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INDUSTRIALIZATION, EMPLOYMENT AND THE CHOICE OF ALTERNATIVE VINTAGE EQUIPMENT IN LESS DEVELOPED COUNTRIES

Howard Pack and Michael Todaro

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Industrialization, Employment and the Choice of Alternative Vintage Equipment in Less Developed Countries

by

Howard Pack and Michael Todaro

I. Introduction

It is a commonly accepted tenet of development economics, that in order to generate and sustain rising per capita income, poor nations must undergo a process of industrialization.[1] In general two lines of argument are used to support this contention. First, the industrial sector exhibits higher average productivity than either agriculture or services, so that a transfer of labor from these latter sectors to industry results in a net addition to total income. Second, as per capita income rises, regardless of the sector of origin, Engel's law suggests that an increasing share of total expenditure will be devoted to manufactured goods. Since many countries are finding it increasingly difficult to sufficiently expand export earnings, there appears to be little choice but to produce domestically manufactured consumption goods.

The industrialization process usually suggested entails capital formation and a gradual, but continuous modernization of the capital stock. However, in order to obtain the requisite capital goods, these countries must normally obtain adequate foreign exchange, either by exporting primary materials and/or simple consumer-type goods or by seeking foreign aid. Commonly the importation of capital equipment has posed two problems. First, it is an often noted phenomenon that imported capital equipment, originating

[1] See, for example, H.B. Chenery, "Patterns of Industrial Growth," American Economic Review, March, 1960, and S. Kuznets, Six Lectures on Economic Growth.

in the advanced western countries, is usually of a labor saving nature with the result that the lag between output growth and employment generation appears to be very large in the LDC (less developed countries).[1] In addition to the problem of labor absorption, considerable potential output may well be lost because of the lack of correspondence between the factor requirements of the imported, modern machinery and the resource endowment of most poorer nations.

Second, as fluctuation occurs in the demand for a country's exports, investment programs must be continuously adjusted to the availability of foreign exchange. Moreover, import substitution policies which tend to concentrate heavily on consumption goods inevitably generate large demands for capital equipment as well as intermediate imports. The net result is an ever increasing demand for foreign exchange.[2]

In this paper we shall analytically examine some of the implications for output and employment of the continued importation of modern foreign equipment. In particular, when this process is interpreted in terms of a vintage model of capital accumulation, many of the seemingly paradoxical phenomena of "successful" industrialization programs become more intelligible; and, furthermore, some of the more common policy prescriptions appear to be ill advised. It will be our argument, therefore, that the establishment of domestic machine producing capacity to replace imports can contribute substantially to the possible solution of many of the aforementioned obstacles to continued and rapid economic development.

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[1]See, for example, W. Baer and M. Herve, "Employment and Industrialization in Developing Countries," Quarterly Journal of Economics, February 1966, p. 91 for some cross-sectional data on this employment lag.

[2]See J. Sheahan, "Imports, Investment and Growth: Colombian Experience since 1950," forthcoming.

II. Some Observations on the Nature of Imported Machinery

Almost all models of the relationship between capital accumulation and economic growth in the LDC view capital as a homogeneous factor. Moreover, the explicit production function is usually one of constant returns to scale for all technological processes, be they capital or labor intensive, fixed or variable proportions. In spite of the analytic convenience of working with these traditional concepts of production theory, careful observers of developing countries have occasionally suggested that returns to more capital intensive processes may be greater than those to labor intensive processes.[1] Moreover, there is a growing body of data which brings into question the validity of the traditional neoclassical relationship between capital intensity and factor productivity. In particular, with a constant returns to scale (CRTS) production function, increasing capital intensity should be associated with diminishing average productivity of capital. However, when the International Labor Organization analyzed the experience of a number of developing countries they observed that "it does not appear to be the case that techniques that employ more labor per unit of capital always yield a larger output per unit of capital. Indeed, in a number of cases, it has been observed that some techniques that use much labor also use much capital per unit of output."[2] Similarly, in a well-documented study of alternate techniques of production, G.K. Boon cites evidence from the Japanese manufacturing industry indicating that in a significant range of production, the productivity of capital, as well as labor, rises as the capital-labor ratio increases with increasing

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[1] See, for example, H. Bruton, Principles of Development Economics, p. 41.

[2] International Labor Office, Employment Objectives in Economic Development, Geneva, 1967, p. 61.

firm size.[1]

Rather than using constant returns to scale functions with homogeneous capital in analyzing the LDC it seems more plausible to take explicit cognizance of the heterogeneous nature of imported equipment. We shall assume, therefore, in the following analysis that the process of capital accumulation in developing countries involves the continuous modernization of the capital stock resulting from the importation of equipment of more modern vintage. Furthermore, we shall assume that each new vintage is both more capital intensive and exhibits a lower labor coefficient. The analysis wil then proceed along the following lines. First, purely for heuristic purposes in the spirit of the above assumptions, but in conformity with the traditional methods (i.e., continuous, twice differentiable production function with homogeneous capital), we consider the implications of a production function which exhibits greater returns to the more capital intensive processes relative to more labor intensive technologies. Thereafter, we provide an explicit formulation of a vintage approach, which, as we have suggested above, is the more realistic way of handling the problem. It will be found that the results of both procedures have similar implications for the nature of the development process and underline the importance of establishing a domestic capital goods industry.

III. Differential Returns to Scale, Employment and Output--a Heuristic Approach

Instead of the usual two factor production map with fixed returns to scale (be they constant, increasing or decreasing) for all processes, let us assume that the production map faced by firms in developing countries

[1] G.K. Boon, Economic Choice of Human and Physical Factors in Production, North Holland Publishing Co., 1964. Tables 3.18 and 3.22.

is one which exhibits distinctly greater returns to scale for more capital intensive techniques of production.[1] These assumptions are reflected in the shape and position of the isoquants of Figure 1.

