percent annually.

A similar general pattern emerges for the case of Korea.[2] Devaluation in 1964 and a doubling of interest rates in 1965 laid the basis here for a shift from import to export substitution accompanied by dramatic changes in output mix and technology. Here also labor-intensive industrial exports, including electronics, textiles and footwear, amounting to 15 percent of total exports in 1962, rose to 80 percent of total exports -- themselves growing at more than 35 percent annually -- by 1968. (Small scale manufacturing exports, the most labor-intensive part of the spectrum, moved from 18.6 percent of the total in 1963 to 31.4 percent in 1968.) Industrial labor absorption rate by that time had risen to 7 percent annually and the percentage of the labor force in agriculture dropped from 68 percent (in 1955) to 51 percent (in 1968) of the total, as well as absolutely. A comparison of the aggregative savings and growth performance of the economy over the period again supports the finding that a more endowment and technology sensitive development strategy tends to support simultaneously both output and employment objectives. The domestic saving rate which had been negative as late as 1958 rose to more than 10 percent by 1967 and the annual growth rate, a mere 1 ½ percent during the last half of the 50s, to more than 9 percent over the same period.

The Japanese historical case of overall successful development is too well known for much comment here. Suffice it to say that her own import substitution period, beginning with the Meiji Restoration in 1968, was relatively brief and mild by contemporary standards.[3] By the turn of the century changes in monetary policy as well as in the ownership of directly productive activities (from

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[1]David Turnham, "Income Distribution--Measurement and Problems," S.I.D. Conference Paper, Ottawa, May 1971.

[2]Differences between the two countries which need not detain us here, are spelled out in the author's "The Role of the Industrial Sector in Korea's Transition to Economic Maturity," Korean Economic Planning Board Papers on the Third Five Year Plan, to be published, Summer 1972.

[3]Due to limitations on Japan's tariff autonomy imposed from the outside, as well as the unavailability of the full arsenal of interventionist tools perfected in the 1930s.

public to private) signalled the beginning of export substitution, accompanied by a switch from land-based raw silk to labor-based silk yarn exports. For the industrial sector as a whole we note the effect of the increased importance of labor using technology and output mixes, as reflected in the decline in the rate of industrial capital deepening, from 2.8 percent annually during 1892-1900 to 1.7 percent during 1900-1906.[1]

In all three cases cited the overall favorable economic performance recorded was due in large part to the different role the technology transfer mechanism was capable of assuming in the export substitution phase of development. Not only was there a chance now for initial borrowing choices (from the shelf) to become more selective, but -- and more importantly -- for the associated labor-using adaptations to assume much larger importance. In a more market-oriented, competitive environment, entrepreneurs were now faced with the need to employ the economic calculus rather than putting their energies into the pursuit of those little slips of paper which guarantee windfall profits under import substitution, almost regardless of what is produced or how. Once the changing resource endowment could be reflected, at least partially, in more realistic relative price signals (interest rate, exchange rate, inter-sectoral terms of trade), what amounts to social optimality could be gradually approached in the course of the technology transfer and adaptation process.

The importance of output mix changes permitting abundant unskilled labor supplies to be massively exported for the first time in the form of new industrial exports can best be (and has been) demonstrated at the aggregative level. But the considerable, and necessary, companion piece of substantially enhanced technological flexibility is best demonstrated at the micro level to which we shall now turn. In this context we intend to again rely mainly, but not exclusively, on examples from the same "deviant" subset of developing countries.

Taking the Japanese historical case first, this time, we have evidence both of considerable selectivity in borrowing, i.e. as between the latest available Western shelf technology and of a very substantial adaptive innovative effort. In cotton spinning, for example, the latest Lancashire spindles were almost invariably imported while, in weaving, which lent itself to a more decentralized cottage industry type of organization, non-automatic looms were usually preferred. As the U.S. Tariff Commission put it:

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[1] A detailed analysis of the aggregative Japanese performance is beyond the scope of this paper. See, however, the author's "Factor Proportions in Japanese Economic Development," American Economic Review, September 1957 and "On the Empirical Relevancy of the Fei-Ranis Model of Economic Development: A Reply," (with John C. H. Fei), American Economic Review, September 1971.

> the price of the automatic loom is more than twice that of the plain loom, which, with the additional expense involved in the importation from the United States or Great Britain, made the total outlay too high in a country where the interest charges on money were relatively much higher than the cost of labor. Japanese mill managers have, therefore, hitherto preferred to employ more workers and to forego the more labor-saving but more expensive machinery, in contrast to the situation in the United States there the high-priced labor is economized rather than the machinery.[1]

Another account, relating to the production of printed goods, is equally instructive:

> Recently, a Japanese manufacturer of plain linoleum decided to undertake the production of printed goods. He dispatched a representative to the United States to purchase the necessary equipment. The representative was familiar with the modern linoleum printing machines, printing several colors at one time and turning out as much as 15,000 square yards in 9 hours, but he considered it too expensive a piece of equipment, especially since his labor was being paid only about 50 cents a day, and so he sought out, in an American plant, an old hand block printing outfit. It was not for sale. Its parts were lying about in a storeroom of the factory. Some of them were 40 years old, and the whole outfit had been discarded 15 years before. But the Japanese representative purchased it and had it shipped to Japan. In the immediate outlay of capital he saved money, for he purchased the old equipment at the price of a printing machine or even below the prices of a new hand outfit, but he installed in his plant equipment that could only have been disposed of as junk in the United States. He started in Japan a new industry in a stage of technical development that had become obsolete years before in the older industrial countries.[2]

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[1] The Japanese Cotton Industry and Trade, U.S. Tariff Commission, Government Printing Office, Washington, 1921, p. 116. The same study reports that a shipment of imported automatic looms which arrived, apparently by mistake, shortly after the turn of the century, had been found so difficult to operate that, after removing the batteries and warp-stop motions, they were instead run as plain looms.

[2] John E. Orchard, Japan's Economic Position, New York: McGraw-Hill, 1930, p. 246.

Japan clearly did not wish to borrow the latest technology, possibly ahead of her entrepreneurial and other endowment capacities, if there existed viable alternatives -- especially if such a choice might inhibit the potential for further adaptive technology response in a labor using direction. We thus have evidence of a good deal of pragmatism in technological borrowing and relatively less evidence of prestige-distorted choices.

Nevertheless, leaning heavily on the results of previous R&D expenditures in the advanced countries (i.e. what Veblen calls taking advantage of being a late comer) and, in spite of (or perhaps because of) the substantial two way traffic of Japanese and foreign engineers, most of the technological borrowing was of the late vintage variety -- as it is in today's LDC's. The really important areas for technological flexibility thus were (and are) to be found, rather, in the technological assimilation sphere.

It is perhaps useful in this context to differentiate among three types of labor-using adaptive technology change: that relating to the machine proper, or core activity; that relating to the inter-machine within-plant production process, or machine-peripheral activity; and that relating to the total production process, including organizational variants by plant and stage of processing, or plant related activities.

With respect to core or machine-related capital stretching innovations, the simplest and quantitatively probably most important Japanese example was the running of imported U.S. and U.K. machinery at rates and speeds substantially in excess of those used abroad. For example, once the kerosene lamp made night work possible, spinning could be done on two, sometimes three, shifts daily, with but two or three rest days a month. This meant that the average work week per machine was two to three times that encountered in the country of origin; and, since physical depreciation is much less important than economic obsolescence, using a machine twice as intensively does not wear it out twice as fast. This heavy use of machinery typical of the 19th century Japanese industrial sector meant that the normal gap between the physical and economic life of a machine was substantially narrowed and capital was considerably "stretched."

Moreover, there was in evidence a related speed-up of the very same spinning machines thus permitting substitution between labor and intermediate input quality. By running the machines at faster speeds and/or by substituting cheaper raw materials, i.e. raw cotton -- and making up for it by increasing the number of women to handle the resultant increase in the number of broken threads -- an additional major saving in capital could be achieved:

> Certain differences in the industries of the two countries are important and must be noted. The raw material is essentially different. Though the Japanese do use some American raw cotton, the bulk of their cotton is from India and is of shorter staple, more likely to breakage...and requiring more labor to put it through the machinery. The yarn spun has much more of the coarser counts that require more labor...By adding more labor it is run somewhat faster than American practice... All of these factors are in some way related to the cheap labor policy. They are there because the labor is cheap.[1]

Japanese spindles were equipped with a 7/8 inch instead of a one inch front roll to accommodate the shorter staple cotton when operated at higher speeds.

For these several reasons, i.e. differences in the yarn count and differences in the speed of the machine, as well as differences in the number of shifts, we find that there was a very marked substitution between capital and labor in the cotton spinning industry. For example, Orchard reports that a competent Japanese spinner working on a 20 yarn count operated from 300 to 400 spindles, while an American spinner on the same count yarn tended from 1,020 to 2,688 spindles, that is, between 2½ and almost 7 times as many.[2] As the U.S. Tariff Commission reported:

> In order to distribute the fixed overhead charges in the way of high interest and depreciation costs, and to earn the large amounts needed to pay a normal rate of dividend, every effort has been made to obtain the largest possible output from the expensive equipment and plant. Machinery is therefore run at high speed, and almost since their inception the Japanese spinning mills have been operated night and day, employing two 12-hour shifts (22 actual working hours) for an average of 27 days a month.[3]

Here again, given a standard count of yarn, the average Japanese spinner is seen as tending 240 spindles, while the American counterpart on the same machine tends about 1,000 spindles. As late

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[1] John E. Orchard, op. cit., p. 367.

[2] Ibid., p. 367.

[3] The Japanese Cotton Industry and Trade, op. cit., p. 99.

as 1932 weekly manhours per 1,000 homogeneous spindles of the same quality ranged from 328.8 in Japan to 164.8 in the United Kingdom and 143.1 in the United States.[1]

A somewhat similar story can be told with respect to cotton weaving. Once again,

> the high cost of mill construction is considerably reduced if you consider the hours during which the mill is being put to effective use. So far in Japan the wheels have turned round during 20 out of 24 hours, while in Europe only 8 hours are being worked. Effective working time in England is less than 38 hours per week, as 2 hours out of these are devoted to cleaning; this is done in Japan after working hours.[2]

Again, the U.S. Tariff Commission reports that "in weaving staple cotton sheetings, the ordinary Japanese weaver seldom operates more than two plain looms, while the American weaver, with perhaps some assistance in supplying fresh bobbing, normally tends from 8 to 10 plain looms."[3] Taking cotton spinning and weaving together, the U.S. Tariff Commission concluded:

> the average Japanese spinner or weaver tends about one-fourth the number of spindles or looms usually assigned to one person in an American mill. A comparison of the total number of persons employed in the two countries to operate individual plants of similar size, and, viewed more broadly, a comparison of the total number of persons employed in the whole American industry, per 1,000 spindles, with the number that would be required on the similar balanced basis under the Japanese conditions, confirms the general relation observed, that the Japanese mills require between three and one-half as many operatives as the American.[4]

In the case of silk production, which, together with cotton, made up more than 70 percent of total Japanese industrial output

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[1] The World Textile Industry: Economic and Social Problems, Vol. 1, International Labour Office, Geneva, 1937, p. 209.

[2] Arnold S. Pearse, Japan and China, Cotton Industry Report, International Federation of Master Cotton Spinners' and Manufacturers' Association, Manchester, 1929, p. 86.

[3] The Japanese Cotton Industry and Trade, op. cit., p. 100.

[4] Ibid., p. 113.

about 1900, we have similar evidence of the ability to innovate in a capital-stretching direction on the machine proper. In raw silk, for example, the Japanese employed more than twice as many girls as did the same reeling basins in Italy. Quite early in the game it is reported that a "modified technology" in silk yielded a capital-labour ratio of .26, a capital-output ratio of 1.45, as compared with 1.06 and 4.22 respectively for the "unadjusted" large-scale technology.[1]

Turning to machine peripheral activities, much of the inter-machine handling and transporting is done by hand. In place of mechanical, human conveyor belts were devised. Receiving, packaging, and storing was done by hand. The same was true for the handling of intermediate inputs required, e.g., as Orchard again reports:

> at one of the largest copper smelters in Japan, clay for the lining of the furnaces is carried down from a nearby hillside on the backs of women. At the plant of the Tokyo Gas Company, coke is put into kegs by hand and then carried by coolies, some of them women, to the barges in the adjacent canal. Coal, even in the larger Tokyo plants, is unloaded by hand and carried in baskets to the power houses.[2]

In sum, the quantitative importance of this ability to substitute labor for capital in activities peripheral to the machine proper was apparently quite substantial. Very often such activities were machine paced in the Hirschman sense, i.e. while they might have looked wasteful to the untrained Western eye, they were, in fact, paced by well-spaced machinery as part of the same production line which contained large numbers of unskilled laborers.

A third type of adaptive technology change of which much use was made in historical Japan is of what we have called the plant-related variety. This is often characterized by the co-existence of different historical stages of production in the same industry. Raw silk production and cotton weaving represent outstanding examples. In the former industry silkworm rearing and cotton production were handled mainly by farmers' wives in small home-made sheds, extentions of the rural households. In cotton weaving, most of the yarn was "put out" to farm households, with individual looms dispersed in farm houses and worksheds. But even in the more modern factory-style spinning industry, preparatory and finishing processes were carried out largely at the cottage level.

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[1]Katsuo Otsuka, "Technical Choice and Technical Progress in the Silk Industry," unpublished Hitosubashi University seminar paper.

[2]*Ibid.*, p. 255.

This rather remarkable survival of domestic industry on a sub-contracting basis must be explained largely in terms of the exploitation of complementarities between many small labor-intensive operating units and the large industrial management units. The traditional merchant middleman, as a representative of the sub-contracting unit, served as both supplier and market for the goods to be worked up domestically. A specialization of functions as between workshops, even as between the members of a given family, developed. One-roof economies could be achieved in this fashion, i.e. by using cheap labor in cooperation with old-fashioned machinery at the workshop level, while economies of scale could be achieved in the financing, purchasing and merchandising stages.[1] The continued relative importance of this household type of enterprise is quite remarkable; cottage style industry contributed more than 2/3 of industrial output in 1878, almost 60 percent in 1895, and retained substantial importance well into the twentieth century. Not only lacquerware, pottery, porcelain, sake, fruit and fish canning but also such new consumer goods coming to the fore over time as bicycles, electric lamps and rubber, were to exhibit the same characteristics.

Plant amounts to more than 50 percent of total investment in plant and equipment in most countries. The ability to utilize households for putting-out operations and thus reduce expenditures on plant undoubtedly amounted to a major kind of capital stretching innovation. By deploying familiar but improving machinery over large numbers of scattered mini-plants, large amounts of unskilled labor could be deployed in both direct production and in satisfying the resulting increased demand for transportation and handling activities. In this fashion, Japanese entrepreneurs were able to, first, incorporate pure labor services and, later, domestic ingenuity and skills, into their industrial production and export bundle.

The Japanese thus combined some discrimination in the process of technology borrowing with a very substantial amount of technology assimilation. The latter capacity seems to be substantially assisted not only by the relatively free access to resources by dispersed decision making units, at relatively realistic prices, but also by the ability to train up the required additional supervisory personnel through both within-plant training and less formal learning by doing processes. At least in textiles, the need for a continuous supply of what might be called an adaptive engineering capacity was supplied by the establishment of applied engineering schools through the pooled efforts of a number of textile firms.[2]

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[1]"Sometimes even a single part is not completed in one shop or home but is shaped in one and painted or plated in another." H. G. Aubrey, "Small Industry in Economic Development," Social Research, September 1951.

[2]Gary Saxonhouse, unpublished Yale Ph.D. Dissertation, 1971.

