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TECHNOLOGY CHOICE, EMPLOYMENT AND GROWTH

Gustav Ranis

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Technology Choice, Employment and Growth*

Granted that overall LDC growth performance in the 60's was substantially ahead of that in the 50's, there can be little doubt that the biggest crisis lies just ahead. This is so partly because as more and more people are beginning to recognize, that progress has been very unevenly distributed, and partly because the threat is for much more of the same in the 70's and 80's. Perhaps the most important manifestation of that uneven participation in the past is that, even in the fastest growing countries, unemployment and underemployment rates have been rising. Secondly, all available guesstimates and projections for the future seem to agree that even if population growth could be substantially dampened tomorrow, given the age structure of the present LDC population, a labor force explosion of major proportions must be expected over the next decade or so.[1] Add to this the fact that the volume of foreign aid and of foreign private capital both available and acceptable in the 70's--in spite of all hopes, pleas, and efforts to the contrary--is likely to fall substantially below that of the 60's and the true dimensions of the problem ahead become clear. If major political as well as economic crises are to be avoided, it is thus reasonable to assert not only that the LDC's are going to have to somehow solve their future output problem not at the expense of employment and distribution, but also that this will have to be accomplished largely by their own efforts.

During the 50's and early 60's most of the LDC's engaged in what has been called, in short-hand, import substitution policies This usually

*Paper prepared for the ILO conference in Geneva in July 1970.

[1] For example, even Taiwan, one of the more "successful" planned parenthood cases, which experienced 1.7% and 2.5% annual average increases in the labor force during '58-'59 and '60-'61, respectively, is experiencing increases of nearly 4% now and projecting annual increases between 3.5% and 3.7% for the 70's.

included in one package a by now well-known syndrome of policies: exchange controls and import licensing, budget deficits, overvalued exchange rates and low (sometimes negative) real interest rates. The aim, generally speaking, was to redirect pre-independence traditional colonial flows in favor of the creation of social and economic overheads, and of import replacing consumer goods industries. The consequences of this set of policies on economic performance have by now been fairly well recognized and acknowledged, i.e. a spurt in industrial growth but inefficient, i.e. capital and import-intensive, in character, accompanied by a discouragement of exports and agricultural output, low domestic saving rates, a relatively heavy dependence on foreign aid, and low rates of technological change.

As LDC governments became increasingly aware of the economic cost of these policies, one could observe, during the 60's, a growing tendency to move towards a new policy package. This package can be characterized, if at the cost of some oversimplification, as tending to reduce some of the gross inefficiencies attending industrial development by readjusting a number of crucial, previously distorted, relative prices, including the exchange rate, the interest rate and the internal terms of trade. By replacing quantitative controls in the foreign exchange market with tariffs and moving towards more realistic exchange rates, via either a de jure or de facto devaluation, replacing severe credit rationing with higher interest rates, and forced procurement of food at artificially low prices with a relatively free market, developmental access and participation could be offered to medium and small-scale entrepreneurs in both agriculture and industry for the first time. The effects of this type of restructuring, where it has occurred, at least part of the way, e.g., in Korea, Taiwan and

Pakistan, have indeed been remarkable in turning situations of virtual stagnation in the '50's into sustained growth situations in the '60's.

More specifically, once agriculture is no longer discriminated against by unfavorable terms of trade this sector can begin to play its historical role of generating surpluses which, when successfully channeled, can provide simultaneous employment opportunities for the unskilled labor being released; a more broadly based industrial development pattern using a relatively more domestic material and labor-intensive technology can emerge; exports--especially of the non-traditional labor-using variety--are no longer discriminated against and can begin to expand; domestic saving rates can move up into the Rostow take-off range; and indigenous technological change can assume much greater importance.[1]

Perhaps most important from our point of view here is the fact that the new signals induce the adoption of different, more labor-using and unemployment reducing, technologies and output mixes. In this context the vital role, for better or worse, of technological flows between rich and poor countries must be kept in mind. The very coexistence of countries at very different levels of technology undoubtedly represents one of the most important influences on the performance of LDC's, past, present and prospective. It is the precise nature of these technological flows and the way in which they have been accommodated by LDC's which has, in our view, had a decisive impact on overall performance during these past two decades of development. Alternatively put, it is also in this area where the greatest potential for improved LDC performance in the 70's can and must be located.