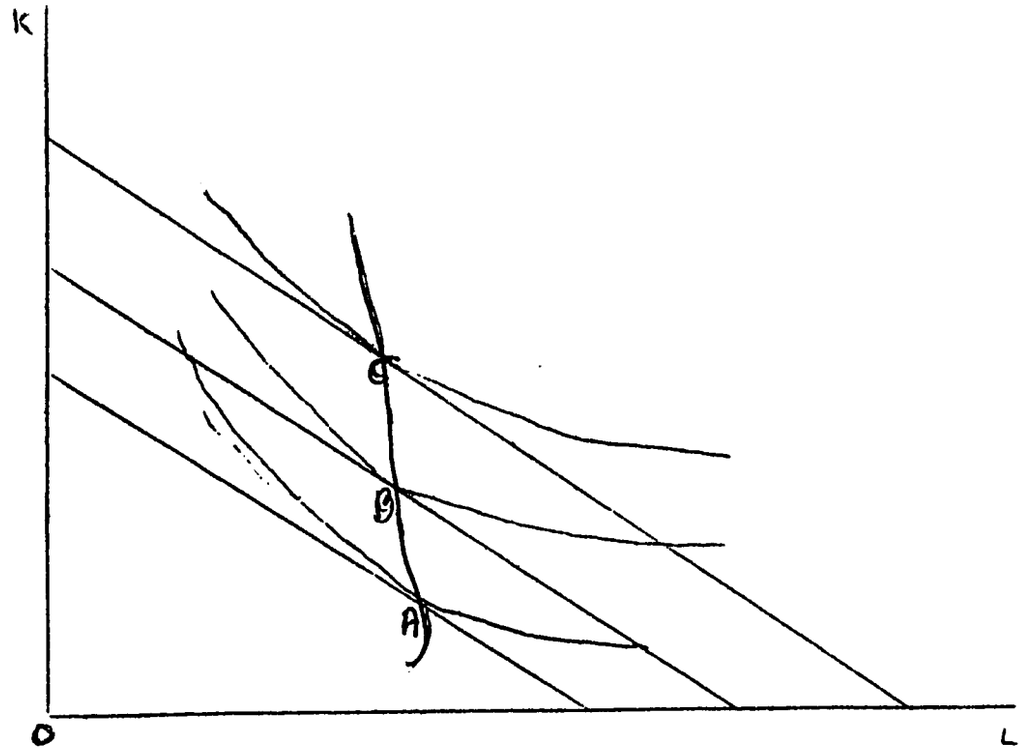

Figure 1

Now consider an expanding industry in which existing firms face the above set of isoquants.[2] If the differential returns are great enough, then as output increases the expansion path ABC could easily exhibit a negative slope over some range. This simply means that, assuming fixed

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[1]This is not to be interpreted as implying that there are absolutely increasing returns along the more capital intensive rays. It is difficult, moreover, to justify our differential returns to scale assumption in the context of homogeneous capital. In fact, the underlying basis for this assumption is the vintage nature of capital which we will explicitly incorporate into the model of Section IV. The present approach is purely heuristic, but does bring to light in a familiar way the implication of differential returns to alternative capital intensities.

[2]This map differs from a neoclassical production function insofar as $f_{KK} > 0$ rather than $f_{KK} < 0$.

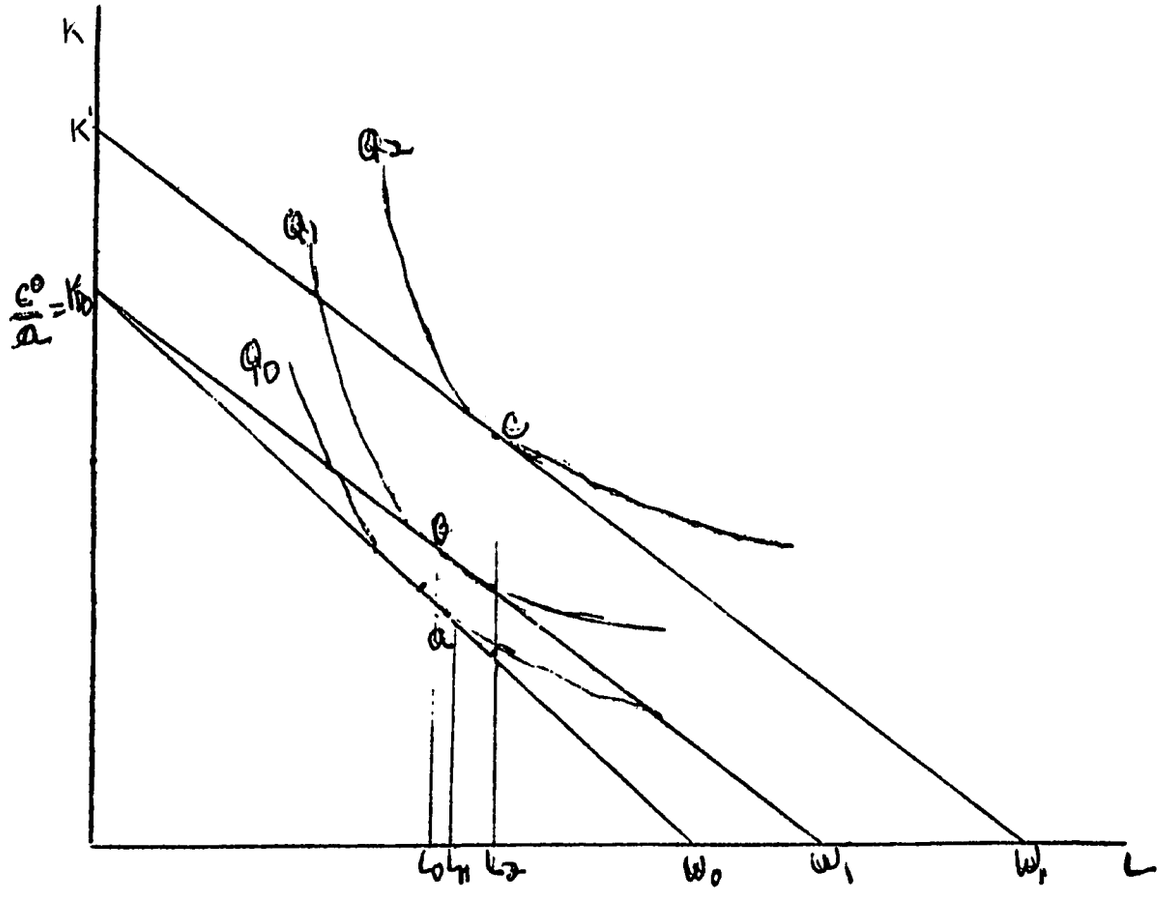
factor prices, as output expands more capital intensive technologies become increasingly more efficient in terms of unit costs. In this context, labor is seen to be an inferior factor on the basis of the assumed technology, although actual inferiority may constitute an extreme case.[1]

An interesting implication of the isoquants of Figure 1 when considered in the context of the typical capital market conditions existing in the LDC, is the low probability of successful labor absorption resulting from policies designed to reduce the relative price of labor.[2] A frequently proposed measure is the subsidization of labor in order to reduce its market price towards its shadow price in an attempt to generate more employment. However, if we analyze this proposal within the framework of our assumed technology and the frequently noted financial constraint (e.g. credit restriction, often reflecting the poor financial intermediation structure), it will be seen that it is likely not to be successful and could conceivably have a perverse effect upon employment. Consider Figure 2.

