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

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Some Observations on the Economic Framework for Optimum

LDC Utilization of Technology: Abstract

This paper attempts to explore the relationships between the choice of technology and the problems of rising unemployment and worsening income distribution in the developing world. It is addressed mainly to the issue of whether or not, given present constraints on technology choice and output mix, developing countries can be reasonably expected to be able to escape from the straitjacket which seems to force a difficult choice between the achievement of output growth, on the one hand, and employment/income distribution goals, on the other. Two kinds of evidence are examined in support of the contrary hypothesis, namely that a more endowment-sensitive growth path can yield more output, employment and, possibly, a better distribution of income at the same time: the historical experience of a small "deviant" sub-family of LDC's and cross-sectional evidence from a larger number of country cases.

The paper first analyzes the mechanism of technology transfers from rich to poor, distinguishing between the process of borrowing from a shelf of international technology and the domestic technology adaptation process. Secondly, the changing relative importance of these two processes in a time-phased historical context is brought out, as the typical labor surplus developing country moves from import substitution through the export substitution sub-phase of growth. The empirical record of historical Japan, along with that of contemporary Korea and Taiwan, is examined in this context--both at the macro and micro levels. It is found that technology assimilation, especially during the export substitution phase when relative price signals are comparatively less distorted, can be extremely

important in terms of both output mix and technology change. The same kind of evidence on technological flexibility seems to emerge when we look across scales within countries still generally under import substitution policies-- but where the impact of such policies varies by size of firm.

The paper points attention to the major specific manifestations of industrial technological flexibility at the machine and plant level and briefly discusses the importance of R & D expenditures, government infrastructure, educational strategy, and type of private sector organization as additional dimensions of an adequate economic framework for optimum LDC technology choice. Finally, Section IV summarizes the overall findings of the paper and presents conclusions for policy of relevance to both the technology borrowing and lending countries.

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

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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 or 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.

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

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.[1] What is more, unlike in 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.

[1]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.

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 .05 to

[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.

.5 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.[1]

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.

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

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[1]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.

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 from the shelf and the potential for <u>further</u> reductions in the capital-output ratio "on top of" the import. We will, however, find it useful to maintain a distinction between

[1]It should, moreover, be noted that "picking something off the shelf" may not be quite as simple as it sounds. A so-called turn-key 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 labor productivity, a capital-saving innovation.

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 helps pull resources into the hands of the public sector, for social capital construction, on the one hand, and provides 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

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

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 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.

[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.

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 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 60s 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 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,

[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.

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 entrepreneurs 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

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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.

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 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

[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.

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 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 1/2 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 1868, was relatively brief and mild by contemporary standards.[1] By the turn of the century changes in monetary policy as well as in the ownership of directly productive activities (from 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

[1]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.

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.

[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.

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:

> 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.K. and U.S. 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 2 1/2 and almost 7 times as many.[2] As the U.S. Tariff Commission reported:

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

[2] Ibid., p. 367.

> 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.[1]

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 as 1932 weekly man-hours 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.[2]

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.[3]

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 bobbins, normally tends from 8 to 10 plain looms."[4] 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

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[1] _The Japanese Cotton Industry and Trade_, _op. cit._, p. 99.

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

[3] Arnold S. Pearse, _Japan and China_, Cotton Industry Report, International Federation of Master Cotton Spinners' and Manufacturers' Association, Manchester, 1929, p. 86.

[4] _The Japanese Cotton Industry and Trade_, _op. cit._, p. 100.

> 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 and four times as many operatives as the American.[1]

In the case of silk production, which, together with cotton, made up more than 70 percent of total Japanese industrial output 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-labor 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.[2]

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.[3]

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.

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[1] *Ibid.*, p. 113.

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

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

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, extensions 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.

This rather remarkable survival of domestic industry on a subcontracting 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,

[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.

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.[1]

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

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

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 thr 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;

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

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 lower 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 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 processs 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 subcontracting arrangements 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 Kachsiung 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]

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

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 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 changes in their environment associated with 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 <u>de facto</u> 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 rate 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,

[1] The author, in fact, believes that a typological approach (i.e. a different framework of analysis for different LDC sub-families) 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.

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.[1]

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.[2] 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."[3]

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 hot-house import substitution conditions, the Northern Border Industries (about 300 U.S. subsidiaries and 150

[1]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.

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

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

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 Korea-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,[1] 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.[2] This in 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 tools in the local machine shops.[3] 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.[4]

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;

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

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

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

[4]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.

this extension of 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 South-East Asian car, with different processes to be located in Indonesia, the Philippines, Malaysia, Singapore and Thailand. Philips and Volkswagen have, for some time, been experimenting in this field of the international division of processes which, given the close association 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 directions.

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 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 establishment.

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 that system usually, in sum, face a set of signals closer to equilibrium values. If we should then be able to uncover diffferential 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 statically[3] but the incentive to innovate and adapt in a labor-using direction

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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.'s 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 metalchipping (core) processes used in a cross section of rich and poor countries, almost 50 percent were sensitive to relative price conditions as well as lot size, ("Optimal Technology in Metal-chipping Machine Tools," May 1968, Stanford University; see also his Choice of Techniques, El Colegio de Mexico, forthcoming).

dynamically is equally enhanced.[1] 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.

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.[2] The types of goods subject to such flexible use of technology include textiles, electronics, metal working, non-electrical machinery, food processing, tires, tubes, leather

[1] 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.)

[2] For example, in addition to the already cited substitution of short for long staple cotton in Japanese spinning, Baranson 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.

products, rubber and plastic footwear, wood and wood working, 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.[1]

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 cum income distribution objectives.

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.[2] 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.

[1] 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.

[2] 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).

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."[1]

6. Export processing zones have apparently served as effective transitional devices for countries moving from import substitution to export 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.

7. Multi-national corporations seem to play a large, though by no means exclusive, role in this new process--focused international division of labor,

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[1] Jorge M. Katz, *op. cit.*, p. 24.

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 uncertainty 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 entrepreneurs without previous access to resources cannot bring their technological ingenuity to bear.[2] 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.[3] 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

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

[2] 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.

[3] 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.

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.

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 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

[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.

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 Philips 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 multinational 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 loose 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 quanity 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 intensive 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 salving 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 D.C. corporations apply for investment guarantees, either of the multilateral or bilateral (e.g. OPIC) variety, evidence of the scope for decentralized subsidiary decision making on technology and output or process

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

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 industry" 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

[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.

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.[1]

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