[1]For a fuller discussion of the typical import substitution phase in LDC development and of the transition to a more efficiency-oriented phase, see the author's "Relative Prices in Planning for Economic Development," NBER volume, to be published.

The move, beginning in the middle '60's, from an import substitution to an export-substitution dominated growth pattern--and the consequent marked changes in economic performance--is, today, however, still the exception, not the rule, as far as the less developed world as a whole is concerned. In spite of the demonstrations of what can, in fact, be accomplished, there remain formidable obstacles to the dismantling of the import substitution regime. Direct controls imply absolute power--as well as supplementary incomes--for the civil service which it is loath to surrender lightly. Moreover, the inevitably greater role for private enterprise under any liberalized regime runs up against associations with colonialism and fears of anti-social give-aways.

In addition to this pull of vested interests and some quite well-intentioned doubts concerning the general risks of liberalization, there remains a good deal of skepticism concerning the major role we have accorded here to technological change as a determinant of success in development. In particular, many LDC officials, aid donors, and scholars share the point of view that most technological change, especially in non-agriculture, must take place abroad, and that the borrowing LDC's, in fact, have only a very narrow set of technological choices open to them. If only the coefficients attaching to the latest vintage machinery produced in the advanced countries are relevant, all the talk about alternative factor proportions in response to alternative resource endowments becomes largely irrelevant--or restricted to changes in output mixes via trade.

Skepticism on both these points, the merits of abandoning import substitution and the scope of technological choice, is, of course, not unrelated; for if there is no real alternative to the large scale capital-intensive

industrial structure, perhaps the most powerful argument for changing the basic policy package loses much of its force. The rest of the paper will therefore concentrate on presenting, in Section II, a suggested more realistic view of the nature of the innovation process in the borrowing developing countries. The empirical relevancy of this view is then explored in Section III.

II

There is less doubt now than ever before that the success of a development effort is likely to be much more related to technological change than to the growth of physical inputs. Nevertheless, in spite of this acknowledged importance of technological change, it has been difficult to achieve a clear understanding of the process by which innovations are actually made in a typical developing or borrowing country.

First, and foremost, it must be remembered that, unlike in an advanced country where technological change is viewed as rather automatic and routinized, or as capable of being generated through R and D expenditures according to some rules of cost/benefit analysis, we know that in the contemporary developing societies technological change cannot either be taken for granted or afforded through R and D allocations. In this situation we cannot avoid the question of what, given the existence of a shelf of technology from abroad, is the pattern by which the typical less developed economy, in fact, manages to innovate. This question in turn forces us to look at least at the following dimensions more carefully: 1) the precise nature of that technology shelf; 2) the availability within the LDC's of

required initial managerial and entrepreneurial capacity; and 3) the changing nature of that required managerial and entrepreneurial capacity in the course of transition to modern growth.

The technology shelf developed in the mature industrial economies abroad may be described by a set of unit activities following a smooth envelop curve as in Diagram I. A particular technology can be described by an L-shaped contour producing one unit of output with a given pair of capital and labor coefficients. The technology shelf is composed of the complete set of such activities or technologies which have been demonstrated to be feasible somewhere in the advanced countries at some historical point in time, including the present. Since there exists a number of technology exporting countries, e.g., the U.S., Germany, U.K., Japan, with continuous technological transfers amongst themselves as well as with the LDC's, it is not unreasonable to postulate the existence of a single technological shelf for the lending world as a whole. For example, unit technology A_o may have been generated in Germany in 1920, A_1 in the U.S. in 1920, A_2 in the U.S. in 1950, etc. In other words, as we move to the left along the shelf we run into more modern technology, i.e. technology of more recent vintage and of higher capital intensity. As capital per head increases this means that the typical workers has learned to cooperate with more units of capital of increasing technical complexity. This capital deepening process, in other words, is more complicated than the textbook version of "homogeneous" labor being equipped with more units of "homogeneous" capital.