Suppose a firm has available to it funds equal to C_0. Expressed in units of homogeneous capital goods, this finance constraint is represented by C_0/r where r is the price of capital. Given an initial wage rate of W_0

[1]Actually, in a number of instances, this perverse employment-output relationship has been observed. For example, Mead cites a study of Harbison and Ibrahim which provides "several examples where the introduction of more capital equipment in Misr companies resulted in marked increases in textile production while employment stayed constant or even fell" and notes that "this group of companies is known for its forward-looking management as well as for its desire to use the most advanced machinery and equipment." Growth and Structural Change in the Egyptian Economy (Richard D. Irwin, 1967), p. 120.

[2]See, for example, J. Tinbergen, The Design of Development, Johns Hopkins Press, 1958.



point A is the least cost factor combination for producing output Q_0. If a subsidy were granted to firms based upon the number of employees, the wage cost per worker to the firm would decrease to W_1 as represented by line K_0W_1. With the technology which we have depicted, employment will actually fall if the firm seeks to maximize output subject to its cost constraint. The firm may have had little choice but to utilize a labor intensive technique when the price of labor was relatively high. However, the wage subsidy releases enough funds to permit efficient production of a more capital intensive nature. The mechanism of adjustment is analogous to the well-known income and substitution effects of consumer theory, in this case the

negative scale (income) effect severely inhibits the positive substitution effect.

The seemingly unorthodox result, i.e., that labor is in a sense a Giffen factor, derives from the dual assumption of strong differential returns to scale and a binding finance constraint. In effect the firm depicted in Figure 2 is maximizing output subject to its limited finances as opposed to minimizing cost for a given level of output. In this sense, the possibility of labor inferiority in less developed countries can arise.[1] However, even if one removes the assumption of a binding financial constraint (i.e. allowing for a parallel movement of the budget line, say to K_1W_1) which permits the minimization of cost for the given output, it will be observed that the net employment effect, L_1L_2, is still small relative to what it would have been had a typical CRTS function prevailed.

It is instructive, furthermore, to consider the production equivalent of the Slutsky equation of consumer theory. The response of employment to a wage change would be represented by the following equation,

$$(1) \quad \frac{\partial L}{\partial W} = \left(\frac{\partial L}{\partial W}\right)_{Q = \text{const.}} - L\left(\frac{\partial L}{\partial C_0}\right)$$

where $\partial L/\partial W$ is the <u>total effect</u> of a change in the wage rate on the demand for labor, and $(\partial L/\partial W)_{Q = \text{const.}}$ is the <u>pure substitution</u> effect of a change in the wage rate and $-L(\frac{\partial L}{\partial C_0})$ is the scale effect of the wage change. Consequently, if the scale effect is positive and greater in absolute value than the pure substitution effect (which is always negative), a reduction

[1] It should be noted that with perfect competition in both factor and product markets, this possibility of "Giffenocity" of a factor could not theoretically arise. See J.R. Hicks, <u>Value and Capital</u>, Chapter 7 and Appendix thereto. For a recent elaboration of this problem see R. Russell, "A Graphical Proof of the Impossibility of a Positively Inclined Demand Curve for a Factor of Production," <u>American Economic Review</u>, Vol. 54, Sept. 1964, and D.W. Winch's Comment, <u>Ibid</u>. Vol. 60, No. 4, September 1965.

in the wage rate could lower the quantity of labor demanded. Of course, an outward shift in the finance constraint, as pointed out above, would modify this result.

Furthermore, if we multiply the terms on both sides of equation (1) by W/L we obtain the factor elasticity equivalent of the Slutsky production equation.

$$(2) \quad \frac{W}{L} \cdot \frac{\partial L}{\partial W} = \left(\frac{W}{L}\right) \cdot \left(\frac{\partial L}{\partial W}\right)_{Q = \text{const.}} - \frac{WL}{C_0} \left(\frac{\partial L}{\partial C_0} \cdot \frac{C_0}{L}\right)$$

The expression on the left-hand side of equation (2) is the total wage elasticity of demand for labor. The first term on the right side is the <u>pure</u> wage elasticity of labor demand (again, always negative) while the second term consists of an expression representing the share of total expenditure devoted to labor, WL/C_0, and an expression for the expenditure elasticity of demand for labor, $\frac{\partial L}{\partial C_0} \cdot \frac{C_0}{L}$.

We see, therefore, that the elasticity of labor demand will have its usual negative sign only so long as $\left(\frac{W}{L}\right) \cdot \left(\frac{\partial L}{\partial W}\right)_{Q = \text{const.}}$ is greater in absolute value than $-\frac{WL}{C_0} \left(\frac{\partial L}{\partial C_0} \cdot \frac{C_0}{L}\right)$ assuming that the latter expression is positive which is likely given our assumed technology. Empirically, the most interesting component of equation (2) is $\frac{WL}{C_0}$. For it can be seen that the larger the wage share of total outlays, the more pronounced could be the inhibiting effect on employment. Since the firms which account for a major part of employment in less developed nations are small, labor intensive, and have a substantial wage component in total costs (especially when statistical allowance is made for the absence of imputed wages to family employees in addition to normally recorded wage and salary data), the existence of this perverse relationship between wages and employment becomes a distinct possibility.