Turning next to the contemporary Korean case at the micro level, there seems to be less evidence of much conscious rejection of the latest shelf technology, although a good deal of thought was apparently given, subject to existing aid and other constraints, to the choice between late model Japanese, German and U.S. machinery. When it comes to capital stretching assimilation, however, examples abound, especially in textiles, electronics and plywood production.[1] With respect to the manufacture of silk, for example, the core activity contrasts a ratio of one girl per two looms with one girl per 6.8 equivalent looms in contemporary Japan. In reaction to now rising wages in Japan, Korea is taking over the lower quality yarn spectrum where more girls can be employed to make up for the inferior quality of the raw material. In cotton weaving, one Korean girl mans 3 looms as contrasted with 4 in Japan; in spinning the contrast is between 600 and 900 spindles. Moreover, Korean machinery is run for 3 eight-hour shifts daily as contrasted with only 2 such shifts in Japan. Peripheral to the machines proper, we may note that the contemporary Japanese use of a conveyor belt system, for example between the carding, gilling and combing operations, is replaced by human hands in Korea.

In the production of plywood what at first appears as production processes very similar to those carried on in the U.S., i.e. fixed proportions, in fact, turn out to be quite flexible -- interestingly enough mainly because of the greater machine speed combined with much more labor-intensive repair methods used. In the United States, defective pieces of lumber are cut out automatically by machine and discarded. In Japan, defective pieces of lumber are cut out by hand and the section is discarded. In Korea, defective sections are cut out by hand, the scraps saved, and the defect plugged manually. Here once again a lower quality raw material can be upgraded to an equivalent quality output through the application of cheap labor. Consequently, overall we found twice as many workers per unit of capital equipment in Korea, i.e. 123 workers are engaged per equivalent capital production line as contrasted with 72 in Japan; moreover, a Korean line is worked a 22-hour day as compared to 20 in Japan. At the same time between 10 and 15 percent more workers are engaged in inspection, repair and maintenance of both materials in process and the machinery in place.

In electronics, machine-related or core-type adaptations are most prominent. In transistor assembly operations, for instance, given wage rates 10 times higher than what equivalent operators get in the U.S. (in the same firm), the machinery is run at physical full capacity, i.e. six days, three shifts a day which is 20

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[1]The help with Korean plant interviews of Professor Sung Hwan Cho of Sogang University, Seoul, is gratefully acknowledged.

percent above the U.S. equivalent. Moreover, certain special operations such as feeding and packaging are usually done by hand on the assembly line, instead of automatically. In spite of the greater use of labor, productivity per worker seems to be higher due partly to the faster learning process (it was repeatedly stated to take at least two weeks less to train Korean girls in assembly than Americans) but mainly to the greater discipline and attentiveness on the assembly line throughout. For example in one firm the difference in speed of assembly on identical equipment yields a 30 percent differential in output (from 68 units per machine hour to 85) and in a die mounting process it rises to more than 100 percent (from 113 units per hour to 240). These greater speeds of operation, either due to faster machine or operator pacing, are once again accompanied by putting additional girls into more intensive testing, inspection and repair efforts than is encountered in Japan or the U.S. Defective pieces are not thrown away but repaired by hand. Similarly, with machinery itself working at physical full capacity, considerably more manpower is allocated to the maintenance and repair of the in-place capital equipment.

With respect to other, plant-related technological assimilation, the most important phenomenon clearly resides in the area of subcontracting, both domestically, and internationally. Domestically, subcontracting to local equipment and parts manufacturers is being increasingly practiced, especially in the electronics industry; sometimes, as the experience of several companies indicates, it takes two to three years before the domestic subcontracting supplier, via a learning by doing process, has become a lower cost producer than the main plant or import alternatives. While such capital saving innovations, mainly via the reduction of plant and large-scale urban overhead requirements, are not yet as wide-spread in Korea as in historical Japan (and contemporary Taiwan), they are markedly on the increase in a number of other industries as well. Internationally, of course, accepting a sub-contract for the labor intensive phase of a multi-stage and elsewhere technologically demanding production process, is a potentially very efficient way of harnessing virtually pure labor services to the development process. Bonded export processing schemes, consisting of tariff free zones into which often under subsidiary or sub-contracting arrangement with Japanese or American firms, raw materials are imported and then reexported after value in the form of cheap labor has been added, have proven to be most helpful in this context. Such arrangements now yield more than 20 percent of a Korean export volume which itself, as we have noted above, has been rising at annual rates of between 30 and 40 percent during the past few years.

Firm interviews in Taiwan yielded evidence that, assisted substantially by the establishment of the Kaohsiung Export Processing Zone, a similar type of technology assimilation process has taken place, mainly in assembly and fabrication processing stages. For example, in a large plastic factory plant, while the continuous process (producing resin for PVC plastics) showed about the same capital-labor ratio as parent company plants in the U.S., the ratio in fabricating was only about one half of the American plants.[1]

The use of labor is most intensive in electronics assembly. While parts are mainly assembled with the aid of machines in the United States, this work is performed by women workers in Taiwan. According to the general manager of one major electronics firm, the amount of labor used in assembling one set of television in the Taiwan plant is 50 percent greater than that in a plant of the parent company in the United States. In fact, most of the electronics firms interviewed were making efforts in one way or another to introduce labor-intensive methods. While the capital-labor ratios in this industry, like most, have been rising globally through time, the largest electronics factory in Taiwan has experienced an increase of capital by nine times and an increase of employment by sixteen times between 1965 and 1969. Throughout the electronics industry, capital-labor ratios have apparently fallen during the 60s.

One further conclusion derived from the Taiwan plant visits, and confirmed elsewhere, is that the closer the production process is to the raw material processing stage, i.e. backward linkages, the smaller the chances for capital stretching types of adaptive technological change; the closer the process to the finished product stage, the greater are these possibilities.

It is sometimes asserted that the experience of Japan, Korea and Taiwan is so atypical, for reasons of size, as well as special cultural, educational and geographic features, that it is not relevant for LDC's generally. We do not wish to dispute the basic point, i.e. that large countries, like India and Brazil, clearly face a somewhat different problem in terms of their much smaller possible reliance on trade to help achieve major changes in output mix and associated changes in technology. Every LDC is clearly different in many other essential dimensions as well, such as its human versus natural resource endowment, its political structure

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[1]The help with Taiwan plant interviews of Professor N. R. Chen of Cornell University is gratefully acknowledged.

and the stage of development it has already reached -- including here the aforementioned choice it may have already made (possibly difficult to reverse) as to where to head at the end of primary import substitution.[1] Nevertheless, at a minimum the evidence collected to date casts serious doubt on the supposed tyranny of the LDC's use of technology and seriously underestimates the potential inventiveness of indigenous entrepreneurship if the economic environment can be changed.

To make this point and at the same time to at least partially respond to the adherents of the "special case" position, let us, therefore, before concluding this section, cite a few relevant examples from other countries. Unfortunately not many have as yet adopted the full policy package associated with export substitution, most conducive to yielding the kind of evidence we are after. But several have undertaken partial evidence of technological flexibility which is believed to be instructive and will be briefly referred to.

One such example is provided by West Pakistan, an area no one will confuse with Korea or Taiwan, during the first decade of the 60s. After following a more or less classical set of import substitution policies -- with more or less classical consequences in performance -- West Pakistan moved towards a more outward looking environment, including through a de facto devaluation import liberalization, and adjustment (in favor of agriculture) of the internal terms of trade around 1960. As a consequence, at the aggregative level, the saving rose from 5.5 percent in 1958 to 9 percent in 1966, the growth rate from 1.2 percent to 3.4 percent and the growth rate of exports from 2.5 percent to 8.3 percent. More importantly as a consequence of the, admittedly only partial (relative to Korea and Taiwan) move to export substitution, non-traditional exports rose by 89 percent between 1959 and 1964 and accounted for 60 percent of the total in 1964 (compared to less than 10 percent in the 1950's). This restructuring was materially aided by what, to most observers, was a surprising growth of engineering and other small-scale industries, especially in the Punjab. At least according to one study, this growth was also associated with a good deal of adaptive technological change, especially in the construction of local tube-wells, pumps and other light engineering products.[2]

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[1]The author, in fact, believes that a typological approach (i.e. a different framework of analysis for different LDC subfamilies) is necessary, and a good deal of the work of the Yale Growth Center reflects this view. The subject is again, however, too broad to be tackled here.

[2]Edward H. Smith, Transfer of Technology. Choice of Techniques and Economic Growth, Yale Ph.D. Dissertation in progress. In spite of what has happened in, and to, Pakistan since, largely as a consequence of political decisions, the experience of the early 60s remains valid for our purposes.

Another example is Kenya, a much smaller and thus, from the beginning, more open economy in which a substantial amount of technological flexibility seems to be in evidence, both at the borrowing level, i.e. through the use of old equipment, and at the assimilation level, especially in a variety of machine-peripheral activities.[1] Even in India, which has only recently, and with considerable hesitation, moved in the direction of liberalization, evidence of capital-stretching can be found. Ozawa, for example, reports that a Japanese glass company operating an Indian subsidiary was able to cut plant size in half and triple the number of workers (relative to Japan) because "sheet glass is manually cut, the transport of raw materials within the plant and the crushing of coal are not automated but performed by labor."[2]

Finally the experience of the Mexican Export Processing Zone, specializing to date mainly in electronics assembly and textiles, is relevant. While Mexican industry generally is still living under hothouse import substitution conditions, the Northern Border Industries (about 300 U.S. subsidiaries and 150 Mexican firms) have been facing a slightly less distorted set of price signals and perhaps more importantly, pressures to be competitive in the U.S. market. Plant interviews here clearly indicate that what is occurring is an early and as yet incomplete version of the Korean-Taiwan story. U.S. multi-national corporation subsidiaries, for example, are normally established with the single purpose of taking advantage of the relatively low Mexican wage rate,[3] with little initial technology change contemplated -- in fact, resistance from headquarters to tampering with the coefficients lest the quality of output be adversely affected. After a year or so (6 to 8 months in Korea/Taiwan) local managers often perceive additional ways of reducing costs by using the imported machinery more intensively. This takes the form of a more continuous use of the machinery including multiple shifting and letting machines remain in place much longer than in the U.S.[4] This is turn is compensated for, on the one hand, by much more attention being paid to repair and maintenance activities, including the replacing and adjusting of machine

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[1]For further details, see Howard Pack, "Employment in Kenyan Manufacturing," Yale Economic Growth Center Paper, January 1972.

[2]Terutomo Ozawa, "Report on Japan's Transfer of Technology to Developing Countries," UNITAR, mimco, August 1970.

[3]As well as Section 807 of the U.S. Tariff Code which exempts all but value added abroad from U.S. duties.

[4]Occasionally machines no longer used in the U.S. are exported to the subsidiaries.

tools in the local machine shops.[1] Local subcontracting, though still constrained by the absence to date of much ancillary industrial activity near the border and high transportation costs elsewhere, also increases with time, especially with respect to packaging materials, wire and other simple components.[2]

The Mexican Border Program illustrates in an even more extreme form than Korea and Taiwan (due to the more extreme proximity factors, at least as far as the U.S. is concerned) the growing possibilities of an international system of subcontracting by process, in accordance with differential factor endowments; this extension of the the division of labor by commodity principle provides a larger scope for adaptive LDC technology. Japanese synthethic textile firms, for example, do their material purchasing centrally, let the dying and weaving be done in Taiwan, the yarn knitted in Hong Kong, and then handle the exports to the U.S. centrally. The leather for a U.S. baseball glove manufacturer is tanned in Japan, the stitching done in Korea. Both Ford and G.M. are currently considering the construction of a Southeast Asian car, with different processes to be located in Indonesia, the Philippines, Malaysia, Singapore and Thailand. Phillips and Volkswagen have, for some time, been experimenting in this field of the international division of process which, given the close assocaiation between output mix and technology, tends to give further major scope to indigenous technological assimilation.

Dynamically, we may note, e.g. for the U.S. and Japanese electronic firms operating in Korea and Taiwan, a tendency to move, over time, from simple assembly operations to adding processing stages both forward and backward as local skills improve, for example, from transistor assembly to cutting the silicon wafers and precision welding, on the one hand, to the final finishing processes on the other. Another tendency which can be detected within any one export processing zone, as well as looking across zones of different maturity, is the inclination to transfer relatively low volume series or processes first, i.e. where economies of scale play a lesser role, as well as to keep the number of style or model variants to a minimum -- and later, as changing capacity permits, to gradually expand in both direction.

The amount of spatial flexibility multi-national corporations have shown in moving their processes about on a global scale is also quite remarkable. The U.S., Japan and Hong Kong, for example have reacted to sustained Japanese wage increases in recent years by moving textile, wig, leather products, electronics

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[1] As an aside, it is interesting to note that Mexico earns more than $2 ½ million annually from the repair of U.S. office machinery, T.V. and radio sets.

[2] The cost effectiveness of such procurement, including savings in transportation, has to overcome the loss of the U.S. tariff waiver on U.S. components.

and plastic footwear operations to Korea and Taiwan. Similarly, Singapore has lost its unskilled labor-intensive processes and acquired more skilled labor-intensive ones. Such flexibility includes changes in the selection of commodities and processes relevant to particular commodities at a fairly disaggregated SITC level.

As we have pointed out repeatedly, the vast majority of contemporary LDC's still find themselves in the grip of an import substitution policy regime -- some for good, some not so good reasons. Since we expect a more endowment sensitive type of environment to be a necessary (if not sufficient) condition for the demonstration of the flexible use of technology, as part of the profit maximizing calculus of dispersed decision making units, we are somewhat handicapped in our effort to marshall yet additional "deviant" country evidence. There remains, however, one other area of investigation, which -- while we can only touch upon it briefly -- provides some additional empirical support for the arguments of this paper. And that is cross-sectional evidence within the industrial sectors of given countries, by scale of establishement.

It is well known that in countries subject to the usual distortions of import substitution, such distortions fall unevenly on large and small firms. A low interest rate policy, for example, usually means that large scale firms, as prime borrowers, get the tightly rationed credit at official rates, while medium and small scale firms do not, and have to either do without or borrow at substantially higher rates. The same holds for imports, usually available at official exchange rates to the large well-established firms who get their import licenses, but available only at higher prices, after resale, to the small and medium firms. With respect to labor, it is the large firms who feel they must (and can afford to) pay the highest wages, while other scales will be content to stick to the legal minimum or even evade the legislation altogether. Since a distortion of relative prices, in other words, implies a direct rationing system, the small and medium scale firms who have to work their way around the system usually, in sum, face a set of signals closer to equilibrium values. If we should then be able to uncover differential behavior in terms of technology choice by scale of industry within the same country, our argument is further strengthened.

As it turns out, the phenomenon of so-called "industrial dualism" which we are now talking about -- including as one of its manifestations the expected differential use of technology --

has been documented for a substantial number of countries.[1] The results almost invariably indicate that the medium and small scale firms are substantially more "efficient" in terms of the intensive use of scarce capital and the extensive use of abundant labor, as reflected in lower capital-output and capital-labor ratios.[2] Many of the same studies show, either directly or by implication, that real industrial economies of scale (as opposed to those caused by unequal access to resources) are often exaggerated -- at least in industries in which continuous processes are not dominant. Not only are medium and small scale firms thus facing a more competitive environment and forced to make a more careful, i.e. endowment sensitive, technology choice statistically[3] but the incentive to innovate and adapt in a labor-using direction dynamically is equally enhanced.[4] In short, cross sectional evidence, by scale of operation, within countries still under import substitution tends to further support the basic notion that changes in the economic environment are essential for an approach to the optimum LDC utilization of technology.

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[1] e.g. for Pakistan in Gustav Ranis, "Production Functions, Market Imperfections and Economic Development," Economic Journal, June 1962; for Mexico in Saul Trejo, "Industrialization and Employment Growth: Mexico 1950-1965," unpublished Yale Ph.D. Dissertation, 1971; for Colombia in Albert Berry, "The Relevance and Prospects of Small Scale Industry in Colombia," Yale Economic Growth Center, mimeo, October 1971 and John Todd, "Size of Firm and Efficiency in Colombian Manufacturing," Research Memorandum 41, Center for Development Economics, Williams College, October 1971; as well as for other countries, in the U.N. Industry and Productivity, annuals.