At any point in time the typical LDC is then theoretically free to borrow a particular unit activity from anywhere along this shelf. What technology is chosen and what happens as an immediate and ultimate consequence

of that choice, i.e. what secondary processes and reactions are set off, is, of course, all part and parcel of the innovational process taken as a whole. The quality of that process, each step of the way, in turn depends on the nature of the entrepreneurial, managerial and skilled labor capacity of the borrower.

The role of innovation must thus be seen as intimately related to the stage in which the developing economy finds itself. In other words, the role of technological change in output and employment generation must be viewed as sensitive to the same discernable phases of growth as the economy moves in transition from open agrarianism to Kuznets' modern economic growth. In the first post-independence or import substitution phase, previously described, an effort is made to increase the supply of domestic entrepreneurship and the economy's learning capacity, partly through the importation of people via aid, but mainly through the system of protection established by government policies. In fact the most reasonable explanation for the import substitution syndrome is that it is a response to a real or imagined shortage of entrepreneurship and that it permits time through informal learning-by-doing or more formal educational processes for this entrepreneurial capacity to develop.[1]

In terms of our Diagram I, this means that although the technological shelf may look as indicated by curve SS, the actual choices available to the developing country during the import substitution phase are more aptly described by S'S'. In other words, due to the inadequate state of

[1]Some few countries, like Malaysia, with command over a very strong and reliable natural resources base, may be able to avoid such a phase altogether. Moreover, there clearly exist better and worse (i.e. less and more costly) import substitution packages to choose from, e.g. comparing Brazil and Ghana, but we cannot expand on this very interesting subject in the context of the present paper.

entrepreneurial capacity during the early post-independence period of physical controls, the efficiency of the operation per unit of capital in the borrowing country is likely to be substantially below that in the lending country. This is likely to be more true the more capital-intensive the import, i.e. the further removed from the cultural inheritance and economic experience of the borrower. Such technological imports are often accompanied by imported engineers, even managers and supervisors--adding up to what is often called a turn-key project. The most advanced and sophisticated technology can, of course, be made to "work," in the physical sense, even in the most backward developing economy. But a shiny new plant imbedded in a society many decades distant is bound to be substantially less efficient. This is true for a thousand direct reasons, such as the absence of even minimal skilled labor supplies, domestic subcontracting and repair and maintenance possibilities, as well as for many more subtle sociological reasons which enter into the total milieu in which the plant is asked to operate. The more sophisticated and removed from the rest of the economy the technological transplant, in other words, the greater the relative inefficiency, as indicated by the shape of the S'S' curve.

If and when the economy then moves away from the import substitution phase and enters into the second phase of liberalization and export substitution, a second important, if unintentional, type of innovation is likely to make its appearance, namely a reduction in the extent of the inefficiency of the original transplanted technology. Call it X-efficiency if you like, but the cost of the pure transplantation is likely to be reduced, quite unintentionally, i.e. largely as a result of factors external to the profit maximizing behavior of the productive unit itself. This

increase in productive efficiency over time will increase in quantitative significance as the import-substitution hothouse temperature is gradually turned down and a more competitive economy emerges. In Diagram I the effects of gradual enhancement of efficiency may be represented by the arrows tending, over time, to move S'S' back towards the original SS position.[1]

Another more conscious and quantitatively more important type of innovation begins to gather importance during this same second phase of transition. This phenomenon may be called innovational assimilation, i.e. innovating "on top of" imported technology in the direction of using relatively more of the abundant unskilled labor supply. As the economy shifts from a natural resource based growth pattern in the import substitution phase, to a human resource based system in the export substitution phase, this means an increasing sensitivity to the continuously changing factor endowment, first in terms of the efficient utilization of the domestic unskilled labor force, and later in terms of the incorporation of growing domestic skills and ingenuity. In other words, the appropriate type of technology finally in place must be one in which not only the initial choice from the shelf but also the adaptations and adjustments consciously made thereafter in response to changing domestic resource and capability constraints, play an important role.