IV. A Vintage Capital Approach to Output and Employment

While the preceding analysis provides a heuristic framework for analyzing the process which we believe to be the common experience of newly industrializing countries, (i.e. that growth is associated with capital deepening and lagging employment), it disguises the underlying phenomenon which gives rise to this result, namely, that the process of capital accumulation is usually accomplished through modernization of the existing stock.[1] Consequently a realistic analysis of the process must take account of the heterogeneity of capital and the probability that it pays growing firms to take advantage of increasingly modern vintages.

Let us assume, therefore, that the following technological relationships prevail among different vintages of capital:

1) Each new vintage embodies labor saving technological progress in the sense that physical labor requirements per unit of output decline and, additionally, the machine costs per worker increase.[2]

2) Once a vintage is chosen, there are no substitution possibilities, i.e., each vintage exhibits fixed proportions.

3) All vintages exhibit constant returns to scale.

Formally, these three assumptions may be expressed as follows:

$$Y(t, v) = \mu_{\varsigma}(v)\, K_{\varsigma}(v) = \lambda(v)\, L(t, v),$$

or

$$L(t, v) = \frac{\mu_{\varsigma}(v)}{\lambda(v)}\, K_{\varsigma}(v)$$

where,

$Y(t, v)$ is the output in period t produced by capital of vintage v,

$\mu_{\varsigma}(v)$ is the average (marginal) productivity of vintage v capital ex-

[1] See, for example, various issues of U.N. Industrialization and Productivity Review, for case studies.

[2] Since capital is no longer homogeneous, instead of each new vintage being associated with a higher capital intensity in the physical sense, we must speak in terms of machine cost per worker. Qualitatively, the concepts are very similar.

pressed as unit capital costs and is constant for each vintage.

$K_{\$}(v)$ is the dollar cost of vintage (v) capital equipment,

$\lambda(v)$ is the average (marginal) product of labor used on vintage v and is constant for each vintage.

$L(t, v)$ is the amount of labor used on vintage (v) capital in year t. Since $\frac{\mu_{\$}(v)}{\lambda(v)}$ is the labor requirement per dollar of vintage v capital in use, assumption 1 requires that this ratio decline with each vintage.

4) Finally, let us assume that the minimum output at which each new vintage can be efficiently operated becomes progressively larger.

These assumptions are reflected in Figure 3 where more modern vintages are represented by progressively steeper rays, and where along each ray, unit additions to output are equally spaced. Moreover, the spacing of these unit output additions becomes progressively smaller for each more modern vintage. Each ray has a minimum efficient output level which also increases with more modern equipment.[1] Lastly, in order to represent efficient factor choice when the investment decision involves different vintages, we have represented capital by dollar costs on the vertical axis rather than by units of physical capital since the latter concept has no meaning in this context.[2]

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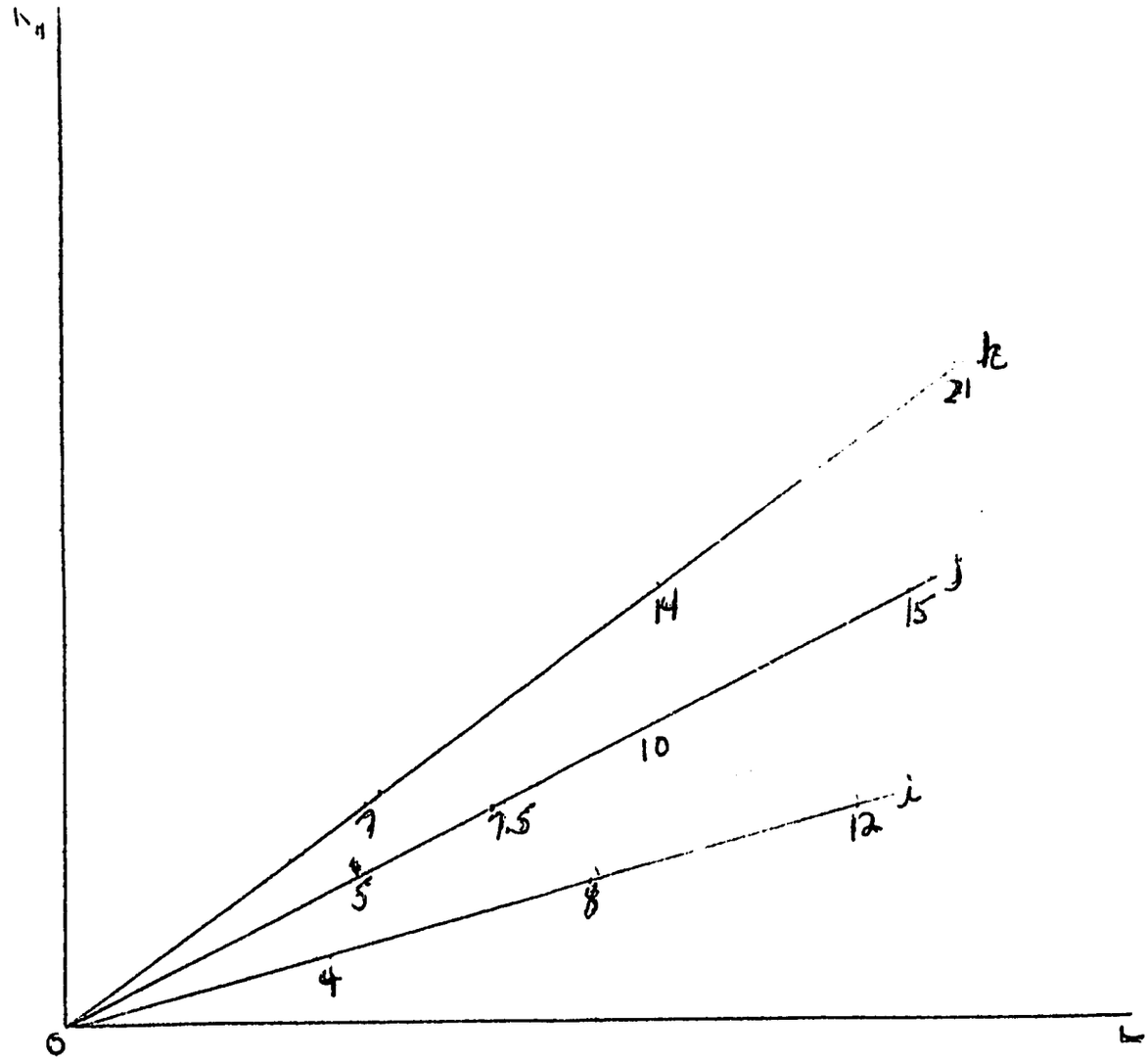
[1]The choice of specific numbers assigned to individual isoquants in Figure 3 is purely arbitrary, and is merely intended to reflect the spirit of our assumptions. Obviously, the actual numbers will depend on the particular industry considered and its technological opportunities.