[2] A similar phenomenon, incidentally, has been found to hold for LDC agriculture, i.e. a more intensive use of land on medium and small scale plots, e.g. in India, Brazil, Colombia and Pakistan.

[3] For example, G.K. Boon found that of 88 metal Chipping (core) processes used in a cross section of rich and poor countries, more than 50 percent were highly sensitive to relative price conditions as well as lot size ("Optimal Technology in Metal-Shipping Machines Tools," May 1968, Stanford University).

[4] Moreover, the Galenson-Leibenstein type of argument to the effect that larger wage bills today will yield lower employment tomorrow -- due to the lower savings and capital accumulation entailed -- have not been standing up too well to empirical tests. Small farmers and industrialists seem to be among the highest savers (see also a number of U.N. studies on the sources of savings as well as G. Ranis, "Investment Criteria, Productivity and Economic Development: An Empirical Comment," Quarterly Journal of Economics, May, 1962.)

IV. Conclusions for Policy

Some of the major conclusions flowing from our analysis may now be briefly summarized:

1. There exists only a limited scope for LDC choice in technological borrowing. The choice of from whom to borrow and what vintage seems to be narrowly constrained, both by a lack of information, by prestige factors, and by institutional impediments attending the transfer of capital. On the other hand, there exists very substantial scope for technological assimilation, i.e. indigenous innovations of a labor-using variety.

2. The potential for adaptive technology change today seems to be most pronounced in core and machine-peripheral activities, as well as, if to a lesser extent, in plant-related activities. In the course of such innovations, most often unskilled labor is substituted for machinery, but sometimes also for the quality of the raw material input.[1] The types of goods subject to such flexible use of technology include textiles, electronics, metal working, non-electrical machinery, food processing, tires, tubes, leather products, rubber and plastic footwear, among others. The ability to adapt seems to be related directly to the importance of production costs relative to the total sales price, and indirectly to the importance of quality over price considerations in marketing.[2]

3. Changes in adaptive technology and in output mixes using such technology require a set of relative factor and commodity prices which are more sensitive to endowment and endowment changes. This can be best observed by contrasting the relevant behavior of industrial sectors over time (as they move from import substitution to export substitution) as well as, to some extent, by looking across industry scales within a country. More realistic relative prices appear to be a necessary but not sufficient condition for softening or eliminating the LDC conflict between output and employment income distribution objectives.

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[1]For example, in addition to the already cited substitution of short for long staple cotton in Japanese spinning, Bararson finds similar examples in the pulp and paper industry, i.e. the blending of short and long fiber pulps, and even in petroleum refining, where domestic crude mixed with imported renders the use of a smaller scale plant efficient.

[2]See W. A. Yeoman, "Selection of Production Processes for the Manufacturing Subsidiaries of U.S.-based Multi-National Companies," Unpublished D.B.A. Thesis, Harvard Business School, 1968, as quoted in Raymond Vernon, "U.S. Enterprise in Less Developed Countries," in The Gap Between Rich and Poor Countries, Gustav Ranis, editor, MacMillan, 1972.

4. The ability to quickly convert relatively "raw" unskilled labor into an efficient disciplined industrial work force seems to be borne out by all the evidence. In fact, not only "hard working" Korean and Taiwanese girls but Mexican as well apparently exhibit superior labor productivity characteristics when compared to their U.S. counterparts in exactly the same operations.[1] One constraint which does apparently inhibit fuller resort to labor using adaptations, however, is the scarcity of skilled supervisory personnel, e.g. for night shifts, as well as of a problem solving type of adaptive engineering capacity.

5. Adaptive research and development -- usually carried on within the machine shops of LDC plants and focusing on endowing machines with a larger productive life through heavy maintenance, as well as the insertion of small, labor using devices and adjustments -- seems to have had the highest pay-off. Basic research, carried on mainly within LDC universities and government institutes, on the other hand, seems to have had a much smaller pay-off. Our interview evidence thus supports the findings of Katz to the effect that "the 'learning' of the decade of the 60s has been associated with the presence of a significant local technological effort, more than with the permanent reception of knowledge from abroad, additional to that received at the beginning of operations."[2]

6. Export processing zones have apparently served as effective transitional devices for countries moving from import substitution. Export processing permits general organizational and technical talents to be imported -- along with capital and intermediate goods -- while domestic entrepreneurial maturation is still going on in most of the economy. Then, as value is added in the form of mainly unskilled labor before re-export, adaptive domestic engineering ingenuity plays an increasingly important role in both cost reductions for a given operation, as well as the adding of processes and the broadening of the output (or models) mix. Some of this technological "learning by experimenting" then seems to spill over to the rest of the economy -- reversing the usual historical notion that one had to "cut one's teeth" on the domestic market before being able to export competitively.

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[1]For example, the Electronics Control Corporation reports that one girl in its Matamoros, Mexico, plant produces 3500 units per day on the same equipment which yields only 2500 units per day in its Eulers, Texas, plant. Less chatting, fewer coffee breaks, and the ever-present threat of the "reserve army" outside are the usual explanations offered. (Business Week, January 1972)

[2]Jorge M. Katz, op. cit., p. 24.

7. Multi-national corporations seem to play a large, though by no means exclusive, role in this new process -- focused international division of labor, including the utilization of tariff-free export processing zones. This is probably in large part due to the fact that such companies have more global information and control of specific markets. This is especially relevant since markets for intermediate goods are substantially less well organized than those for primary goods, on the one hand, and finished goods, on the other.

These conclusions lead one, in turn, to a number of suggestions with respect to the policy setting, both on the part of the technology borrowing and lending countries, most likely to result in improved LDC utilization of technology. Taking, first, policies within the control of the technology borrowing LDC's:

1. Technology change cannot be harnessed effectively to the simultaneous solution of the output generation/employment/income redistribution problem if macro-economic policies continue to seriously distort major relative price relationships in both factor and output markets. All the policies which render capital artificially cheap and labor artificially expensive -- as well as many policies which distort the relationship among output prices (e.g. price controls on some consumer goods, subsidies on some capital goods, and exchange rates which discriminate against exports) all have the effect of seriously inhibiting the search for labor-intensive technologies and output mixes. Neglect of marked improvements in this general environment, while moving on to "direct actions" in inducing a more appropriate use of technology will not work -- certainly not with respect to the private sector. Any substantial move towards a better use of technology requires facing up to the sometimes politically difficult decisions involving at least gradual liberalization at the end of the primary import substitution phase. It is, moreover, important that any such policy trend, even if slow, be consistent. Frequent back-and-forth oscillations between a more control and a more market-oriented environment cause too much uncertainity and probably yield the worst results.

Capital intensive technology choices may well "dominate" in certain industries:[1] labor intensive in others. But unless the "game" is made fairer, new medium and small scale entre-

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[1]This point is made by Pack and Todaro, among others.

preneurs without previous access to resources cannot bring their technological ingenuity to bear.[1] A fiscal system which artificially subsidizes cottage industry (e.g. India's khadi) is as wasteful as one which subsidizes high technology industry (virtually every LDC); neither path is likely to encourage the use of modern but labor intensive technology.

2. With respect to the public sector, the pressures of domestic competition and trade, of course, operate less forcefully since many public enterprises can afford to run continuous deficits "in the common good" and much of their output is in non-traded commodities. Nevertheless the use of shadow pricing would be very helpful here, especially when relative market price signals continue to be distorted. Much can be done, for example, in road construction and public housing, both of which offer a relatively wide range of technology choice.[2] But realistically, a major problem to be overcome, even in the rare case when the public sector does use social rate of return calculations, is that such calculations are often employed ex post facto, i.e. long after the political decision to go forward with a project has been taken. Perhaps the choice of technology for a given project bundle is somewhat more "open," and shadow pricing should, in any case, be pursued whenever possible. However, it must be recognized that prestige and other institutional considerations play a perhaps even larger role in the public than in the private sector. Emphasis on reducing LDC "technological dependence" on the rich countries, put alongside the frequent protests against other forms of dependence, might help overcome this tendency, while serving as a healthy demonstration for the private sector.

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[1]We are not suggesting that a fair game means equilibrium prices, e.g. that real wages could or should be brought down to their shadow price levels--nor that most LDC's have the administrative capacity to effectively subsidize the wage bill--only that real wages should not be allowed to rise very much as long as a labor surplus persists and real interest rates should not fall as long as there is an excess demand for credit.

[2]Even the Soviets, especially in the production of light machinery and engineering goods, seem to have successfully devised efficient ways of adapting labor using technologies. (See, for example, David Granick, "Economic Development and Productivity Analysis: The Case of Soviet Metalworking," Quarterly Journal of Economics, May, 1957.) Public sector machine-paced labor intensity is in evidence especially in road construction, housing and other public works projects. For example, in India and Pakistan reinforced concrete is poured by linking up a cement mixer with a long chain of workers passing the cement from hand to hand; it is put in place just before it is ready to cool and harden.

3. A more realistic set of price signals, while thus an essential ingredient of any improved use of technology on the part of the LDC's is, however, not enough. There do exist potential bottlenecks in the form of supervisory and adaptive engineering personnel, already referred to, which inhibit the fuller use of unskilled labor relative to capital -- especially with regard to multiple shifting and the introduction of new labor-using machine attachments. The supervisory personnel problem seems to be capable of solution through the eliciting of especially gifted individuals from the unskilled in-plant labor ranks, usually after 6 to 8 months or a year. With respect to the appropriate kind of engineering skills, however, both the Japanese and the Taiwan cases already cited lead to the conclusion that special indigenous training programs, possibly supported by the very companies likely to benefit, should be encouraged. Many plant officials expressed the view that the wrong kind of experience or training often proved worse than none in this regard.

4. Closely related is the question of Research and Development. We share the view of Richard Nelson, who, after careful consideration of the difficult issues involved, finds "the arguments in favor of building up a strong LDC basic research capability unpersuasive."[1] Aside from the trial and error costs which are in large part avoidable -- with mainly search costs having to be incurred by the LDC's -- there is the question of the critical mass or minimum economies of scale involved in the basic R&D production function in itself. Yet it is interesting to note that, in spite of the previously referred to relatively lower LDC expenditure on R&D (relative to GNP or budget), the percentage allocated to basic research is substantially greater than in the advanced countries. Since this is undoubtedly, in large part, due to the concentration of R&D in government and university institutes which tends to allow researchers excessive freedom to set their own standards (frequently unduly imitative of their DC "frontier" colleagues), encouragement of industry supported applied research institutes seems warranted. Some such institutes including the Chung-hua Electronics Development Corporation in Taiwan and the Leather Research Institute in India seem to have been quite successful. The Soviets also have apparently realized that research institutes need to be drawn into doing at least some short-term applied work for industry -- and compensated for it in relation to results -- if they are not to become increasingly irrelevant.[2] In

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[1] "Less Developed Countries, Technology Transfer and Adaptation, and the Role of the National Science Community," Yale Economic Growth Center Discussion Paper 104, January 1971, p. 28.

[2] "Science Policy in the U.S.S.R.," OECD, 1969.

addition, for specifically defined industry purposes, e.g. adaptive technology in footwear, electronics or textiles, the sponsoring of international institutes, along the lines of the International Rice Research Institute in agriculture, should be carefully considered -- preferably in conjunction with country-specific adaptive research efforts. Such institutes could substantially reduce the dangers of wasteful duplication, with each LDC exerting its own efforts at devising a capital-stretching shoe technology, for example.

5. The establishment of export processing zones, especially during a transitional period en route to a more generally liberalized economic policy package, should be encouraged and the necessary overhead facilities and customs arrangements provided by governments. The attitude towards the role of multi-national corporations in this context should be as pragmatic as possible. There is considerable evidence that some foreign firms exhibit considerable technological flexibility, probably more than domestic public or private firms -- at least at the initial stages. On the other hand, most such companies also suffer from some of the strait-jacketing associated with fixed central management rules, e.g. on global interest rate and break-even points -- even in such relatively endowment and technology sensitive firms as Phillips and Volkswagen. Foreign subsidiaries, especially if admitted into a comfortably protected domestic market, thus sometimes exhibit inflexible behavior on technology, in addition to their collusive market sharing, anti-export and other "anti-social" behavior. Here again we have an argument for tackling the macro-economic environment as a prime instrument for reducing some of the negative, while retaining some of the positive, effects of multi-national corporation activity. Just as with the large-scale private domestic firm, much of the so-called anti-social behavior will disappear under the pressure of competitive forces in an export substitution-oriented environment.

In addition, of course, LDC governments have every right to regulate such companies' practices including their tax, royalty, technical assistance payments, the use of export prohibition clauses, the training of local managerial and supervisory personnel, as well, possibly, the move from equity control to licensing arrangements over time. (Some of the features of the Andean Group's Treaty of Cartagena are relevant here.) But while we recognize that this issue is a highly charged one politically, LDC's should also be aware that substantial benefits for technological flexibility, including via the international division of labor by process, can flow from this form of foreign capital. Such companies do have a better opportunity to scan resource endowments and markets on a global basis and to move quickly

and flexibly to take advantage of this knowledge. It should, finally, be noted that, in contrast to the inflow of foreign public capital, private investments may be less tied (at least legally) to specific countries of origin and less likely to insist on financing only the import content of projects -- thus less prone to artificially enhance industrial sector import and capital intensity.

6. Few LDC's nevertheless will want to rely too heavily on the foreign multi-national corporation for their capital and technology imports. Increasing participation by domestic firms of all sizes is therefore a political as well as economic necessity. Every such firm clearly is not in a position to be up-to-date on the international market conditions, resource endowments, and trade channels, including obtaining the necessary "illumination" of the technology shelf and of technology assimilation possibilities tried elsewhere. LDC governments should, therefore, consider taking on some of the social search and information functions, perhaps through the establishment of specific industry-oriented information service centers.

Turning, finally, to actions which can be taken by the technology exporting, rich countries:

1. There exists, it seems to us, a transcendental and primary obligation on the part of rich country aid donors, as well as the multilateral institutions, to make discussion of the macro-economic policy setting, central to the LDC technology issue, a central part of any discourse between donor and recipient. This is not to say that aid should, or could, be conditioned on any specific steps to be taken -- but it is to say that failure to discuss the importance, the method and the timing for a transition to a more endowment and technology sensitive regime at the appropriate time may well render all other well intentioned "direct actions" substantially null and void. There is no shortage of awareness of the dimensions of the problem in most contemporary LDC's, nor a lack of awareness of the direction policy must take if a continued conflict between growth and employment cum income distribution is to be avoided. Nevertheless, there exist strong political as well as other obstacles to liberalization within every import substituting LDC. On the one hand, large scale private industrial interests are loath to lose their windfall profits, just as civil servants may be loath to let the market displace some of their power (and income); on the other, technocrats may fear revenue and foreign exchange losses if tariffs were to be reformed and import control regimes liberalized. With respect to both these obstacles, temporary "aid ballooning" can be helpful in the realm of gentle persuasion as well as in making such transitions in policy package practically feasible.

2. Not only the quantity but also the quality or composition of the aid package is likely to be important in this context. It is difficult to discuss the distortions in favor of capital extensive technology when one's own, albeit marginal, contribution to the total effort substantially contributes to the same distortions. We are referring here to the well-known effects of aid tying, projects-only and minimum local-cost-financing biases of many donors. Such policies induce import and capital intensity and reduce the scope for technological assimilation. Program or sector loans, on the other hand, preferably untied and with minimum transaction requirements removed -- especially if linked to changes in the LDC's own policy environment -- have a much better chance to help in the direction of letting the "technological chips" fall where they may, while permitting vital indigenous innovational juices to flow.[1] It cannot be emphasized sufficiently that rich country credibility in regard to the present mushrooming concern with matters of technology choice, employment and income distribution will depend in large part on the ability to put one's aid package where one's mouth is.