The more liberalized the economy, in terms of the government's performing a catalytic role through the market, by indirect means, rather than trying to impose resource allocation by direct controls, the better the chances that the millions of dispersed decision-makers can be induced, by

[1] A more sophisticated analysis, differentiating between the labor and capital-saving nature of this move, depending on the region in which the economy is operating, is possible, but will not be introduced here.

the sheer force of profit maximization, to make the "right" decisions. Even in the absence of technological change, as long as surplus labor overhangs the market, and the expectation is for even more of the same in the future, we can expect little upward movement in real wages and little capital deepening. Superimposed on this is the aforementioned assimilation type of innovational behavior which tends for the same reason to be slanted in the labor-using direction. In the typical labor surplus type of economy--or one likely to become one over the next decade (as is probably the case in much of Africa)--all this means as much efficient accommodation of pure labor services as possible.[1] Whether this will lead to a sectoral output shift in favor of labor intensive export commodities or a mix predominantly addressed to the domestic market, of course, depends, ceteris paribus, on the type, e.g., size, of the economy. No strong generalization as to the relative importance of shifts in output mix vs. changes in technology for given mixes is likely to be valid. It should be clear, however, that the important issue is that the search for innovation can now be considered a conscious activity of the individual entrepreneur--and given the combination of more realistic relative price signals after liberalization and given greater entrepreneurial capacity--that it is likely to be directed towards various forms of indigenous capital stretching types of technological change on top of the imported technology. Such capital-stretching can be represented by a reduction in the capital coefficient per unit of output. The effective post-assimilation set of unit technologies, i.e. after domestic assimilation, may thus be represented by curve S"S",

[1] It is important to emphasize the word "efficient" since we are not concerned here with the possible legitimate objective of employment creation as a separate social goal to be traded off against output.

with the strength of the indigenous labor-using innovative effort indicated by the amount of the "downward" shift in the capital coefficient.

It should be noted here that a negatively sloped technology shelf, e.g. SS, representing pure technological transplantation, permits, as you move to the left, higher labor productivity levels, but only at increasing capital cost. In a country characterized by capital scarcity this may mean increased technical unemployment (a la Eckaus) and hence a lower value of per capita income for the economy--in spite of the higher level of labor productivity achieved. Domestic capital stretching however, can materially affect that situation by enabling more workers to be employed per unit of the capital stock. If the post-assimilation unit technology set, e.g. S"S", is upward sloping, as the economy moves to the left by first borrowing abroad and then innovating domestically on top of that borrowed technology, higher labor productivity levels become consistent with lower capital-output ratios.

In summary, once the overall policy setting, as described in Section I has turned more favorable and permitted the economy to enter the second phase of transition, it is this indigenous capital-stretching capacity which we consider to be of the greatest importance--especially for the contemporary developing economy facing the formidable labor force explosion predicted for the 70's and 80's. It is in this specific area also where the skepticism of planners, engineers, and aid officials generally is most pronounced--especially with respect to the range of technology choice really available when all the dust has settled. Using mostly historical examples from the Japanese case, we will attempt to demonstrate the existence and potential importance of such capital-stretching innovations for the contemporary developing country, in Section III.

III

As has been pointed out by many observers, including Allen and Lockwood[1] the most significant feature of the Japanese landscape in the early Meiji period--following hard on two centuries of self-imposed, nearly complete, isolation--was her ability to choose relatively freely from among the items on the technological shelf perfected in the West. The reopening of foreign trade and the resumption of other related contacts, especially the flow of technical personnel in both directions, led immediately to the stimulation of technological change by direct borrowing. But while the Japanese have often been characterized as possessing a consummate ability to copy and imitate, it is noteworthy that, in fact, very soon the majority of domestic innovation activity "consisted of the adaptation of foreign techniques to domestic conditions."[2]

The reasons for this relatively early move to a responsiveness of the industrial sector's technology to domestic endowment conditions are complicated and cannot be dealt with satisfactorily within the scope of this paper. Suffice it to say that post-Restoration Japan did not engage in very extensive or prolonger import-substitution policies--partly because extra-territoriality deprived her of the ability to establish strong protective import barriers, and partly because the government quite early

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[1]George C. Allen, Japanese Industrialization: Its Recent Development and Present Conditions, New York: Institute of Pacific Relations, 1940; W. W. Lockwood, Economic Development of Japan, 1868-1928, Princeton, N. J.: Princeton University Press, 1954.