[2]This aggregation procedure can be justified theoretically by reference to the Hicks-Leontief theorem on composite goods. Since the relative price of the heterogeneous capital goods is set by the fixed relationship between the productivity of capital of different vintages, one can treat "capital" as a cost concept just as one treats "all other goods" as income in the theory of consumer behavior. In effect each vintage must be treated as a different factor of production so that inputs consist of all equipment of all vintages plus labor. But, this does not preclude us, as demonstrated below, from uniquely determining optimal vintages when the price of labor is given. Furthermore, from a strictly practical viewpoint, the fact that this equipment is imported from the large industrial countries means that relative equipment prices are set in the international market and are unaffected by shifts in the domestic economy.


K
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L

Let us now consider how a typical firm might go about choosing some various vintages in order to implement desired increases in output. Suppose we have a firm producing 4 units of output with relatively labor intensive equipment of vintage i as represented by point g in Figure 4. It is anticipated that demand will increase to 12 units. The question therefore arises as to how best to achieve this desired output level. The answer is ultimately related to the choice among alternative vintages.

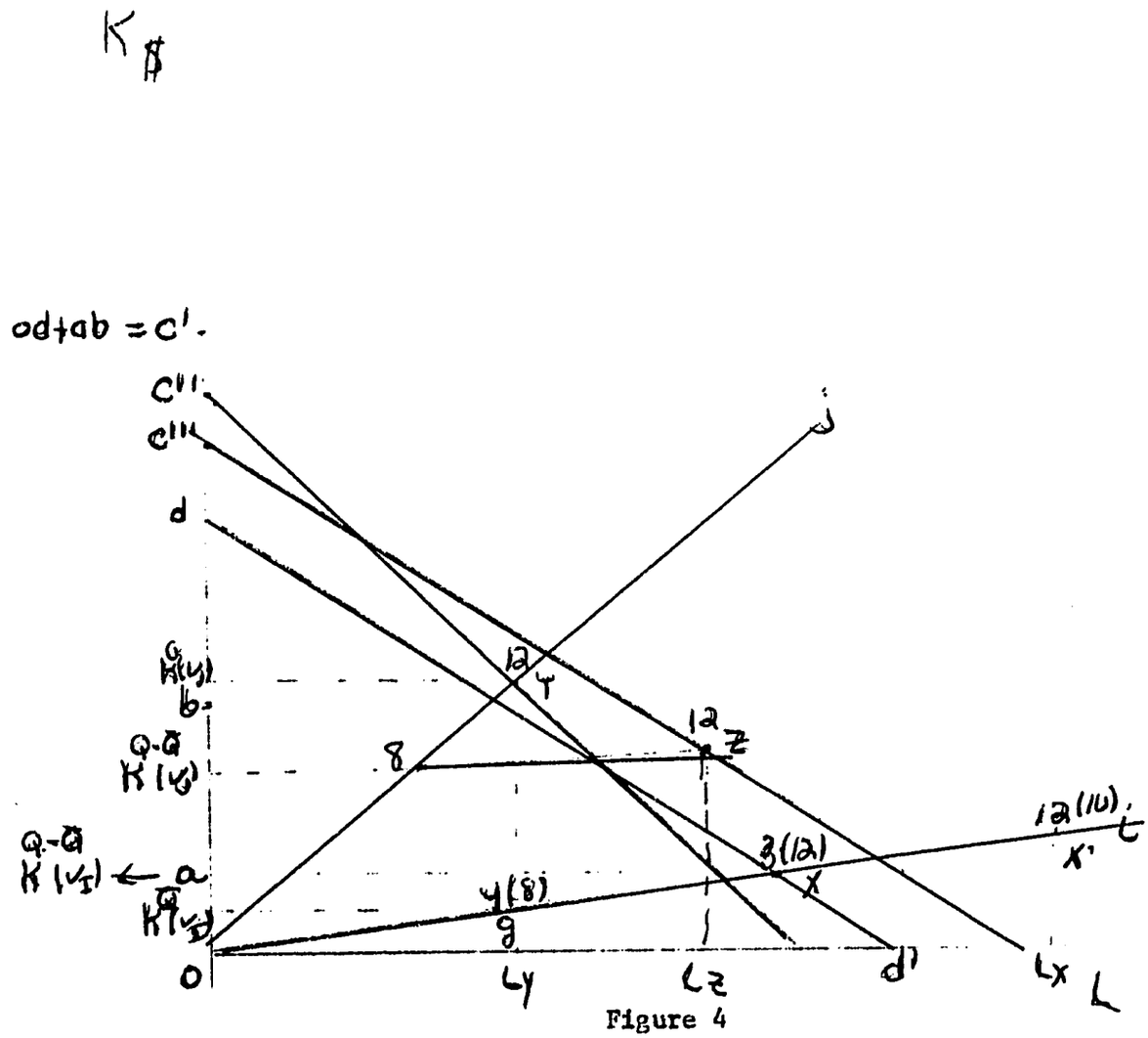

Figure 4

The criterion for choosing the optimal vintage or combination of vintages would be provided by the simple rule of cost minimization for the desired level of output. The relevant costs that must be considered, however, depend on the nature of the vintages chosen. Assuming that the cost of existing capital is a foregone alternative, this cost calculation would dictate choosing the minimum among the following alternatives.