3. With respect to aided public sector projects, cost benefit analysis, using shadow prices for capital and unskilled labor, as well as possibly for skilled and technical personnel, has a role to play -- subject to the aforementioned caveats on the actual use to which project analysis is usually put and the perhaps more important caveat that solving one's conscience by partial equilibrium attention to projects only could represent a case of seriously misplaced concreteness. More attention, especially to the technological choices within projects, e.g. different-sized tractors and different earth-moving, excavation and road-construction techniques is indicated. Even crude adjustments by the use of shadow prices could be very helpful in both project and technology selection.

4. Efforts should be made to influence the behavior of foreign private investors in the same direction of technological flexibility. For example, when DC corporations apply for investment guarantees, either of the multi-lateral or bi-lateral (e.g. OPIC) variety, evidence of the scope for decentralized subsidiary decision making on technology and output

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[1]Project loans through financial intermediaries can be used in much the same way.

or process mix could become one of the criteria; at a minimum multi-national corporations could be made increasingly sensitive to these issues in the course of the negotiations.[1]

5. The success of LDC efforts in broadening participation and softening any existing conflict between output and employment cum distribution objectives is intimately related to the strength of competitive forces domestically as well as in the international markets -- thus forcing entrepreneurs to optimize, instead of merely satisficing. An important dimension of the extent to which this strategy is feasible, of course, has to do with the extent of rich countries' readiness to accept the labor intensive goods produced in this fashion. Much can and remains to be done here, not only in terms of the granting of temporary preferences (following the infant industry argument) but also in terms of a really effective rich country adjustment assistance program at home which would nip currently powerful "sick country" defensive reactions in the bud.[2] Moreover, LDC's should be encouraged to look for non-traditional trading partners, i.e. each other, along with the non-traditional, i.e. labor intensive export substitutes. At every SITC level, whether in textiles, shoes or electronics, there exist quality ranges in which some labor surplus LDC has a comparative advantage over others; vigorous trade among vigorously growing LDC's, as they each restructure their protected domestic economy, need not be a fanciful pipe-dream.[3] Today LDC's carry out only 2 to 3 percent of total world trade in manufactured goods, 35 percent of which takes place within the group. The scope for expansion is large. When all is said and done, the potential of competitive trade opportunities may be more helpful than anything else in moving the LDC's to understanding the potential role of technology transfers and to undertaking the necessary changes in environment.[4]

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[1]To avoid criticism many such companies, for example, often resort to higher-than-average (employment-reducing) wage policies, while their performance on employment generation by resisting such pressures and innovating in labor-using directions might lead to better private as well as social results.

[2]It might well be argued that "aid funds" spent in this fashion, in return for a reduction of DC quotas and tariff barriers are in many ways superior, in terms of both economic and political effectiveness, to aid funds spent abroad.

[3]Regional complementary trade, including by process, can be furthered by the granting of reciprocal preferences, the harmonization of incentive programs and tax policies, among others -- as is currently being explored in the context of the South East Asian G.M. or Ford car.

[4]On this point also see Graham Jones, The Role of Science and Technology in Developing Countries, p. 161.

DEVELOPED COUNTRY PERSPECTIVE: Julian Engel, NAS

Ranis argues persuasively that changes in the economic environment are essential for the optimum LDC utilization of technology. Essential, to be sure, but not sufficient, one would retort, in the absence of a well-established indigenous technological capability. The lack of weight and systematic attention given this factor stems from the limited view Ranis takes of the technology transfer function, the nature of technology transferred, and the process of adaptation.

Appropriateness of technology is confined to the single dimension of labor-for-capital substitution, to the exclusion of new technology formation, downscaling and relaxation of design and quality standards of existing technologies to suit local market requirements and conditions.

Adaptation is illustrated largely with technology at the upper end of the scale of technology itensity--all drawn from the "international technology shelf."

The substance of technology transfer is seen as of two kinds:

-- off-the-shelf borrowing with no change, occuring especially during the primary import substitution phase

-- adaptation/assimilation, usually in the later, more export-oriented phase by means of secondary innovations, i.e. pragmatic, machine-shop modifications produced by the "ingenuity" of technical personnel "on top of" a given set of borrowed technology.

The range of indigenous capability required for absorption is consequently rather narrow:

-- information search capabilities

-- technical know-how and management aptitudes

-- industry-supported applied research institutes.

There naturally follows a skeptical view of LDC efforts to build up a "strong basic research capability," an aim which in the context of the Ranis paper calls for more precise and detailed definition. How strong is strong? How basic is basic? Which sciences are relevant, which not? What level of competence is necessary for achieving a national intelligence sophisticated enough to filter the obtruding universe of technology that lies without? These are live questions pressing themselves on a growing number of LDCs.

Basic research conventionally defined and the type of technological adaptation endorsed by Ranis are points widely apart on the innovation chain; between them lies a broad range of innovational steps for which the LDCs appear increasingly determined to acquire their own capabilities. Among other motivations, add to the fear of ever continued dependency on the developed countries' technology, product preferences or import requirements, the recognition by the LDCs that the international shelf may be bare of technology answering indigenous needs and employing indigenous resources.

Ranis' prescriptions for change in the policy package of donors and recipients alike would be greatly strengthened were they to address with equal cogency the measures both sides--and especially technical assistance agencies such as AID--should take to enhance the LDCs' capacity to generate, absorb and assimilate technology. His suggestions (cited above) are fragments or building blocks, they do not constitute a framework or systematic policy. The need for a policy and a program should be evident since the resources being channelled into the development of LDC science and technology infrastructure are not inconsiderable and are likely to grow.

Furthermore, time-lags involved in the build-up are exceptionally lengthy. One has to contend here with periods of a decade or longer, taking into account the training of high-level personnel, the development of high-quality institutions to produce this manpower, the development of supporting technical services, the maturing of a research/development/engineering capability, and especially its confident interaction with the industrial, educational, and governmental sectors.

Ranis notes that in the first industrialization phase--the hothouse period of import substitution--resources tend to flow into social-overhead capital. This generally also includes the establishment of rudimentary science and technology systems, with all the distortions and misallocations of resources for reasons of prestige, irrationality, and the like which beset the industrial sector in that phase. The science and technology infrastructure is poorly linked to industrial development. When the country eventually shifts to an export promotion policy, and discovers the need to harness its technological capabilities to the production function, the mismatch becomes starkly apparent.

There appears to be a need for analytical tools which would provide a methodology for approaching this problem. It might make possible the formulation of a sectoral program strategy such as is now in fashion with respect to the more traditional areas of agriculture and industry.

DEVELOPING COUNTRY PERSPECTIVE: Mahbub Ul Haq, IBRD

Professor Ranis is an outstanding and eloquent advocate of the power of correct price signals in encouraging the right kind of technologies in the LDCs. One may certainly agree with him in most of his analysis but, at the same time, the conviction remains that price signals work within definite institutional constraints. There are a number of questions that one would like to raise:

First, how large is the applicability of price corrections within the various sectors of an economy? While they do have a role in the modern sector, what about agriculture and services? While they have worked in some small countries like Korea and Taiwan, what about large countries like India and Brazil?

Second, to what extent distortions in income distribution are as significant, or perhaps more significant, in misallocating scarce resources as price distortions? For instance, income distribution was so skewed in Pakistan in the 1960's that $300 million was spent on private motor cars as against $20 million on public buses. Similarly, 80% of housing investment was of the luxury type. In this context, what would have been achieved by merely raising the price of capital without attacking the root cause of the problem which was skewed income distribution?

Third, it is normally assumed that price corrections can be more easily undertaken by a country than fundamental institutional reforms. It is often forgotten that without institutional changes price corrections may not even be possible. Price distortions often transfer income to the privileged groups or to the relatively well organized sectors of society: there are not many price distortions which benefit the poor and persist for long. If tractor prices are low, they reflect the power of the commercial landlords vis a vis the landless laborer and they are going to remain low till there is redistribution of economic and political power within the system. Thus, even if price corrections are powerful, are institutional changes not necessary first?

Finally, there is the question of the macro-environment on which Professor Ranis has placed considerable stress. The development strategies pursued so far in most LDCs reflect the Arthur Lewis two-sector model in which the traditional sector is gradually absorbed by the fast rate of growth in the modern sector. The trouble is that such a model is based on built-in inequalities. The modern sector has much higher wages. While the Lewis model expected a differential of 30-40%, in the real world the differences have been in the neighbourhood of 300-400%. Again, in many societies rapid population growth has kept feeding the labor surplus in the traditional sector at such a rate that its absorption into the modern sector has been extremely slow and prolonged. It is now

becoming clear that such inequalities have started straining the limits of tolerance of many societies. The question is: If there is a dual economy, why not have a dual development strategy? On the one hand, a modern sector which grows fast and experiments with all kinds of price incentives and tolerates the prevalence of inequalities for some time. On the other, a large traditional sector where organisation and institutional framework overcome the scarcity of capital and development is taken to marginal men through the organisation of rural and urban works programs.

Two final thoughts: (a) in many areas no ready made shelf of appropriate technologies is available for the LDCs since the developed world has no incentive to keep manufacturing technologies of the 1950's vintage which still may be more appropriate for the developing countries today. Should such technologies be developed by countries like India, Brazil and China and their procurement by other LDCs encouraged by extending the cover of international assistance? (b) Professor Ranis' strictures on basic research are well taken. In most developing countries, the so-called basic research represents wasted investment with little contribution to evolution of appropriate technologies needed by these countries. Such research should not be encouraged and definitely not aided.

THE USE OF LABOR INTENSIVE TECHNIQUES IN KENYAN INDUSTRY

by

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A common phenomenon observed in developing countries is the failure of manufacturing employment to grow rapidly enough to absorb quickly growing numbers in the urban labor force. On the other hand, the ratio of employment to output growth does not differ much as between the LDC's and the DC's.[1] Nevertheless, in view of substantial urban unemployment, the LDC's should be more labor intensive in their growth process. The failure of employment to grow faster is usually attributed to growing capital intensity, assumed to be induced by a growing ratio of wage to capital costs. However, such assertions are backed by only limited empirical evidence as capital stock data are rarely available. Usually indirect evidence is used, such as wage and capital cost data, and competitive assumptions are used to justify estimation procedures which lead to the result that capital deepening is the major cause of low employment absorption.[2] While this interpretation may be correct, it requires a strong leap of faith given the lack of any adequate micro-economic evidence and the absence of strong competitive pressures in most LDC's. There are also questions of whether growing productivity may result from increasing capacity utilization. However, little evidence exists on this question. A series of intensive interviews in Kenya suggest that at least in this economy the conventional view may miss the mark in a number of important dimensions.

Currently, the plants which were visited are extremely labor intensive, although somewhat more labor intensiveness might be possible. This can be seen by comparing some critical ratios with those provided in U.N. publications,[3] comparisons with past U.S. data and by detailed comparison with recommended production methods either in current engineering texts or U.N. publications. It is worth emphasizing that for the most part the factories visited have rather simple technologies and it is quite easy to observe places where more labor intensive methods could be used.

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[1]See H. Pack, "Employment and Industrial Growth - Some Cross Section Results" Economic Growth Center Discussion Paper.

[2]Ibid.

[3]UNIDO, Profiles of Manufacturing Establishments

Moreover, there was enough factory to factory variation to permit the observation of slightly more mechanized processes in some and what appeared to be fairly primitive methods in others.

The first set of comparisons involves the use of data on individual firms provided in the Profiles just cited. Data on individual firms for 1964 give estimates of output, labor inputs, capital (at estimated replacement cost), number of shifts and so on. I have analyzed this data in considerable detail elsewhere;[1] for purposes here some simple comparisons are useful. Among the branches of manufacturing analyzed in Kenya for which considerable profile data are available are paint production and cotton spinning. Tables 1 and 2 present data for Indian, Japanese and Israeli plants in the two industries.[2]

In both industries capital-labor ratios have been adjusted to correct for differences in the number of shifts. Two plants with the same capital stock will exhibit different capital-labor ratios if one is used on a three shift basis and the other on a one shift schedule. In paint production the Kenyan plants are considerably less capital intensive than the Israeli plants and indeed, than one of the Indian plants. On the other hand, even more labor intensive methods seem to be available as evidenced by two of the Indian plants and the Japanese plant.[3] In textiles the Kenyan plants rank toward the middle of the Indian spectrum, but considerably below both the highly capital intensive Indian plant and the Israeli plant.

An additional comparison may be made with a recent analysis of the costs of establishing integrated cotton textile plants by the Economic Commission for Latin America.[4] The capital-labor ratios for a 1950, 1960, and 1965 technology were estimated. The capital estimates include plant and equipment and working capital, and were $6700, $12,700 and $20,700 respectively. Assuming half of these amounts are non-equipment costs, the estimates suggest that current equipment-labor ratios in Kenya are below those viewed as best practice in 1950.

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[1] "Capital-Labor Substitution - A Microeconomic Approach" Mimeo.

[2] As the Kenyan data were obtained during 1971, the replacement estimates given in the profiles were adjusted to a 1971 base, using a variety of data, depending on country.

[3] There is probably some understatement of the Japanese capital intensity vis a vis other countries insofar as yen was undervalued relative to the countries from which the non-Japanese plants obtained equipment. Even allowing for a 15 percent revaluation would still leave the Japanese plant below the Kenyan in paint products.

[4] Cited in UNIDO, Textile Industry (New York, U.N., 1969) p. 44.

TABLE 1

Equipment-Labor Ratios in Paint Production

	U. S. Dollars (1971)
India - Plant 1	672
India - Plant 2	1110
India - Plant 3	4620
Israel	8632
Japan	1958
Kenya (Average of several plants)	2063

Source: UNIDO, Profiles of Manufacturing Establishments and interviews

TABLE 2

Equipment Labor Ratios in Cotton Textile Industry

	U. S. Dollars (1971)
India - Plant 1	2072
India - Plant 2	1484
India - Plant 3	2212
India - Plant 4	1722
India - Plant 5	6160
Israel	8318
Kenya (Average of plants)	2044

In sum, analyses of capital data indicate that Kenyan production looks as if it is relatively labor intensive, on a par with many Indian plants. Comparisons in the other industries examined led to similar conclusions. Apart from cost data it is possible to examine suggested methods of production in engineering textbooks. The current descriptions in such books of desirable production techniques are of interest chiefly for their complete absence from Kenyan plants.

Finally, it is of interest that most plant managers had previous experience in Britain and indicated that their current practice was equivalent at the most to British techniques in the late 1930's or immediate post war years.

The following section describes some salient aspects of the observed production process at some length. In view of widely held notions of unsuitable capital intensive processes in LDC's it is deemed important to comment extensively on some opposite evidence from Kenya. Section II suggests why Kenya may constitute an exception to patterns in other countries.[1] Section III indicates some characteristics, particularly unutilized capacity, which may have considerable short run potential for generating additional urban employment.

It is extremely important to emphasize that much of this paper is based on partial findings. In particular, the interviews were conducted in only a small sample of industries (food processing, paint production, cotton spinning). While they represent fairly complete coverage of relatively large firms in these sectors, I am hesitant about generalizing to other sectors without more evidence. On the other hand the industries represented here are important in both the current and near term industrial structure.

I. CURRENT PRODUCTION METHODS - PROCESSING BY STAGE

The general features of the technical processes salient to our concern are the following. All plants can be characterized by five basic processes. Material receiving, material processing, material handling among processes, packaging and storage of the

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[1] It is perhaps not inappropriate to note that very little micro evidence of they type presented here exists for other countries. An exception is the book of W. Paul Strassman, Technological Change and Economic Development, (Ithaca, Cornell University Press, 1960). Most statements are based on data which indicate a rapid growth of labor productivity and assume this must be due to capital deepening. In many cases this is undoubtedly true, but more micro evidence would allow one to hold this view with greater certainty.

finished product.[1] Considerable emphasis in the literature has usually been placed upon the possibilities of substitution in the actual processing operation or direct production. However, in most plants a relatively small percentage of the labor force is involved in this operation. Thus in a large fruit processing plant employing over one hundred workers, the actual processing of jam or the cooking of other fruits is done in a vat into which three workers pour ingredients which have been mixed by hand. A more advanced process would involve automatic weighing of the ingredients and filling of the vat. Nevertheless, the three represent a small fraction of the total force and if they were replaced by automatic vat filling equipment requiring one person to flip dials, total plant employment would decline by only two workers. The same feature holds in paint production. Most of employment occurs in the auxiliary activities and it is here that the opportunities for substituting capital for labor are of greatest quantitative significance.