[2]M. Miyamoto, Y. Sakudo and Y. Yasuba, "Economic Development in Pre-Industrial Japan: 1859-[illegible]4," [illegible] December 1965, p. 557. The same authors also report [illegible] capital or land stretching innovations took place during the [illegible] the agricultural sector, mainly via new cultivation methods on the intensive margin.

thought it more efficient to work through the market, i.e. by using taxes and subsidies, rather than through extensive controls and government ownership. Those government plants in directly productive areas which were established during the immediate post-Restoration period were viewed mainly as pilot projects and sold off to private interests by 1890. Thus Japan moved relatively quickly into the second phase of transition.

In assessing the importance of capital stretching innovations, i.e. innovations which move the actual production shelf down to position S"S" in Diagram I, it may be useful to recognize distinctions between innovations relating to the machine proper; innovations relating to the production process as a whole, emphasizing the importance of activities within the plant but peripheral to the machine; and innovations with respect to the production process as a whole, emphasizing plant size and organization at various stages of that process.

With respect to machine-related capital stretching innovations, the simplest and quantitatively probably most important example was the running of imported U.K. and U.S. machinery at rates and speed 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. 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

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[1]John E. Orchard, Japan's Economic Position, New York: McGraw-Hill Book Co., Inc., 1930, p. 367.

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.[1] As the U.S. Tariff Commission reported:

> In order to distribute the fixed overhead charges in the way of high interest and depreciation costs, and to earn the large amounts needed to pay a normal rate of dividend, every effort has been made to obtain the largest possible output from the expensive equipment and plant. Machinery is therefore run at high speed, and almost since their inception the Japanese spinning mills have been operated night and day, employing two 12-hour shifts (22 actual working hours) for an average of 27 days a month.[2]

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.[3]

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

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[1] Op. cit., p. 367.

[2] The Japanese Cotton Industry and Trade, U.S. Tariff Commission, Government Printing Office, Washington, 1921, p. 99.

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

> 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.[1]

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."[2]

Perhaps the most convincing evidence that these adjustments along the machines proper constituted a rational response to very marked differences in factor endowments was that in weaving, in contrast to spinning, the latest automatic equipment from abroad was not, in fact, invariably imported. Quite frequently non-automatic looms were taken from the shelf instead, permitting more stretching than would have been possible in the case of technologies to the left along that same shelf. Unlike some of the contemporary less developed countries, Japan clearly did not wish to import ahead of its entrepreneurial and skilled labor capacities.[3] As the 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,

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

[2] The Japanese Cotton Industry and Trade, op. cit., p. 103.

[3] The U.S. Tariff Commission (op. cit., p. 116) reported that a shipment of automatic looms, imported 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, two looms to a weaver.

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 where the high-priced labor is economized rather than the machinery.[1]

Taking cotton spinning and plain loom weaving on similar products together, they concluded, in summary, that

> the average Japanese spinner or weaver tends about one-fourth the number of spindles or looms usually assigned to one person in an American mill. A comparison of the total number of persons employed in the two countries to operate individual plants of similar size, and, viewed more broadly, a comparison of the total number of persons employed in the whole American industry, per 1,000 spindles, with the number that would be required on the similar balanced basis under the Japanese conditions, confirms the general relation observed, that the Japanese mills require between three and one-half and four times as many operatives as the American.[2]

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

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[1] The Japanese Cotton Industry and Trade, op. cit., p. 116. A related interesting example of technical flexibility f[illegible] and what most engineers are willing to admit to is provided by the Toyoda automatic loom, one of the few indigenous Japanese inventions in this area. Subsequently manufactured by Platt's and Oldham's under a Japanese patent, it was advertised to require 20 girls per loom in England; 50 girls had always been used in Japan.

[2] Ibid., p. 113.

century, 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 reeling basins in Italy. In other areas, well into the twentieth century, Japanese railways employed 19 workers per mile of track compared with 7 in the U.S.[1] In the production of printed goods, the following episodal account may be 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 machine, 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

[1] Orchard, op. cit., p. 375.

a new industry in a stage of technical development that had become obsolete years before in the older industrial countries.[1]

Many of the extra workers in Japanese plants are not engaged on the machine proper, but in what might be called machine-peripheral or handling activities. In place of mechanical conveyor belts, human conveyor belts are devised. Packaging is more often done by hand. 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 bags by hand and then carried by coolies, some of them women, to the barges in the adjacent canal. Coal, even in the larger Tokyo plants, is unloaded by hand and carried in baskets to the power houses."[2] The ability to substitute labor for capital in such activities peripheral to the machine proper apparently existed and the quantitative incidence was 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.[3]

A third type of capital-stretching innovation of which much use was made in historical Japan is what might be called the plant-saving variety. This is often characterized by the co-existence of different historical stages of production in the same industry. Raw silk production and cotton

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[1]Orchard, op. cit., p. 246.