a) The additional cost (both labor and capital) of meeting the new output requirement by purchasing more of the same vintage equipment plus the labor cost associated with the continued use of the existing equipment. Symbolically:

$$\begin{aligned} C' &= K_{\$}^{Q-\bar{Q}}(v_i) + \Delta L_i W_i + \bar{L} \cdot W_i \\ &= K_{\$}^{Q-\bar{Q}}(v_i) + \frac{1}{\lambda(v_i)} \cdot (Q - \bar{Q})W_i + \frac{1}{\lambda(v_i)} \cdot \bar{Q} \cdot W_i \\ &= K_{\$}^{Q-\bar{Q}}(v_i) + \frac{1}{\lambda(v_i)} \cdot Q \cdot W_i \qquad (1) \end{aligned}$$

where Q is desired output, $\bar{Q}$ is initial output, $K_{\$}^{Q-\bar{Q}}(v_i)$ is investment cost of vintage i equipment, W_i is the wage per worker when only vintage i equipment is used.

b) The total cost of producing the entire output with a completely new vintage, allowing the existing equipment to fall into disuse. This can be expressed by

$$C'' = K_{\$}^{Q}(v_j) + \frac{1}{\lambda(v_j)} \cdot Q \cdot W_j \qquad (2)$$

where $W_j > W_i$.[1]

[1]The wage rate paid by the firm using the more modern vintage alone is likely to be greater than that paid when only the older vintage is used, due to the higher profitability of producing with the newer equipment. We shall have further comment on differential wage structures later in the paper.

c) The additional cost of producing the required output with a combination of both vintages e.g., by purchasing some of the new vintage and using it with the existing equipment.

$$C''' = K_{\$}^{Q-\bar{Q}}(v_j) + [\frac{1}{\lambda(v_i)}(\bar{Q}) + \frac{1}{\lambda(v_j)}(Q - \bar{Q})]W_i \qquad (3)$$

Returning to Figure 4 recall that the firm is initially producing 4 units of output at point g and must decide how best to produce the additional units. Its choice possibilities consist of producing at point X, i.e. purchasing additional vintage i equipment sufficient to produce 8 more units of output;[1] point Y representing production only with an entirely new stock of vintage j equipment; and point Z which utilizes the existing vintage i equipment to produce 4 units of output and purchasing enough vintage j equipment to produce the remaining 8 units.

The cost corresponding to choice X is represented by point C' on the vertical axis. This total is arrived at as follows: with dollars measured on the vertical axis and W_i the initial wage rate, the slope of line dd' reflects this initial wage rate W_i. The total cost associated with producing 8 units of output using vintage i capital is od or in terms of the cost equation, $K_{\$}^{Q-\bar{Q}}(v_i) + \frac{Q - \bar{Q}}{\lambda(v_i)} W_i$. To this it is necessary to add the cost of labor utilized on the already existing capital, viz., $\frac{\bar{Q}}{\lambda(v_i)} W_i$ which can be shown to equal ab(=bd). Adding ab to od yields oC'. Similarly, the cost corresponding to choices Y and Z are equal to C'' and C''', noting that the wage rate associated with choice Y is $W_j > W_i$ and the wage associated

[1] The numbers in parentheses along process i represent total output achievable with the additional vintage i equipment recognizing that there already exists equipment sufficient to produce 4 units of output.

with choice Z is once again W_i (the average labor productivity on vintage i capital). Note, finally, that when choice Y is made the associated cost of <u>utilized</u> capital equipment, $K_{\$}^{Q}(v_j)$, is <u>less</u> than the total value of existing capital $K_{\$}^{Q}(v_j) + K_{\$}^{\bar{Q}}(v_i)$ due to the scrapping of vintage i equipment.[1]

The above analysis illustrates the rationality of modernization from the individual firms' point of view in the developing countries. Basically there are three reasons for this phenomenon, only the first of which is really reflected in Figure 4. First, the greater factor productivity of the more modern equipment offsets the relatively higher capital costs and wage rates to such an extent that unit factor costs of output, the relevant desideratum, are lower with this more modern vintage. Second, the above analysis did not allow for the inevitable physical depreciation of the existing equipment. Recognition of such depreciation would have the effect of requiring replacement so that the actual parenthesized numbers in Figure 4 would be somewhat lower than those shown. This would strengthen the tendency to choose the more modern vintage by increasing C'. Finally, from a practical point of view even if the cost criterion were to indicate further investment in vintage i equipment, it might well be that either the machinery itself and/or spare parts would no longer be available from the advanced countries which had since changed to the production of newer vintages.[2]

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[1] One implication of this statement is the strong possibility of existence of idle but potentially physically productive equipment in the larger firms. The phenomenon of excess capacity at the firm level in capital scarce economies has often been noted. We believe that the vintage approach provides an economic rationale for explaining this apparent paradox although part of the explanation also lies in market and structural imperfections.

[2] See Footnote 1, pp. 23 below.

Consider now the employment implications of the growth process depicted in Figure 4. Corresponding to each choice, X. Y. Z is a level of employment L_X, L_Y, L_Z on the horizontal axis.[1] It is immediately evident that the choice of more modern equipment involves a smaller increment of labor for the same additional output than that associated with further investment in older, more labor intensive equipment. Consequently, there is a conflict for the individual firm (and industry) between the dictates of cost minimization and the social criterion of labor absorption. It is fairly safe to assume that when such a conflict arises, private profit maximization will prevail.

Extending the analysis of Figure 4 to a longer run consideration of the growth process might lead to a relationship between output, optimal vintage choice, and employment as depicted in Figure 5. A hypothetical expansion path generated by the choice process just outlined is abcde. The corresponding employment path is shown in Figure 5b. As more modern vintages are adopted, it can be seen that the divergence between efficient employment levels from the firm's point of view and that which would have occurred had expansion occurred with the more labor intensive vintages (e.g., compare c' and s) becomes increasingly large. In effect, this implies a decreasing marginal employment-output ratio. It will be noted, of course, that the average productivity of employed labor is constantly increasing over time.

[1] L_X is not vertically aligned with point X, but with point X', which shows the total labor requirements of 12 units being produced only with vintage i equipment.