In all plants, to take the operations in order, receiving is done by hand, trucks being unloaded, material carried to storage places from which it is carried onto the production line. In only one firm was there an attempt to introduce automatic receiving equipment in which a truck would dump raw fruit directly into a bin, which would then automatically send fruit into the factory where it would be kept near processing machines. The automation had little to do with factor prices. Rather, the current method involved handlers standing in the truck, often on the fruit, and throwing fruit down into the bin. This resulted in a large percentage of damaged fruit and, given the importance of fruit in total cost, mechanical unloading was being introduced. While this new operation will replace 10 workers, it was far from clear that the total capital-labor ratio for all operations would increase, as a smaller number of trucks would be needed to collect fruit as unloading could now be done in minutes rather than an hour. Thus both capital and labor requirements were reduced. It appeared that the substitution would have occurred, even had capital costs been considerably higher in order to save on raw materials. Indeed, this company used a two year payback investment criterion and still found this substitution highly profitable. Here was a clear case where the two factor substitution model abstracted from quite important aspects of reality.

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[1] A similar scheme was used by Harry Jerome in his Mechanization in Industry (New York, National Bureau of Economic Research, 1934). This monograph summarizes extremely careful studies of the process of capital deepening in a large number of industries and has considerable relevance to the question of labor-capital substitution in the LDC's today. I am indebted to Simon Kuznets for this reference.

Paint processing yields another example of the lack of automation even on the receiving line. Whereas in the U.K. ingredients needed in production are delivered directly into storage drums, and is then pumped through pipes automatically when paint is to be mixed, in Kenyan plants drums are unloaded by hand and kept in the factory, although one plant is about to introduce automatic handling equipment (and as we shall later point out, this plant is an anomaly among Kenyan firms). In general, then, receiving is a quite labor intensive process in most plants, exceptions occurring because of quality control requisites.

In intra-factory material movements among primary machines there is little further scope for increasing labor intensity. Although our a priori expections were of a considerable reliance on conveyors, there was virtually none. Even quite heavy jobs where automatic methods might well be profitable (if batches were large) are manually operated. Thus, after paint ingredients are weighed, they have to be raised to a platform from which the ingredients are emptied into a mixer. In all plants except one this was done by hand, two men carrying the drum rather than using either an electric hoist or, as is done in advanced processes in western countries, using a set of pipes through which the ingredients are moved to the platform. To take another example, in meat processing, after meat has been trimmed and sliced, it is typically put into bins which are then moved by hand to the next processing stage, rather than sent along a conveyor.

Filling operations generate major amounts of employment in many of the plants visited. Rather than automatic filling operations which are conjured up by statistics of productivity growth, one finds relatively primitive operations. It was by no means uncommon to find something like the following sequence. After a product is processed it is brought by hand to the filling area and hand ladled or tipped into a filling machine. The machine is then operated by a foot lever - at the press of a foot an amount of the flour or other product is dropped into a bag held by the operator, who in turn either puts it on a conveyor which moves it to the worker a foot away, or this worker just takes it from a fixed place. The second worker then weighs the package on a simple scale, and if the weight is not correct, uses a spoon to obtain the correct amount. The package is then given to a sealer who closes it with a simple device. Variants of such simple packaging procedures are common. In a number of paint plants, the mixed paint was poured into cans by tipping the vat and using a simple funnel. In pineapple plants, crushed pineapple is hand filled. However, there was more plant to plant variation in filling than in any other operation, although nowhere was there any considerable amount of automation.

It was, however, true that every manager interviewed suggested that automated filling was one of the simplest processes to introduce. The reason for the failure to do so was that typically batch size was so small that such equipment, given its productivity, would lie idle much of the time. However, at greatly expanded output, usually estimated at ten times current level, it was felt that such devices would be profitable to introduce regardless of the lowness of the wage. There was almost universal agreement about the economic waste of such installation at low quantities. The desirability of automation at high volume was reinforced by the fact that even if it were desirable to duplicate current processes, hand operations required much more space than automated processes of equivalent capacity. This suggests some substitution between labor and plant as well as the more common kind between labor and equipment. On the other hand, it was far from obvious why large increases in output could not be achieved by increasing the number of shifts. We examine this question below.

Finally, conventional expectations would assume that once the final product is packaged, storage would be done using some mechanical device such as a fork lift truck. In only one of the companies visited was such a device used and here it was necessary because the packages (drums) were quite heavy. Although it might be possible to break down the drum size, this is not possible where there are international specifications. The storing process often occupied about 20 percent of the plant labor force. At current wages rates, plant managers argued that mechanization does not pay. Moreover, there is the same problem as with filling. As long as output is not substantially increased, there is little point in having an 80 percent idle fork lift truck. The Kenyan government seems to believe such trucks are much more widely used as it has just introduced a 30 percent tariff on them. Not only are mechanical devices absent, but even elementary chutes are rarely seen.

II. EMPLOYMENT AND PRODUCTION GROWTH

While official two digit data in manufacturing indicates little rise in productivity in the industries we are considering, this does not agree with firm data. One difficulty is that official data include sales and office personnel as well as executives.[1] However, in most firms labor productivity has increased considerably when plant workers alone are considered.

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[1] There are other difficulties with the official data such as changes in firm classification which give me more confidence in firm data.

This was established by obtaining data on output and production workers for recent years. Although some limited capital deepening has occurred, both our own calculations (from recent investment data) and managers' description of changes in production method suggest that little of this growth in labor productivity could have arisen from such deepening. Our calculations suggest that 70 to 90 percent of labor productivity growth was unexplained by capital deepening, depending on the assumed elasticity of output with respect to capital. However, because of considerable excess capacity in most of the firms, the capital input measure (which was defined to reflect utilization rates) could contain some errors.[1] Most growth is thus of the disembodied form and an examination of its role in the firms studies is necessary.

In the entire production function literature it is assumed that "technical" progress is the same for all regions of the isoquant - no distinction being made about the probable rate of progress at various levels of capital intensity. However, if one considers the possibilities for disembodied progress, it appears plausible that a large number of such changes are possible in the simple processes described above, whereas in more automated processes it is more difficult to implement "disembodied" changes. Indeed, much of the production function literature seems quite unreal on this score, long time series being analyzed, and yet the nature of technical change (whether embodied or disembodied) is assumed to be of the same type over the entire period. It would seem sensible to assume that as an economy becomes more capital intensive, the potential nature of productivity growth changes from disembodied to embodied.

It is quite clear in the Kenyan context that substantial productivity growth has taken place simply as a matter of reorganization of production and better training and supervision.[2] A typical change involved a simple rearrangement of the position of two processes within the plant. A worker who had formerly been idle half of the time (evenly spaced over the day) was more fully employed when two processes converged on him. As important as these types of completely disembodied change were some which could be called slightly embodied insofar as they were implemented with internally produced "equipment" containing material and labor worth less than £50; nevertheless they increased productivity noticeably. The archetype of this type of innovation occurred in a fruit processing plant in which crushed fruit had formerly been individually packed into cans. The manager had.

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[1] Such errors would probably decrease the amount of growth accounted for by capital deepening.

[2] A similar point is made by Lloyd Reynolds and Peter Gregory in Wages, Productivity and Industrialization in Puerto Rico, (Homewood, Richard D. Irwin, 1965), particularly Chapter 6.

the machine shop bore holes the size of a can top into a simple sheet of metal. This was installed at the end of the processing line. As the crushed fruit came down onto this metal, one worker simply shoved the fruit through the holes until they were full. The manager estimated that this increased output per worker at this point four fold and this was undoubtedly true when the older process was observed in another plant. Many similar stories about very simple reorganization or cheap internal devices (which would lead to imperceptible increases in capital per worker) could be spun.[1]

What lesson is to be drawn from these descriptions? First, productivity raising innovations are easily achieved because of the existing labor intensive nature of the technology and (as we shall see) because of the presence of at least one highly trained engineer usually the plant manager, who has had extensive experience with the process and understands why things are done the way they are, and what the possibilities are of doing it in other ways.

An implication of this analysis is that during early stages of growth, employment is likely to lag behind output growth even if capital deepening doesn't occur. In a sense low labor absorption may be an inevitable accompaniment of the growth process under conditions such as those in Kenya, particularly, low initial mechanization.

On the other hand, such disembodied growth clearly has limits: there is an exhaustible set of innovative opportunities and as these are exploited, continued output growth requires more labor and capital.

We noted above that the innovations making productivity growth possible were the result of the presence of one or more people at the managerial level who possessed a firm understanding of the technical aspects of the production process. Perhaps surprisingly, in view of the conventional wisdom that foreign owned firms (or those employing western trained technicians)

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[1]There was also some evidence of increasing utilization of the labor force. In some firms subject to decreases in demand (attributable to problems within the East African common market) a number found themselves with "excess" labor. Initially all workers were kept on as each had a special job not performable by others. The firms considered trained the workers to perform a large number of jobs. As some workers quit there was no need to replace them as the remaining force could perform their jobs. As no workers were fully employed at one task in the old situation, increases in output could occur without additional workers. Unlike innovations, increasing utilization of the labor force is unlikely to be a source of continuing productivity gains; once output regains old levels, increased employment will be required.

will duplicate western methods, it was typically a subsidiary of a foreign firm which carried out the labor intensive adaptations. To the extent that indigenous owners had technical training there was little difference; indeed, one of the most innovative plants had an indigenous owner with a U.S. Ph.D in engineering. But to the extent that foreign plants are likely to be directed by those with considerable technical expertise, while locally owned ones are more likely to be run by owners who have extended their selling operations backward, foreign ownership in this dimension may well be desirable. Indeed, foreign ownership was often instrumental in permitting an extension of the isoquant as well as innovating in the extended region.

One of the plants visited, a local subsidiary of a major U. S. producer had almost no new equipment. Indeed much of it was 25 to 40 years old although it had been reconditioned. Although the machinery was obsolete by U. S. standards, it was more than serviceable. Strikingly, it was the parent company which had a department specially devoted to searching the used machinery market, to arrange delivery, etc. It is unlikely that a purely local company would have been this successful.[1]

Two plants constituted major exceptions to the above rule of labor intensive production combined with considerable innovation. One was a foreign owned company in the chemical industry in which the parent company set norms in terms of labor productivity per se. The manager's contention to the home office that profits could be increased if labor intensive methods were used was of no avail and a considerable amount of capital deepening had occurred in material handling, filling, and warehousing. Indeed, this was the only plant planning an automated receiving operation. The manager thought that his current work force would have been twice as high and the operation considerably more profitable in the absence of the norms.

The second major exception to labor intensive processing was a food processing company which was locally owned. The owner obviously had limited technical training and there was almost no technical staff. The owner had extended into manufacturing: thus he mainly relied on salesmen of machinery companies and foreign wholesalers for information on processes. The plant was by far the

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[1] The only other source where this point is made is in Ian Little, Tibor Scitovsky and Maurice Scott, Industry and Trade in Some Developing Countries (London, Oxford University Press, 1970) p. 57. Strassman (Chapter 7) and others have emphasized that foreign trained engineers are likely to imitate the advanced technique of the Western countries. However, such engineers were usually working for locally owned companies. Why such disparate behavior in the two types of organization should occur is difficult to understand, unless a greater incentive to obtain profit in order to justify foreign investment is imputed to the subsidiaries. One reason may lie in the higher alternative cost of capital to international corporations than to domestic firms.

most automated in the industry. This is not to say that indigenous owners are incapable of innovation - the critical factor here was the lack of familiarity in a fundamental sense with the possible production function. He was aware of only one side of it.

In sum, employment of production workers may not proceed rapidly in industries characterized by both innovation possibilities and the ability to exploit them. However, by its very nature this is a transitory phenomenon which will become weaker over time. The mirror image of the "undesirable" employment effect is, of course, a lower cost structure as unit labor costs decline. With suitable stimuli, this restructuring could be converted into an important source of growth in terms of both domestic and foreign sales. [1]

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[1]With regard to trade-off between employment and output, consideration should be given to whether the use of labor intensive technologies would increase the number of jobs available only at the cost of a decrease in production. Many of the Kenyan firms surveyed fall in the center of the labor/capital intensity spectrum for similar firms in India, for which interesting data is available as follows. Under the assumption that all firms in an industry become as efficient as the most efficient labor intensive firm, with total capital remaining constant, employment would rise 72% in bicycle manufacturing, 15% in cotton spinning, 445% in wool processing and 318% in paint production. The resulting increases in output, in terms of value added, would be 41%, 84%, 64% and 270%, respectively. Thus, shifts to efficient labor intensive production techniques can lead to increases in output as well as in employment.

DEVELOPED COUNTRY PERSPECTIVE: Daniel Margolies, Consultant, A.I.D.

The type of field analysis made by Mr. Pack as reported in his paper is of great value. Our knowledge of how the industrialization process takes place within developing countries is sketchy. Statistics can lead to misleading conclusions if interpreted against an imperfect understanding of industrial operations. The disaggregation of the statistics is a very useful approach toward a better analysis of how technology is employed within industry.

The discussion has been useful in showing how under certain economic policies prevalent in developing countries market forces are arrayed against the effective use of technology for healthy industrial development. However, even if the economic policies are changed and if market forces favor effective use of technology, this by itself will not be sufficient to bring into being the technological infrastructure required for industrial development along the lines desired. Additional measures will be needed.

Thus far the papers have centered on what changes are desirable with regard to economic policy. There has been little attention given to the additional measures required to build an adequate technological underpinning. In fact, this is a very complex and difficult problem.

One element of the problem is the issue of quality control and industrial standards. Dr. Ranis cites this as one area where additional labor can enhance the quality of certain commodities. Mr. Pack points out that in some situations the reverse is true, and that the substitution of labor for capital equipment can result in a deterioration in quality of the product. Although the ingenuity of trained plant managers is important in dealing with this type of question, an institutional back-up can be of great value. This is a service that should be provided by a government institution.

Similarly, a problem-solving industrial technology and applied science institution can be of great value to industrialists with regard to the selection and adaptation of plant equipment. The requirements for this type of institution are complex and involve proper ties between government, industry and universities. The institution, whether governmental, not-for-profit, or appended to a group of industries, should be suited to the local environment.

The time frame is a major problem since economic policies can be rapidly changed whereas it takes much longer to train professional personnel and build effective institutions. A government strategy and an effective government mechanism is needed to bring this about.

The discussion of basic science overlooks the importance of basic research as a means of training scientists and engineers and of retaining them in the country until economic policies are modified so that they can be drawn more effectively into the industrialization effort. Although it is often stated that basic science is wholly irrelevant to development, a field examination may bring out a different picture. For example, in Korea in 1965, a visit to the nuclear research facility in Seoul disclosed that some of the research at that laboratory was in fact oriented to developmental problems, and that some of the staff in their spare time had set up a separate research institute and were conducting important research in the area of mining and minerals. The head of the nuclear research laboratory took on the task of heading the Korea Institute of Science and Technology which has proved to be a very successful industrial research institution.

The suggestion by Dr. Ranis that the LDC's should be content with technology developed in the advanced countries runs counter to the conclusion of industrialists and scientists on the President's Task Force on Science and Technology which was published in 1970. The Task Force recommended that it would be more useful to transfer our capability to design industrial technology appropriate to the local environment and factor endowments than to transfer our industrial plants bodily to the LDC's. 1/

1/ The President's Task Force on Science Policy, Science and Technology: Tools for Progress, (April, 1970), p. 41.