[2]Ibid., p. 255.

[3]This is very similar to contemporary methods of construction with the use of reinforced concrete in India and Pakistan. Here a cement mixer is linked to the final pouring of the concrete by a long chain of workers passing the cement from hand to hand; the cement is put in place just before it is ready to cool and harden.

weaving represent outstanding examples. In the former industry silkworm rearing, and cocoon 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 workshods. 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 unit. The traditional merchant middleman, as a representative of the sub-contracting unit, served as both supplier and market for the goods to be worked up domestically. A specialization of functions as between workshops, even as between the members of a given family, developed. One-roof economies could be achieved in this fashion, i.e. by using cheap labor in cooperation with old fashioned machinery at the workshop level, while economies of scale could be achieved in the financing, purchasing and merchandising stages.[1] The continued relative importance of this household type of enterprise is quite remarkable; cottage style industry contributed more than 2/3 of industrial output in 1878, almost 60 percent in 1895, and retained substantial importance well into the twentieth century. Not only lacquerware, pottery, porcelain, sake, fruit and fish canning but also such new consumer goods coming to the fore

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

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 in the industrial production processes, largely for export. Other, more contemporary examples of capital-stretching may be cited. In Taiwan, for example, after the liberalization policies of the early 60's substantially reduced distortions in the exchange rate, the interest rate, and the intersectoral terms of trade, marked labor-using innovations took place in the textile, electronics, and food processing industries. Large scale mushroom and asparagus production as agricultural by-employment (similar to silk in Japan), combined with canning processes at the factory level utilizing female labor with greater intensity than anywhere else, is one example. While, in 1955, traditional exports, mainly sugar and rice, still amounted to 76 percent of total exports, by 1968 this had shrunk to 8 percent of a much larger total. Meanwhile export substitution in the form of new agricultural products and, increasingly with time, products embodying a large volume of pure labor services has taken hold. The ultimate expression of

the latter trend can be found in the Kaohsiung Export Processing Zone, a tariff-free area into which, largely under subcontracting arrangements with Japanese or American firms, raw materials are imported and reexported after value in the form mainly of unskilled labor has been added. Largely as a consequence of plant and machinery saving technological change of this type, Taiwan is now reliably reported to be experiencing an unskilled labor shortage and may be one of the very few LDC's which can face its inevitable labor force explosion ahead with some equanimity.

A similar trend has been in the making in South Korea. Devaluation in 1963 and interest rate reform in 1964 laid the basis for major changes in the output mix as well as in the technology employed in given industries. In silk spinning, for example, 33 percent more workers are reported employed per unit of capital than in contemporary Japan. A bonded export processing scheme, built on the same international subcontracting principle as Taiwan's now yields close to 20 percent of an export volume which itself has been rising at an almost incredible 30-40 percent annual rate over the past three years. In 1962 land-based food stuffs and raw materials made up 75 percent of total exports while labor-based light manufacturing industries as a whole, including plywood, raw silk, cotton textile, wigs and footwear amounted to 15 percent. By 1968 the situation had been completely reversed, with 77 percent of the exports in manufacturing and only 14.5 percent in foodstuffs, livestock and raw materials. It should, moreover, be noted that small-scale manufacturing exports, i.e. in units of less than 10 workers, undoubtedly the most labor-intensive part of the spectrum, grew from 18.6 percent of the total in 1963 to 31.4 percent in 1968.