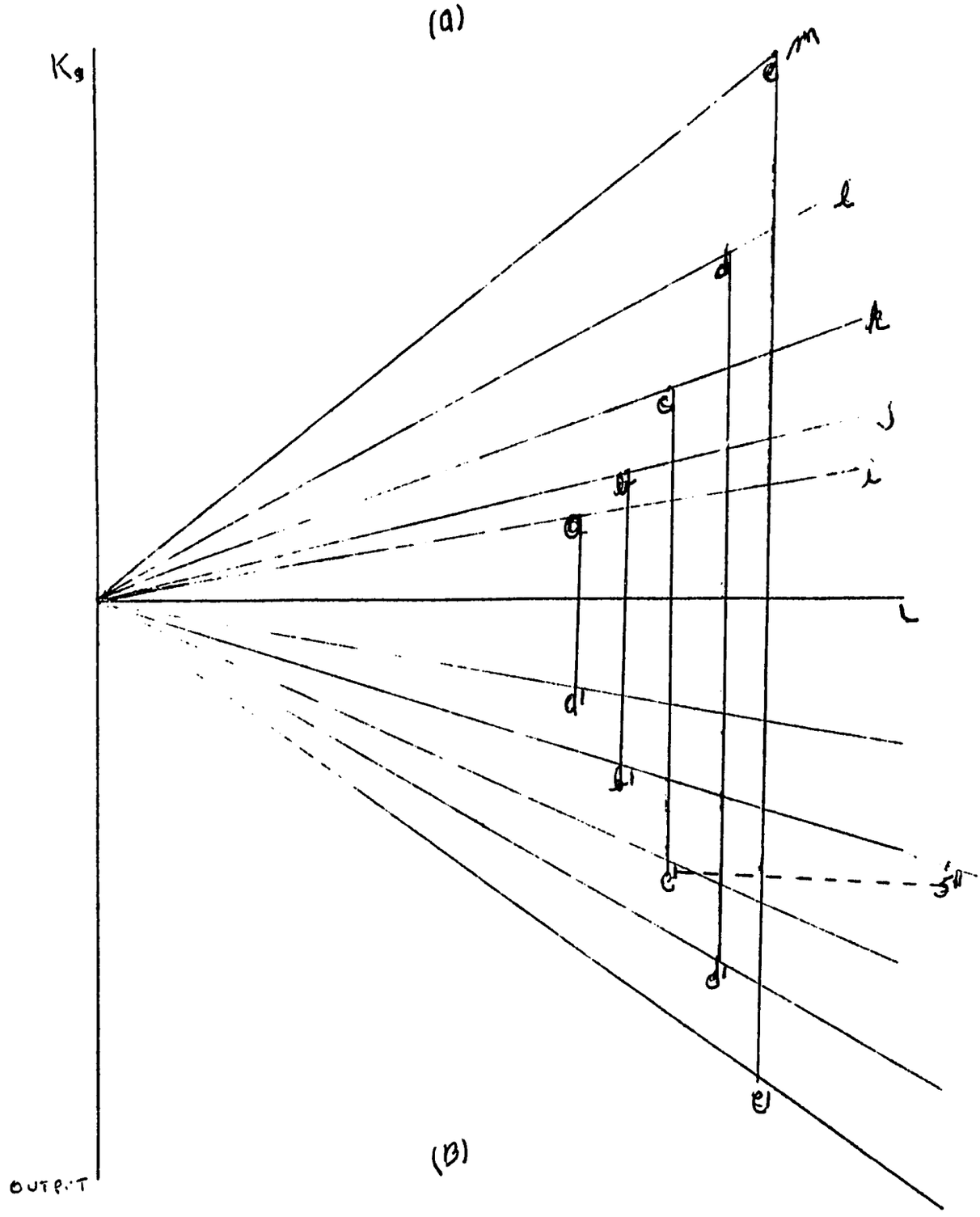

Figure 5

One of the more interesting empirical implications of the above analysis is that one might expect that those industries whose output has grown most rapidly are also the ones which have modernized most rapidly, i.e., they have been able to take advantage of the newer vintages. Such a phenomenon would imply, as pointed out above, that the differential between the growth rate of output and that of employment would be positively correlated with the former. Alternatively the faster growing industries would exhibit greater rates of productivity growth. A recent cross-section study by the U.N. of industry in the developing countries found that

> "...in each case [i.e. for each industry] the expected rate of increase in labor productivity rose as the pace of expansion in output grew."[1]

Furthermore, for heavy manufacturing industries alone it was found that

> "...the ratios of the coupled increases in labor productivity and output were higher for the developing countries than the industrialized countries up to rapid rates in expansion in output probably because a portion of the expansion was supplied by constructing new plants."[2]

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[1] U.N. The Growth of World Industry - 1938-61. International Analyses and Tables, p. 98. For example, when the average annual rates of change in labor productivity, (Y), were regressed on average annual rates of change in production (X), the following equations were estimated for the given industries. (p. 96).

Chemicals	$(1 + \frac{Y}{100}) = .992\ (1 + \frac{X}{100})^{.651}$	$r = .69$
Basic Metals	$(1 + \frac{Y}{100}) = 1.02\ (1 + \frac{X}{100})^{.471}$	$r = .82$
Metal Products	$(1 + \frac{Y}{100}) = .987\ (1 + \frac{X}{100})^{.644}$	$r = .79$
Textiles	$(1 + \frac{Y}{100}) = 1.00\ (1 + \frac{X}{100})^{.583}$	$r = .76$

[2] U.N., op. cit., p. 89.

These statements would seem to lend support to the hypothesis of a relatively large output employment lag arising from rapid increases in labor productivity in the LDC's. These productivity increases are, in turn, attributable to the ability of certain industries in these countries to modernize their capital stocks rapidly and to take advantage of what Gerschenkron has called the benefits of relative backwardness.

Finally, let us consider once again the wage implications of the vintage model. It is an often noted phenomenon that large firms pay higher wages than smaller firms within the same industry. This is alleged to be the result of the ability of unions to negitiate high wage settlements or government pressures to pay high wages which are mainly directed at larger firms. The existence of such a differential wage structure is cited, therefore, as an inhibiting influence on employment growth. However, the apparent willingness of large firms to pay higher wages is also consistent with the implications of our vintage model. Since larger firms can be expected to utilize capital of more modern vintage, and since the wage rate which profit maximizing firms would be willing to pay is directly related to the profitability of the vintage in use, it follows that larger firms would be willing to pay higher wages than smaller firms.[1] Consequently, the observed higher wages are not necessarily the cause of the employment problem but the result of the technological properties of the vintage model. Therefore proposed measures to eliminate wage differentials by removing union and government pressures would seem to result

[1]In short, the willingness of large firms to accede to union pressure is attributable to the higher average (and marginal) productivity of the workers whom they employ on their more modern vintage equipment.

merely in an increase in quasi rents on the existing vintages, and not in an increase in job opportunities.