DEVELOPING COUNTRY PERSPECTIVE: Romulo Ferreira, Organization of American States

Professor Pack's findings in Africa are reflected to a certain extent in Latin American medium and small size firms in housing, ceramics, clothing, foods, beverages, processing agroindustries, etc. - virtually all those that are selling exclusively in the internal market. The situation in these industries with respect to productivity and the use of labor is quite different from that of industries which use capital intensive technologies to meet international standards.

Productivity in small industries is increased by upgrading managerial capabilities through training, both at home and abroad. Local universities are able to train a sufficient number of engineers, but there are not enough jobs for them. Hence, engineers become part of the brain drain. It is not the lack of training or knowledge that hinders progress in the medium-sized industries, but the lack of communication between the entrepreneurs and the national trained personnel. In this context, foreign ownership, which implies knowledge of managerial skills, is not a necessary condition for progress, only an opportunity for it.

Latin America cannot rely on industrialization to solve the problem of underemployment. Big industries are important in the balance of payment and are unlikely to be able to shift away from labor-saving international standards and technologies. Unemployment is the result of underdevelopment.

Factors influencing capital-intensive technological development are:

1. It has been government policy in South America to cheapen capital artificially in order to make it more available, in the belief that increased use of capital would improve productivity (without realizing that what is needed is an increase in the supply of capital).

2. Labor is widely recognized as being abundant and cheap, and in Latin America its range of skills is quite wide. But this resource is becoming more expensive because of fringe benefits (retirement plans, and salary taxes as high as 130%), and this discourages the use of labor in the production process.

3. Financial institutions will not finance improvements on installed equipment. Small firms cannot get credit for innovations, because they do not meet the standards set by both national and international development banks. These institutions prefer to take the easy way out by requiring the use of new capital equipment. Since such equipment is designed taking into consideration the high price of labor in highly developed countries using such equipment reduces the demand for labor.

The documents prepared for the "Specialized Inter-American Conference on the Application of Science and Technology to the Development of Latin America," by the National Technical Committee indicate that the solution of the problems of underemployment lies in a new, long-term strategy which assures the harmonic development of all economic factors without jeopardizing the development process itself by striving for short-run full employment. That strategy should identify those sectors in which the encouragement of capital-intensive development is desirable, while assigning the absorption of labor to other sectors of the economy.

TOWARD A METHODOLOGY FOR ASSESSING THE IMPACT OF TECHNOLOGY IN DEVELOPING COUNTRIES

by

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"What is the use of a house, if you haven't a tolerable planet to put it on?" These prophetic words of Thoreau in a sense symbolize the current anti-pollution crusades of many concerned citizens who have given the art of technology assessment not only sudden legitimacy but also acknowledged urgency. But this topic is far broader than pollution.

Technology assessment has on occasion been associated with Ralph Nader and his efforts to prevent the consumer from becoming the victim rather than the beneficiary of technological advancement. Meanwhile, private organizations are becoming increasingly sensitive to this topic lest over-zealous Government officials exercise their obligations to guard against the side effects of technology in a way that throttles progress.

Technology assessment has usually been defined as the systematic analysis of the effects on society of the introduction, expansion, or modification of technology. Special emphasis is given to unintended, indirect, and delayed effects, on the grounds that direct effects are usually carefully considered in routine planning, in the long run the secondary effects may be the most important, and undesirable secondary effects can often be avoided if they are recognized in advance.

Developmentalists have long given thought to the impact of technology on societies -- since technological change is the essence of development; and the secondary effects of the Green Revolution have brought into sharp relief the need for technological assessment as an integral part of development planning.

Any attempt to describe in a few paragraphs how technology assessment techniques might be adapted to a developing country environment would be presumptuous indeed. The art as it has evolved in the developed countries may offer some insights useful to the developing countries. However, the subject is complex, not susceptible to rigorous quantitative analysis, nor even surrounded with well established theories and methodologies. Nevertheless, highlighting some of the principal issues and concerns may set a framework for discussions that will follow and hopefully last well into the future.

At the start, a few boundary conditions for treating the subject may be useful since technology assessment could be interpreted to involve analysis of the entire development process. These remarks will be directed principally to engineering technologies, which may be easier to grasp than health, agricultural, or social technologies. Secondly, the comments will be limited to technologies which are introduced from abroad, with the introduction directly traceable to one or several deliberate decisions of a developing country Government concerning the specific technology in question. The subtleties of tracing the introduction of a technology to exchanges of people or information, to upgraded educational opportunities, or to indigenous innovation are too formidable to be treated in such a brief manner. Another assumption is that the developing countries have well conceived and articulated development objectives. Obviously, this assumption greatly simplifies the task of technology assessment but does not obviate the need. Finally, this presentation overlooks some of the particularly difficult problems of the least developed of the developing countries, even though they probably should be among the countries of principal concern. Given the dearth of analytical skills in these countries, however, there is considerable question as to whether they could implement some of the suggestions mentioned later.

Technology Assessment in the United States

During the past several years the Congress has become increasingly active in insisting that technological decisions of the Executive Branch encompass far more than technological considerations. The National Environmental Policy Act -- enacted on January 1, 1970 -- has been the most dramatic expression of Congressional concern. The Act requires that an "Environmental Impact Statement" be prepared and publicized prior to implementing any Federal projects significantly affecting the quality of the environment. This provision of the law is intended, inter alia, to (1) force the Executive Branch to identify and "think through" at least some of the environmental implications of Federal projects, and (2) enable interested citizens to express their views -- with recourse to the courts if necessary -- prior to Governmental decisions. During the past two years hundreds of environmental impact statements have been prepared. Among the more publicized efforts have been analyses of the Alaska pipeline, the Florida barge canal, and Calvert Cliffs nuclear plant. In all of these analytical efforts, the principal focus has been the impact on the physical environment, and to a much lesser extent the direct impact on people. With regard to people, the 1970 Housing and Urban Development Act specifically addresses a range of concerns within urban areas, disparities among urban growth patterns, and the needs of poverty and unemployment.

The Congressional debate, together with the subsequent action, on the supersonic transport was clearly an important example of growing interest in the implications of technological advance. While the impact

of the S.S.T. on the environment -- sonic boom and atmospheric pollution -- punctuated the debate, a number of economic issues were also on center stage, including cost of the S.S.T., effect on the Seattle job market, and effect on balance of payments.

Much of the Congressional concern has crystallized in pending legislation to establish an Office of Technology Assessment intended to provide Congress with advice and recommendations concerning technology programs. Such advice would presumably be cast in a much broader context than simply impact on the environment and would include consideration of a wide range of socio-economic effects of technologies. The Office has been authorized by the House at an initial annual funding level of $5 million, but the bill is currently delayed in the Senate pending resolution of disagreement over the authority of the Director and the composition of the Board.

Meanwhile, the Executive Branch is taking a number of steps to foster better understanding and more comprehensive analysis of the effect of technological innovation on society in addition to the actions required under the National Environmental Policy Act. For some years the National Science Foundation has been supporting University programs designed to relate science and technology more directly to societal needs and is currently supporting a variety of technological assessment activities. One of the oldest and largest programs is at Cornell University. Perhaps the most heralded Cornell technological assessment is the recent analysis of the implications of the low cost diode, concluding that this anticipated development could result in a proliferation of microwave devices that would overload a variety of communication systems and that would also have serious implications concerning health hazards.

The most ambitious recent effort in the technology assessment field was a study prepared for the Office of Science and Technology in the Executive Office of the President. This study attempted to develop a methodology for technology assessment. The study recommended that the core of such a methodology should be systematic application of seven steps, namely:

(1) Define the assessment task including range of technologies, groups affected, time period analyzed, types of impacts, levels of impacts, and impact measurements.

(2) Describe the relevant technologies including physical and functional description, current state of the art, influencing factors, related technologies, future state of the art, and uses and applications.

(3) Develop state of society assumptions.

(4) Identify impact areas in categories such as values, environment, demography, economic, social, and institutions.

(5) Make preliminary impact analysis characterized by affected groups, how affected, likelihood, timing, magnitude, duration, diffusion, source, and controllability.

(6) Identify possible action options with attention to controllability, worth, priority, effectiveness, costs, non-financial problems, institutional obstacles, and uncertainties.

(7) Complete the impact analysis.

It is clear that these steps do not take us very far, in a sense are a statement of the obvious, and in some respects are of questionable relevance to the real problems of development. However, it may be instructive to examine how this methodology was then applied. Five types of technological advances were examined in the context of the proposed methodology, namely, the automobile's role in causing air pollution, the impact on society of computer-communications networks, trends in the enzyme industry, applications of mariculture in developing countries, and water pollution from domestic wastes. Each of these inquiries addressed such questions as:

(a) Where does the technology currently stand?

(b) In what directions does it seem to be developing?

(c) In what ways is the technology likely to be applied?

(d) What factors are likely to influence that application?

(e) What are the likely secondary and tertiary consequences of the application?

(f) What benefits and costs are likely to accrue from public efforts to alter either the technology applications or their subsequent consequences?

(g) Which community or interest groups are most likely to be affected by the anticipated impacts of the technological applications and are most likely to take action to incluence those impacts?

Let us quickly examine the mariculture study since it was targeted explicitly on 67 developing countries during the period 1970-1990. The study was intended to cover the following areas:

(a) an analysis of the prospective application of mariculture in solving the problem of animal protein malnutrition and as a contribution to economic development.

(b) an analysis of the factors needed to stimulate and support mariculture application.

(c) an analysis of probable production of luxury and non-luxury crops from the developing countries.

(d) a quantitative assessment of economic impacts of mariculture in the 1975-1990 time frame.

(e) a general qualitative assessment of certain society impacts due to mariculture in the 1975-1990 time frame.

Presumably development planners concerned with worldwide research priorities should be a principal audience since only aggregated data were considered. Also, development planners interested in alternative worldwide food supplies should be interested. Unfortunately, the study degenerated into simply a collection of data showing that mariculture could be a valuable source of food -- under certain types of economic conditions -- with little or no attention to the implications of the statements in country specific situations.

A Technology Transfer Framework

While technology is but one of the determinants of the rate and direction of industrialization, it is frequently a key determinant as to the competitiveness of products, the commercial viability of processes, and the efficient utilization of capital and manpower resources. In changing their traditional methods, the developing countries often have to use the immediately available technologies, even when they are unsuited to their economic and social conditions. They might otherwise forego important development opportunities since they lack the capability for devising an indigenous technology or for appropriately adapting one from foreign sources. At the same time, the transfer of technologies from the advanced countries often has built-in mechanisms and time elements which hinder modification or adaptation. Domestic policies in the developing countries and the conditions attached to foreign aid frequently make capital available on subsidized terms and thus encourage excessive use of scarce resources of capital and underutilization of abundant manpower resources. Among the consequences of adoption of inappropriate technologies have been the growing lack of capital, particularly foreign exchange, the rapidly increasing rate of unemployment, and the inability to develop industrial skills at the rate required.

With regard to technology transfer through the private sector, it is tempting to argue that the best hope for the developing countries lies in their acquisition of technologies that are already applied in more advanced countries, and that it is a mistake and waste of their resources for them to go for research and technical development on their own. There are

several reasons, however, why the developing countries clearly should not rely entirely on foreign sources of technology, although they can continue to gain great advantages by using private investment and licensing and the many other means of acquiring foreign know-how.

It is difficult for a country that does not itself possess a certain number of trained scientific and technical personnel to know what usable technology exists elsewhere, to understand it, to adapt it to the country's special needs or peculiar conditions, to repair and maintain the necessary equipment, or indeed to operate it. If a country builds up its own scientific and technical capacity, it is in a much better position to utilize what exists elsewhere. Lack of appropriately trained persons is often an obstacle to the wider application of technology that is already known and to some extent used in a country. In addition, each country is more able to hold its place in international competition if it has the capacity to introduce innovations (new products or less costly methods of production) based on existing technology.

Finally, the foreign technology is often adapted to very different basic conditions, such as a relative shortage of labor, abundant supplies of capital and a large market. Developing countries, facing almost diametrically different conditions, will often find that a variant of the technology of the developed countries, or perhaps an altogether different technology, is more suited to their conditions. But the choice of an appropriate technology is not readily achieved by a country that lacks indigenous research and development facilities. This research and development structure needs to be heavily weighted towards the problems of production. In many cases, existing institutions need to be brought into closer relation with the country's actual agriculture and industry, and new institutions should, from the beginning, be strongly oriented towards local practical problems and to meeting the needs of local users.

Not the least of the reasons for developing countries to develop their own scientific and technological base for adapting, disseminating and as necessary inventing technologies is that it provides them with a more secure technical and psychological base for expanding productive private trade and investment relations with the more developed countries. The developed countries have the strongest and stablest economic relations with countries in this situation.

Technology Assessment in Developing Countries

What are the practical problems faced by developing country decision makers responsible for the introduction of technologies -- through investments, licenses, or direct purchases? If the technology is to be acquired immediately -- as the result of a political decision, an urgent need, or prior analyses and negotiations -- the options are limited. There may not be time even to identify alternative off-the-shelf technologies, and the developing country often is a captive of the competitive ways of the developed world. At the other end of the scale of lead times,

if a developing country has five or more years to select technologies, there may be an opportunity for R and D which can adapt technological options to local conditions -- to available raw materials, manpower, and supporting services. Unfortunately, planning is seldom carried out so far in advance; also, intervening political and economic forces too often render meaningless such long-range efforts. Hence, it might be most profitable to concentrate the discussion on decisions with a lead time of three to five years -- long enough to seriously weigh options but not so long as to be unrealistic.

The conditions surrounding technology assessment in the developing countries may differ significantly from the framework which is familiar to us in developed countries. Most obviously, pollution side effects are usually of less urgent concern. On the other hand, balance of payments and foreign ownership of local assets are often central issues. Employment factors -- including capital/labor tradeoffs and diversion of skilled manpower -- are frequently significant determinants of technological decisions. The questions of repair, maintenance, and spare parts similarly loom large in many developing countries. In the United States patterns of Federal funding of R and D efforts significantly affect technological directions, with Governmental regulatory powers also of importance. In developing countries the regulatory powers are clearly the more significant tool with R and D activities of much less consequence. Hence, the problem is more of holding technology in check than in developing undesirable technologies.

For many years developing countries have been carrying out feasibility studies and making daily decisions concerning imported technologies. Approval of foreign investment applications and licensing arrangements, contracts for commodities and for services between Ministries and foreign firms, and arrangements for various types of foreign assistance have very direct impacts on the technological infrastructure of a country. Clearly the macro-economic framework (interest rates, tax policies, foreign exchange controls, tariffs, amortization policies) affects a wide spectrum of technological choices. But since this question is treated in other papers, these comments are directed to more specific technological considerations, recognizing that macro economics frequently limit the choices.

In the past, one favorite criterion in decisions on imports of technologies has been the direct impact on foreign exchange -- i.e. the foreign exchange cost of the technology and the foreign exchange that will be saved or generated within a few years. Fertilizer plants provide a good example. However, beyond this relatively easily quantified factor the criteria tend to become fuzzy, often emphasizing -- at least in public documents -- that priority be given to technologies that are labor intensive or that stimulate development of rural areas.

It is tempting to state simply that technological choices should be made on the basis of "systems analysis," which is now becoming a popular word in development circles. Clearly, arranging the alternatives and establishing criteria for selection among them within a framework of

national development objectives is precisely what constitutes a systems analysis in a specific situation. The trick is to carry out the analysis in such a way that the judgements incorporated into the analysis are clearly identified and not buried in a mass of statistics.

Some Specific Cases

One of the most striking examples of the impact of technology on a small nation is the construction of a major dam, such as the Volta Dam. In addition to the flooding of areas extending 200 miles upstream and the generation of more than 80 percent of Ghana's electricity, the dam has had many secondary efforts. The impact of the water manipulation on bilharzia, malaria, and river blindness is relatively easy to identify. Perhaps less well understood are the impacts of the reservoir on groundwater flow, on use of adjacent farm land, on fishery resources, and even on the weather. The attempt to convert fishermen to farmers by moving them a considerable distance from the areas flooded by the reservoir largely failed, and many of them prefer to remain fishermen than enjoy the Government-provided housing away from the reservoir. With regard to other economic activities, the reservoir has become a major tourist attraction and a major north to south transportation artery. In short, while electric power is often the justification for a dam, such a construction effort usually dramatically changes the character of activity for many miles in all directions.