In summary, the typical contemporary LDC may be viewed as moving first through an import substitution phase in which pure technological transplantation is likely to be the order of the day, while shortages in domestic entrepreneurial capacity and other economic overheads are being repaired. Then, as the hothouse temperature is gradually reduced and the economy moves towards greater efficiency with the help of various liberalization policies, labor-using types of technological change, both of the unintentional and of the intentional variety, assume increasing importance. In this phase the famous conflict between output and employment objectives in industrial development may be subject to fundamental challenge. Both the historical experience of Japan and that of Taiwan and Korea in recent years illustrate that the current wide-spread skepticism concerning the supposed tyranny of the rigid technical coefficients may be seriously in error. This error derives in the main from an underestimate of the potential inventiveness of indigenous entrepreneurs, once they are given access, at a price, to the required inputs. And this is no trivial matter. For if our skepticism here is unwarranted, this would be among the most powerful arguments for accelerating the current, rather slow, trend towards liberalization and the erosion of the substantial shadow price/market price differentials in factor and commodity markets.

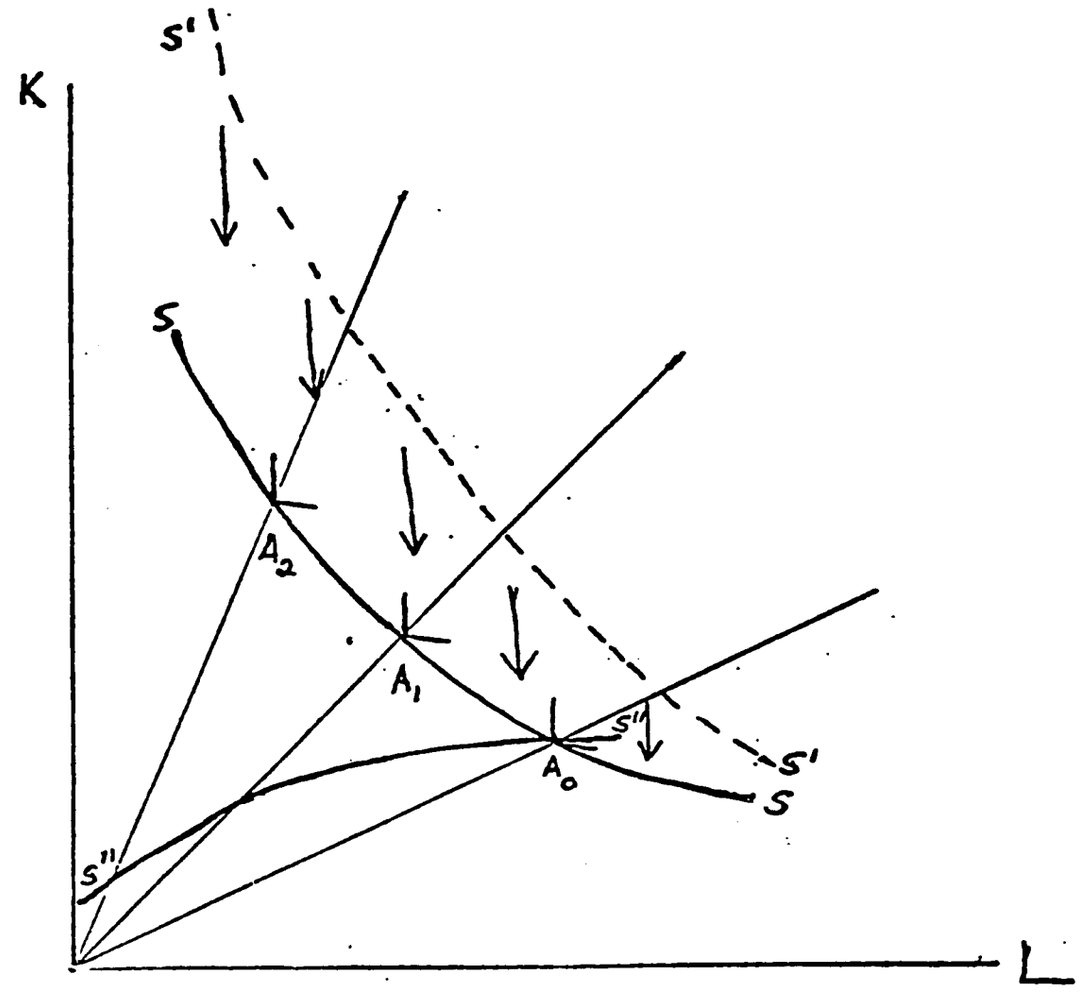

Diagram I