A similar analysis would seem to apply to proposed wage subsidy schemes. Even if it were possible to induce the usage of more labor intensive equipment, the increase in employment could only be marginal as the existing modern vintages are not likely to be scrapped in favor of older equipment as a result of wage reductions. Recalling our earlier discussion of the possibility of "Giffenocity" of labor when a financial constraint exists, it is to be noted that this analysis was based on the explicit (but not implicit) assumption of homogeneous capital and, therefore, overlooked the question of scrapping and permitted instantaneous adjustments in factor utilization (as, indeed, do almost all of the discussions relating to choice of optimal factor intensities in developing countries). Consequently, the possibility of an absolute employment decline as the result of a wage reduction depended in sense on all output being produced with the newest vintage. However, in terms of the marginal versus total cost criterion for optimal vintage choice described earlier, we see that there is no a priori reason why older equipment will be immediately scrapped even though there is reason to believe that it will be replaced by more modern equipment over time. Thus the extreme case of a perverse relationship between wages and employment will not necessarily occur. Furthermore, as output expands and/or the budget line shifts out, employment would be expected to show some increase. The net result is ~~that~~ the aforementioned slow growth of employment, but at a much lower rate than most advocates of wage reductions would envision.

V. Some Implications for Domestic Capital Goods Production

Given the resource endowment common to less developed countries, viz., abundant labor supplies, the industrialization process outlined above, which we believe is a close representation of the one which actually occurs, has disconcerting implications not only for the future of employment generation but also the implied loss in output resulting from wasted resources which are potentially productive. Moreover, even if it were deemed desirable to follow this process, its feasibility depends upon the continuous importation of capital goods and therefore the ability to obtain sufficient foreign exchagne through export expansion and/or foreign aid. However, both the well-known uncertainties arising from fluctuations in foreign markets and the apparent decline in the availability of foreign assistance often severely interrupt planned programs of industrialization through import substitution.[1]

An alternative procedure is the encouragement of a domestic machine-producing industry which is capable of producing efficient, labor intensive techniques for other branches. Let us state explicitly that this is not proposed as a solution to the employment problem at the cost of decreasing the rate of growth of output. Rather, it is proposed on the assumption that both output and employment growth can be accelerated.

A technology designed in the LDC's could, by developing and producing efficient labor intensive techniques, increase the total output to be obtained from a given amount of investment, by improving the average productivity of all workers as well as that of capital with the more labor intensive techniques.[2] In terms of our diagramatic framework, production of such machinery could be interpreted as an increase in the output associated with each factor combination along the more labor intensive rays so that there is less incentive to

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[1] Sheahan, op. cit.

[2] See, in this context, the excellent paper by A.B. Atkinson and J.E. Stiglitz, "A New View of Technological Change," forthcoming, especially section II.

switch to the more capital intensive processes.[1]

In short, the creation of a domestic capital equipment industry with labor using designs could reconcile the existing conflict between the dictates of private cost minimization and the social objective of output growth with significant labor absorption. The establishment of this industry could thus provide both static income gains by producing the means for efficiently utilizing previously idle labor as well as significant dynamic benefits by minimizing the interruptions in the execution of development plans. Finally, another potential dynamic gain is provided by external economies or as Rosenberg has expressed it, the "technological convergence" of processes arising out of the development of machine tools which can be utilized at various stages of production in seemingly unrelated industries.[2]

Although the establishment of a machine-producing sector has always been recognized as an abstract policy alternative, it has received little attention in the LDC as it is assumed that the machine tool industry is

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[1]Although there is evidence from both Japan and India suggesting that efficient labor intensive techniques can be designed, the argument is strengthened by the recognition that most of the desirable labor intensive vintages which advanced countries may have used in the past are no longer available. For example, H. Singer in International Development, Growth and Change (New York: McGraw Hill, 1964), p. 59, observes that

> "...the technology of a hundred years ago would be desirable for them [the LDC] and would make their economic development easier but that technology no longer exists. It has been scrapped and rightly scrapped in the developed countries."

Thus there would seem to be direct benefits merely from reproducing this discarded technology in addition to developing more efficient labor using techniques.

[2]Nathan Rosenberg, "Technological Change in the Machine Tool Industry, 1840-1910," Journal of Economic History, December 1963, pp. 414-443.

capital intensive, and therefore implies a comparative disadvantage in production. However, this position overlooks several important dimensions of the problem. First, the high capital intensity of the branch is supposedly based upon the fact that the industry requires substantial amount of metal products including steel. While these are undoubtedly capital intensive, it does not mean the machine tool branch is itself capital intensive, only that its total capital input (direct and indirect) is high. Thus, if steel can be imported the sector is labor intensive, particularly skill intensive.[1] In Israel, for example, the direct capital coefficient in the machinery branch is among the lowest of all branches of manufactuting.

Even though the requisite skills may not be currently available in some of the LDC, training, which may be viewed as a form of investment, could easily be introduced as the absolute number of workers in this branch is relatively small. Clearly, the establishment of this industry might imply some initial inefficiency and higher costs of machinery. However, this cost differential is likely to be transitory assuming that learning occurs as the absolute cost of skilled labor in the LDC, the single most important input, is much lower than in the Western European countries.

Another feature of the branch is the lack of large scale production for stock. Most orders are on an individual basis and thus there are no economies of scale as such. However, as Rosenberg has pointed out there may be "economies of specialization" e.g., if firms only produce particular machines, say, for the cotton industry. While each machine may differ, the repetition involved in producing only minor variants may provide cost savings. However, unless the market is large it may not be able to support such special-

[1] See, e.g. M. Bruno, Interdependence, Resource Use and Structural Change in Israel, Bank of Israel, 1962.

ization. Thus, in certain situations, our argument is perhaps best understood in terms of regional markets like that of, say, East Africa.

In the final analysis, however, the ultimate reason for establishing the branch is the possibility of producing equipment appropriate for domestic resource endowments. If the branch succeeds in generating a labor using technology, then the average productivity of both labor and capital will rise and the absorption of previously idle or under-utilized manpower will be in the private as well as social interest.