With regard to high technology, introduction of an IBM 360 computer in Uganda provides several interesting lessons. The computer was purchased to provide a basis for the statistics activities of Government agencies. However when the machine arrived there was no manpower in the country trained in the use of a computer. Indeed, one wonders whether there really was a sound basis for this expenditure of foreign exchange. However, a competent U.S. computer expert was able gradually to train a cadre of local specialists who are now semi-skilled computer operators. The machine is currently serving a wide variety of local needs ranging from license plate registration to foreign exchange control with wide ramifications throughout the administrative activities of the Government. Unfortunately, there are far too many less successful attempts to introduce computers in low technology environments.

Another example relates to Pakistan's efforts to introduce nuclear technology. Spurred by the U.S. atoms for peace program, literally hundreds of Pakistanis were trained in physics to provide for a nuclear energy program that had little relevance to development needs. Even with the acquisition of a turn-key nuclear power plant in Karachi, the Pakistan role in operation and maintenance hardly warrants such an over-extended array of physicists. Only recently has the Pakistan Atomic Energy Commission seriously turned its attention to economic development, and still its interaction with other Ministries is minimal.

Two examples from Vietnam are interesting. Given the hugh supplies of scrap steel from the war effort, acquisition of a rolling mill to supplement the current indigenous melting and extruding capability appeared to be a logical approach. The choices included a $600,000 labor-intensive mill from Taiwan or a $1.5 million U.S. mill. Surprisingly, the major attraction of the Taiwan mill was not the labor/capital tradeoff but rather the much quicker delivery time. With regard to rubber production in Vietnam, copper sulphate and other stimulators can be used to accelerate latex flow and reduce the frequency of latex collection activities considerably -- thus resulting in savings in labor costs but not increasing production significantly. This would seem to be an excellent example of trading off foreign exchange to pay for the stimulators against local labor costs. To the chagrin of employment oriented developmentalists the plantation owner profits most from introducing the technology and in the absence of stringent foreign exchange limitations would go in that direction.

A final example relates to product quality. Many engineers argue that they cannot construct roads of lasting quality using less than the best equipment, and reject out-of-hand the notion of labor intensive construction methods for important trunk roads. Similarly, in a number of countries manufacturers contend that their products could not compete in quality terms in the world market if less than the best technology is used. A related consideration is concern that rising labor costs could threaten the commercial viability of labor-intensive approaches. In any event, quality is clearly important, and engineers throughout the world usually equate the latest capital-intensive technologies with the highest quality.

Toward a Methodology

Environmental concerns have been a prime mover in shaping the concept of technology assessment in developed countries. Perhaps these concerns can also provide a point of departure for systematizing the analytical process in the developing countries. Two specific steps have been taken within A.I.D. in this regard. Checklists have been developed to assist in thinking through the environmental aspects of specific types of projects involving construction -- such as roads, dams, and power plants. Secondly, case studies or "post audits" of the impact on the environment of specific development activities are underway. While the checklist/case study approach is hardly a rigorous methodology, in the world of practical reality this technique can be very valuable in quickly identifying particularly troublesome impacts of technology. This approach is particularly attractive for developing countries since seldom are "new" technologies introduced and experiences with "old" technologies are often broadly applicable.

Unfortunately, there has been a tendency by environmentalists to underplay the benefits derived from technology -- from pesticides, dams, and roads through tropical forests -- in their efforts to warn about the penalties associated with developmental activities. In a developing country context, in particular, a proper balance of costs and benefits must be maintained and technology assessment must not become technology arrestment. The developing countries are becoming increasingly impatient with the implication that the alternative to electric power and water for irrigation is "don't build that dam."

Modest efforts are now underway to extend the checklist/case study approach to other areas. Specifically, a comparative analysis of the impact of computers in developing countries is being launched which should produce a checklist of interest to decision makers concerned with computer acquisitions. While a computer is but one very limited type of technology, many lessons can be learned from a serious look at the secondary ramifications surrounding introduction of a computer capability. At the same time, the National Academy of Sciences has commissioned a number of case studies of the impact of science and technology programs in developing countries. The exact character of these studies is still being shaped, but some of the studies should be sufficiently definitive to provide guidance for general categories of technology.

It is likely that technology assessments in developing countries will frequently conclude that the introduction of proposed off-the-shelf technology will result in many undesirable economic and social dislocations, but nevertheless such technology is essential to meet short-term needs. However, an important aspect of such analyses should be identification of those types of innovations that could reduce the adverse impacts, and specific steps that could be taken locally to generate a capability to introduce such innovations in similar future situations. Such innovations might relate to modifying technological processes, changing economic policies that rule out a priori other technological choices, or providing incentives that attract technologies better suited to factor endowments.

One final word about systems analysis and the transferability of the computerized approaches being pursued by A.I.D. in the fields of agriculture and family planning to the problems of assessing the impact of specific technologies -- the theme of this paper. Clearly, a thorough analysis has a higher probability of clarifying trade offs than a shallow analysis. However, the secondary and tertiary effects of a specific technology are difficult if not impossible to trace let alone quantify, and caution should be exercised in attempting to inject excessive rigor into the analysis. Whether a standardized methodology beyond a refinement of the checklist/case study approach can be developed which will be of broad applicability to a multiplicity of technologies is questionable although exploratory steps in this direction appear warranted. Some work has been

initiated in the United States to design multipurpose matrices which can serve as the basis for examining trade offs, but these efforts have been largely confined to rather narrow fields. If such matrices can lay out realistic technological alternatives, on the one hand, and types of impacts — both positive and negative -- on the other, they might be quite useful. Presumably, somewhat different approaches would be needed in considering broad technological decisions (e.g. hydro power vs. nuclear power vs. steam power) and in analyzing micro decisions (e.g. plant location, degree of automation, size of plant). Also, different approaches may be necessary for different types of activities such as heavy manufacturing, light manufacturing, extractive industries, and construction.

A few years ago President Kennedy remarked "Every time you scientists make a major invention, we politicians have to invent a new institution to cope with it." Now technology is intervening every day in the activities of developing countries. While methodologies might be developed which will help illuminate some of the ramifications of such interventions, these techniques will be of little use in the absence of an institutional capability in the developing countries to apply them and a readiness to incorporate the results into the decision-making apparatus. Nine months ago at a conference at Woods Hole, Massachusetts, there was a call for "the establisement of the profession of 'development technologist' to enable developing countries to make a more discriminating selection and effective utilization of science and technology." That plea is repeated today.

Bibliography

Bowers, R. and Frey, J., "Technology Assessment and Microwave Diodes," Scientific American, February 1972.

Carpenter, R.A., "The Scope and Limits of Technology Assessment," Report on Seminar on Technology Assessment, January 26, 1972, OECD.

Coates, J.F., "Technology Assessment: The Benefits, the Costs, the Consequences," The Futurist, December, 1971.

Kiefer, D.M., "Assessing Technology Assessment," The Futurist, December, 1971.

_____, S.2302, A Bill, U.S. Senate, July 1971.

_____, World Plan of Action for the Application of Science and Technology to Development, United Nations, 1971.

_____, Environmental Considerations for Construction Projects, Office of Science and Technology, Agency for International Development, July 1971.

_____, Computer Technology in Developing Countries, Report of Symposium, Agency for International Development, March 22-3, 1971.

Jones, Martin V., et al, A Technology Assessment Methodology, The Mitre Corporation, Six Volumes, June 1971.

DEVELOPED COUNTRY PERSPECTIVE: Peter Clark, IBRD

It does not seem that the technology assessment approach proposed by Mr. Schweitzer addresses itself to the right questions. The paper appears to overlook the key developmental problems which confront the lesser developed countries. These problems turn on the economic efficiency of the technology under consideration.

Some of the issues dealt with in the paper appear to be concerned with qualitative effects of a secondary order and concern for them may be a luxury in comparison with the many obvious problems resulting directly from imported technology. Other issues appear to involve potentially adverse consequences of major economic significance, but such matters ought properly have been dealt with in the earlier planning stage. Furthermore, there is no discussion of whether modern technology can in fact deal effectively with the problems that are raised.

The paper raises useful questions about the benefits of developing an indigenous R and D capacity in the LDCs. But these questions should be studies before the LDCs are encouraged to make costly investments in this area. Professor Pack indicated that innovation is not planned but conditioned by knowledge of local conditions and internal competitive pressure for efficiency. The effective use of that store of engineering skills and scientific knowledge that does exist, and is growing, in the LDC should be encouraged. The best way to accomplish this might be investment in indigenous capital goods industries -- even when they might be considered premature in terms of the existing market size. Several factors lead to the use of capital intensive technologies: the concern of private foreign investors in minimizing risk and maximizing return on the foreign owned resource, the preference of international financial agencies for large projects, the international contract bidding system which discourages factor-saving based on LDC resource availability, project design and capital equipment manufacture by firms responding mainly to the conditions in the developed countries, and the desire to compete in international markets. Therefore, technological adjustment to existing factor proportions is more likely to result from the competition to supply internal demands for capital equipment than from the costly development of R and D facilities in the LDCs.

In general, a methodology is probably desirable in the process of reaching a decision on technology choice. A somewhat different methodology which would be less colored by value judgments would be desirable.

Systems analysis is a useful tool for economic analysis because the quantitative approach makes value judgments explicit while check lists and verbal arguments tend to bury them. An interesting application would be the use of the systems approach to test the relative merits of investment in R and D capabilities against those of investment in local capital goods production.

DEVELOPING COUNTRY PERSPECTIVE: Ojetunji Aboyade, Economic Development Institute

Although Mr. Schweitzer's paper is useful in throwing light on how decisions are reached within the Agency for International Development, the methodology which it proposes as a guide for decision makers within developing countries is not adequately described. The two techniques mentioned - (1) a checklist and (2) case studies - seem very closely to resemble each other. Although the discussion in the paper appears to point to the need for separate methodologies tailored to the conditions in different countries, the conclusion appears to recommend a standardization with the same methodology for all countries.

Many of the points in the paper are valid, particularly the observations that technology is the key to industrial development, that the consequences of choosing an inappropriate technology can be serious, and so on. However, the scope of the paper seems rather narrowly restricted to imported technologies, involving mainly engineering. Other key issues, notably the possibility of local innovation and social issues would appear relevant and important, and need to be considered as well.

Even within the narrow focus of the paper, however, the examples selected to illustrate the application of the proposed methodology are open to question. Computers and nuclear research reactors are in too sophisticated an area. It is essential to focus on technologies relevant to the requirements of the bulk of the population and to the skills and resources that are locally available.

Discussions of industrial development too often drift into a discussion of international trade, and an emphasis on the importance of selecting technologies that will increase the production of this commodity or the other for which there is believed to be a demand within an international market. It would be more useful to address the discussion to the production of commodities actually in demand for local consumption. The needs of the local population are urgent and ways need to be found to meet these needs without insisting that the technology must in some way be linked to international trade.

Similarly, there must be care in discussing the environment question. The main issue involved in the environmental problem is not nature, as some overzealous advocates seem to suggest, but the welfare of man.

In discussing technological choice, it is essential to structure the issues so as to address the real problems of the LDC's as they themselves see them. The use of technology should be to improve the welfare and increase the abilities of the bulk of the population.

BASIC VEHICLE FOR SOUTHEAST ASIA

by

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The program for this seminar describes my contribution as "A Discussion of the Engineering Considerations Involved in the Design of a Vehicle for Production and Use in Developing Countries." That's formidable enough, but if you will bear with me, I also intend to cover the commercial and social considerations that prompted Ford Motor Company to embark on its project of engineering a low-cost multi-purpose vehicle for what A.I.D. terms the LDC's -- the less developed countries.

I make no apology for using the word "commercial" before this group. To put it bluntly, Ford Motor Company believes in the profit motive. But we do not see corporate profitability and corporate social responsibility as mutually exclusive.

As our Chairman, Henry Ford II, said recently: "A corporation can serve society only if it is profitable. And it can stay profitable only if it is responsive to the needs and values of the society in which it operates."

As a corporate citizen of many countries, Ford has to be concerned with the needs and values of a great variety of national and regional societies.

My primary concern in recent times has been the Southeast Asia and Pacific region and the area of need that has preoccupied me has been, naturally enough, transportation. This audience does not require a lecture from me on the importance of transportation in economic development. It is all too obvious that any society whose transportation system is inefficient must suffer economically.

The transportation problems of the Asia-Pacific region posed an interesting challenge to Ford Motor Company as well as a tremendous commercial opportunity. Here is the world's greatest center of population with enormous potential demand for all consumer goods. Yet how could Ford find a product that could meet unfulfilled transportation needs in an area where the average man has to work 28.7 years to accumulate enough funds to purchase an imported conventional vehicle?

Importing vehicles produced by the advanced industrial nations represents bad economics for the less developed countries. An average 20% of their scarce foreign exchange is expended on vehicles -- an outlay they can ill afford.

The high price of imported vehicles coupled with the low average per capita income result in a low volume automotive market in the less developed nations of Asia-Pacific -- just over 350,000 units last year.

Local automotive manufacturing -- at least of conventional vehicles -- is impossible in some of the countries involved, and economically infeasible in others. One reason is the lack of domestic industrial infrastructures capable of supporting sophisticated manufacturing processes.

The infrastructures have not developed because the Asia-Pacific LDC's are rich in labor and raw materials but poor in investment capital, foreign exchange, technology and managerial skills.

There is little electric power produced, and that available is undependable. The basic industries -- steel, mining, oil production and refining -- are stunted or non-existent because investment capital is not available.

Most of the LDC's have severely limited capacity to earn foreign exchange. Their export trade is largely confined to primary products, the demand for which is declining in volume and value. At the same time, the cost of importing manufactured goods continues to rise, thus draining off more foreign exchange.

The advanced technology taken for granted in most of the highly developed industrial nations is just beginning to penetrate into the region. Engineers, scientists, and trained technicians are still in woefully short supply due to a complex combination of reasons including traditional cultural values which exalt the professional vocations and degrade the technical skills. Also, of course, there are simply not enough schools or teachers to provide the region with technically trained personnel.

There is a similar dearth of managerial talent. Academic training in business is scanty, and what there is is apt to be heavily theoretical.

In a region which clings to the traditional concept of the family-owned business, and often one-man leadership which would make the Godfather setup look like a holding company, opportunities for bright young men to work as professional managers are few and far between.

Perhaps the most serious consequence of these factors, as far as an automotive manufacturing program is concerned, is that the domestic supplier industry, vital to such a program, is virtually non-existent. In Latin America, Ford was able to help develop supplier industries in some countries prior to initiating manufacturing programs because there were local plants which could be converted to automotive component manufacture. A toy factory, for example, might start making battery cases. But to do that, you have to have the toy factory to begin with.

The problem is compounded by the political demand for local content, a demand reflected in regulations requiring a certain percentage of vehicles, either by value or by weight, to be produced by domestic industries. That is rather difficult when the local companies don't exist, or can only make the item at a cost which far exceeds that of an imported component even with prohibitive duties.

At Ford we are familiar with these social and economic factors -- we've been operating in the LDC's of the Asia-Pacific region for a long time. Like all the other automotive manufacturers, until recently we did tend to treat these countries in a very traditional way -- as a market for exported goods and as a source of raw materials. We exported to them the products produced by our plants in the industrialized nations -- spin-off products which could be built in exportable quantities only because of economies of scale made possible by developed technology and high volume markets.

Such vehicles, however, were designed specifically for the developed markets with environmental and economic conditions completely different from those in the LDC's. As a result, they were largely unsuited for the climatic and road conditions existing in the region. Unpaved village roads full of chuckholes are rough going for a conventional American or European passenger car.

Further, and more importantly, their high price tag limited the availability of imported cars to a small number of people. The means of transportation available to the vast majority of Asians range from the human foot, through a variety of animal-drawn contrivances to the bicycle and motorcycle. Yet these human- and animal-powered vehicles cannot begin to

meet the very real and growing transportation needs of the region, even when supplemented with a few imported cars and trucks. The obvious solution is to design and build a vehicle more efficient than the traditional animal- or human-powered vehicles but less expensive than the imported vehicles designed for used in developed markets.

We already have reviewed the reasons why local manufacturing of such a vehicle was not done in the past -- lack of foreign exchange and investment capital, low per capita income, low volume markets, and lack of developed industrial technology.

Now add to those the fact that little attention had been given to determining what type of vehicle would really meet the region's transportation needs. When Ford set out to tackle this problem, we knew we would have to take such factors into account and we set certain objectives.

First, the new vehicle had to be low cost, even at low volume production.

Second, it would have to be a vehicle which could be produced with local materials, simple equipment and local labor, taking advantage of existing technology while avoiding the use of scarce foreign exchange. Such an approach also would allow us to meet local content requirements.

Whenever people think of building vehicles, they envision giant plants and miles of assembly line, but we set a goal of minimum investment in production facilities.

Our market research showed that the major need, at least in the foreseeable future, was not for private passenger cars but for a versatile vehicle which could produce revenue in commercial use as well as providing basic transportation for its owner.

To meet these objectives, a basic vehicle concept was developed. The job was quite a challenge for our designers -- instead of conventional design which would have required complex stamping dies to manufacture, they had to come up with a very simple sheet metal body. In the automotive industry, simplicity is often harder to achieve than sophistication.

Fabrication of the body had to be simple enough to be done on equipment as basic as a 70-ton brake press, a manually operated screw press, and simple jigs and fixtures which can be welded together out of readily available materials.

The first prototype was completed in Melbourne, Australia, just seven weeks after the design concept was approved. The protyotype was tested for ruggedness on a special track duplicating LDC rough road conditions built at Ford Australia's You Yangs proving grounds. Test results enabled us to refine vehicle design and to develop several model variations.

The result is a basic vehicle named the Fiera consisting of a simple cab-and-chassis combination. To avoid delay and hold down cost, we chose Ford's proven four-cylinder Kent 1100 or 1300 c.c. engines as powerplants combined with the four-speed transmission used in our Escort and Cortina models.

Model variations are intended to provide the cargo carrying capacity needed by the small businessmen and farmers of the region who cannot afford conventional vehicles. By laying a flat sheet metal bed over the rear chassis area, a simple freight hauling platform is added.

Side panels turn it into a pickup truck model, suitable for many applications in farming and light industry.

Raising the pickup side panels 12 inches gives a high-side model which doubles as a people mover with lengthwise passenger seats which fold down when required. A roof can be added to the high-side pickup for weather protection.

A van model has fully enclosed cargo space of 150 cubic feet, ideal for commercial delivery operations.

The top of the line is a minibus model similar to those already used in the Philippines. It has a 10-passenger capacity in the rear and room for three including the driver in the cab.

Fiera's versatility goes beyond transportation. It can be used to drive a rice husking machine or power a water pump or a saw. The owner only needs to jack up the vehicle, remove a rear wheel and slip a pulley around the hub to tap this power source.

We plan to begin initial manufacture and sale of the Fiera in the Philippines late this year.

Ford already has a modern and efficient plant in the Philippines, and assembly of the Fiera is expected to contribute substantially to accelerated industrialization in that country.

In a very real sense, Fiera will be Asia's own vehicle, largely designed and wholly built in the Asia-Pacific region. The six-model range is aimed at meeting the very basic transportation needs of that market. We believe it will bring the cost of vehicle ownership within reach of many thousands of potential customers in the emerging middle class.

Our market research for the Fiera program was directed towards analysis of economic and social needs in the Asia-Pacific area as they are affected by, or dependent upon, transportation. We believe that by meeting the need for transportation, the Fiera will stimulate increased employment, both in vehicle assembly and the supplier industries, and aid the growth of industry and agriculture.

At Ford, we are very conscious of the fact that economic growth may bring problems, as well as benefits, with it. But unless an adequate rate of economic growth is achieved, it will be virtually impossible to make significant social, political and cultural progress in the Asia-Pacific region.

Through our specialized field of transportation product manufacturing, we want to make our fullest contribution to the realization of the natural aspirations of the less developed countries. The Fiera program is, we believe, a very practical part of that contribution.

OVERVIEW

by

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The Ford Project is imaginative and constructive, and was highly pertinent to the subject under consideration in the seminar. On the basis of experience in India, one might have gained the impression that the approach of the multinational corporations was somewhat conservative and that they were not in the forefront as carriers of innovation. However, there were a number of features of the Ford vehicle program that were out of line with such a concept. The facts that the production facility was on a reduced scale and yet succeeded in maintaining a low capital output ratio, the achieving of a price level geared to the local environment, the emphasis on the use of local materials, and in particular the delegation of authority to local representatives to be innovative were all truly impressive.

The vehicle appeared to have a wide potential use in the area in a number of the countries. The concept of having components manufactured in different countries within the region and regionally assembled was also imaginative, and perhaps indicated the fruitful role of the multinational corporation in the marketing field. There might be some difficulties raised by governments. Protectionism is strong in the area. Apart from that, a number of governments in their concern for equitable income distribution were disposed to discourage the production of passenger vehicles as luxuries and of low priority as compared with capital and other consumer goods. However, this all-purpose vehicle with its potential for earning money might be regarded as being in a different category. The fact that the components would leave considerable scope for product control in the hands of the corporation might be a source of concern to certain governments. However, all in all, it appeared to be a good project.

In regard to the request that general conclusions be drawn in respect to the papers and the discussion which had followed, the first general observation was that the meeting had been well-structured, was of high quality, and was far too short to do justice to the subject matter.

The paper by Professor Ranis had been an admirable opening of the meeting and had set a framework for the discussion that followed. Traditionally, technology had been recognized as an important component in the development process. However two new concepts had recently come in fashion. First, in view of the critical importance of the unemployment problem in the LDC's, technology was now looked to as a way to deal more effectively with that and other social issues. Second, there was a disposition to look at technology in its relation to the environment. Environmental issues are clearly not without relevance to the concerns of the developing countries, but they are of secondary importance. The LDC's in particular should avoid getting hemmed in by the world-wide application of standards evolved by the developed countries.

The presentation by Mr. Schweitzer on technological assessment was useful. Perhaps if the pricing system were better ordered, some of the issues raised in that paper would be resolved.

There was one feature in the Ranis paper that was particularly noteworthy. In connection with the relation of scale to factor adjustment, the Ranis paper introduced the useful concept that small industries face different price signals than the big industries which may lead the small industries into better decisions.

The comments by Mahbub Ul Haq required special comment. It should be noted that he did not take issue with the desirability of correcting the price structure. He felt however that this was not the entire ball game. The indirect approach through market forces must be supplemented by government direct action, since realistically it must be recognized that powerful interests within the LDC's and within the donor countries will resist changes that remove their privileged position.

Maldistribution of income sets forces to work which bring about responses by governments among the LDC's which in turn lead to better income distribution. Once this occurs, this could ultimately affect the choice of products and the direction of industrial development. Donor agencies must encourage more direct response, through such things as public construction activities, to get a redistribution of consumption patterns that may have very important consequences for the process of choosing technologies. Turning to the question of technological transfer, there appeared to be two strands to the discussion as it developed. On the one side, there was the Ranis approach, which seemed to rely extensively on the work of Dick Nelson. This alleges that research and development is really wasteful and irrelevant to the needs of the LDC's, since the technology almost entirely is already available from the developed countries, either on the shelf at the moment or accessible by going back to obsolete models. This position was heartily endorsed by Peter Clark and Mahbub Ul Haq. The view was challenged by Engel and Margolies.

It cannot be denied that much if not most of the research going on in LDC's is irrelevant to the developmental needs of the countries, and much too much is second-rate. However one cannot leave the matter there if one wishes to deal responsibly with the issue of technology in the LDC's.

It is necessary at the outset to distinguish between science and technology. Science is more random, less costly and more remote from profitable exploitation than technology. Science tends to be located in institutions, such as universities, where it is cushioned against market pressures. Technological innovation, on the other hand, is an expensive, profit-seeking activity that can exploit the potentialities of the scientific frontier only selectively. It therefore optimizes; it concentrates on innovations that minimize factor costs in its own parochial environment.

It is agreed that AID should do what it can to illuminate the shelf of existing technology so that the LDC's can widen their choice. The fact is however that there are gaps on the shelf. Indigenous innovation can play a role in filling those gaps, and not merely by going back into history to find technologies that in many cases were deservedly discarded as inefficient.

How this can be done, and what governments should do to bring this about is another matter. Clearly better institutions need to be devised and the links between government and industry need somehow to be strengthened. Technical assistance in this area has admittedly been of poor quality. It appears as though the LDC's themselves will have to fashion the appropriate institutions to deal with this problem. The role of AID should be with due humility to scan what is going on and to lend help to developments as they occur in this area.

GENERAL DISCUSSION

Need for Special Measures to Involve Scientists and Engineers in Economic Development

The initial discussion elaborated on the point that something more than favorable economic measures is required to involve scientists and engineers in activities that contribute to economic development. An example was cited of an engineering school in India. If a student had family connections which provided him with capital and a means of obtaining an import license for some machine, he might with little difficulty be able to set up his own business with reasonable prospects of success. For other students, however, less fortunate in their family background, the situation was quite different. The easiest course to follow, particularly if he was a good student, was to go to a technologically advanced country to continue his studies. This is because the U.S. authorities and those of other developed countries provide him with all the information he needs to apply for admission to a university abroad, to obtain visas and other necessary travel documents, and to apply for financial assistance.

No comparable service was available to explain to the graduate how he might get started in private industry at home, filling some requirement his training had equipped him for. In fact, package deals can be worked out for a graduate of an engineering school with government finance to launch him in a useful and potentially lucrative enterprise. There is, therefor, a real need for a guidance service to make it no less easy for LDC graduates to stay at home and get started in some useful occupation as it is for them to go to the United States or some other developed country for further study.

A similar point was made with reference to scientists who work in research laboratories in LDC's. If appropriate awards are not provided by the LDC's for those working on local problems, the scientists may seek to establish their reputations by working on problems relevant to the developed countries and, therefore, to gain recognition in so-called world scientific circles. Two laboratories can be cited as examples. In the laboratory of the Rubber Research Institute in Malaya, researchers who solve problems that affect rubber production in a practical way are handsomely rewarded by bonuses and promotion. This has been a factor in making the Rubber Research Institute a highly successful industrial research establishment. In contrast, in the Nutrition Research Institute in India, rewards and promotions are based largely on articles published in leading scientific journals of the world. As a result, the Nutrition Institute is composed of brilliant scientists of international reputation but so far as can be observed, the Institute and its staff have made little or no practical contribution to the pressing nutritional problems of India. The difference between

the two institutions is not one of the quality of scientific research but rather of the economic, social and professional norms which influence the interests and focus of the research personnel.

In this connection, it was pointed out that the Rubber Research Institute is directly and intimately linked to a sister institute in the United Kingdom which identifies market trends and research opportunities. In India, the lack of linkage bwtween certain research institutes and user groups has been identified as a serious problem.

As noted in the examples cited above, the developed countries do not make the problems easier for the LDC's because of the vigorous, and well-intentioned, efforts they make to attract away the best science and engineering students and to divert scientists who remain in the LDC's to research which is of greater relevance to developed countries than to the LDC's. It was further pointed out in this connection that the donor countries do not take the practical steps needed to strengthen indigenous technological capabilities. Donor countries, and some multilateral institutions such as the World Bank, set aside substantial funds for feasibility studies in LDC's. However, these funds are not available for use by LDC research groups. No doubt, the donor countries or Banks want the best advice they can obtain before risking their money in a project and that is why they insist on using top engineering firms from the developed countries to make the studies. It was urged that it would be a very useful move if some of these feasibility research funds were earmarked by donor countries, the World Bank, etc., for LDC research groups, limited to jobs they are qualified to do, and linked with technical assistance to enable them to do the work to meet high standards of quality.

Relevance of Social and Political Factors

There was some dissatisfaction voiced with the emphasis on economic factors that influence successful technological adaptation, without giving due regard to the socio-political factors that are also involved. The socio-political distinctions are marked among the various countries mentioned in the course of the discussion: Japan, Mexico, Korea, Colombia, Pakistan, and Taiwan. Factors such as the degree and type of central direction over the economy, the educational systems, the urban-rural population distribution, and traditional patterns of industrial production would appear to merit consideration. Since these factors are highly country-specific, however, it might be useful to group countries into categories in order better to arrive at an estimate of the effect these factors might have.

Similarly, the point was made that labor organizations can play a key role in technological transfer. The transfer and adaptation of technology in the direction of substituting labor for capital intensive equipment may run into difficulties unless the workers can see a positive benefit to their welfare. For this reason, the government and employers would do well to bring representatives of the labor movement into the picture at an early stage.

With reference to the labor picture, it was noted that there was criticism in important sectors of U.S. society of the fact that private U.S.-owned factories in the LDC's were producing goods for the U.S. market with low-wage labor. The argument was put forward that perhaps too great an emphasis was being placed by LDC's on the export market and that a strategy directed at enlarging the internal market and at raising the standard of living of workers and farmers inside the country would be the better course to follow.

Basic versus Applied Research

During the course of the discussion, a plea for a better understanding of the role of basic research within LDC's was made. Due to the fact that in a number of LDC's much money is spent to very little purpose on what is called basic research, a bad reputation has attached to investments in this area. It was argued, however, that basic research is an essential element in building a scientific and technological base for industrial growth and, therefore, should be given appropriate support. Basic research above all is a necessary component in maintaining standards of quality in institutions of higher education in science and engineering and deserves support on this ground alone.

It should also be recognized that the term "basic research" is very broad and covers a wide range of activities. Included in these activities is what is often referred to as basic oriented research; that is to say, research directed toward developing knowledge relevant to national goals. Basic oriented research conducted within the LDC's might well make a contribution to the achievement of developmental objectives.

Those defending basic research as an appropriate claimant on the scarce resources of a developing country do not deny, however, that the level of support for basic research must be weighed against competing demands from the applied engineering research area which is obviously more closely related to the technology transfer process.

The Basic Vehicle for Asian-Pacific Area

A great interest was expressed in the basic vehicle for the Asian-Pacific; and the discussion elaborated on the points made in the presentation. In regard to the role of the program in enhancing the technical skills of the area and in particular of contributing to the capability of scientists and engineers to engage in innovative design work relating technology to local factor endowments, the following point was made. The program would in particular create a demand for what are referred to as semi-skills in the industry. These are not highly-trained skills but involve machinists, welders, machine operators, and the like. These would not be the workers on the assembly line but those employed by the suppliers of component parts. For example, in the Philippines, about 280 suppliers have been lined up on the project, all of whom would hire people. Furthermore, the service stations for the building of bodies on the basic form of the vehicle would create a demand for technical skills. In the Philippines such skills in fact do exist throughout the islands as evidenced by the well-known "Jeepney," a vehicle constructed from World War II Jeeps, of which some 400,000 are in operation today. Work would be done with the suppliers to assure that reliable standards of quality would be achieved and maintained.

It was noted that the research and development costs of the vehicle had been modest and that the recovery of these costs through royalties would be accomplished within the first production year. Therefore, this would be a relatively insignificant element of the cost per vehicle.

It was also noted that the spread of technology in the area has led to an increased demand for equipment of relatively high sophistication. This is illustrated by developments in connection with the technology of rice production where rice producers are now purchasing relatively complex and expensive equipment. In view of the increasing demand for equipment of this character, it appears likely that corporations interested in this market would devote more research to develop equipment specifically designed to conform to the environmental conditions and factor endowments of the Asia-Pacific area.