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Employment and Productivity in Kenyan Manufacturing

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ABSTRACT

This paper reports the results of an extensive set of interviews with Kenyan Manufacturers. The question to which these interviews were addressed is the possibility of absorbing larger numbers of workers in the manufacturing sector. A number of rather surprising patterns appeared. First, existing manufacturing enterprises are relatively labour intensive; rarely do they exhibit the mechanization levels of the developed countries. Second, productivity of labour has risen rapidly not as a result of increasing levels of capital per worker but as the outcome of reorganization, simple innovations and increasing utilization of capacity. These findings suggest that at least in the near future, say five to ten years, though manufacturing employment may grow, it will certainly grow more slowly than output.

Introduction

A common phenomenon observed in developing countries is the the failure of manufacturing employment to grow rapidly enough to help in any substantial way in the absorption of members of the growing urban labor force.[1] The failure of employment to grow faster is usually attributed to growing capital intensity, assumed to be induced by a growing ratio of wage to capital costs. Such assertions are backed by only limited direct empirical evidence as capital stock estimates are rarely available. Usually indirect evidence is used, particularly wage data, and competitive assumptions are invoked to justify estimation procedures which lead to the conclusion that capital deepening is the major cause of lower employment absorption than would have been possible had there been no increase in the capital-labor ratio. While this interpretation may be correct, it requires a strong leap of faith to base policy upon it, given the absence of any substantial body of microeconomic evidence on the subject.

To acquire such corroborating evidence I undertook a series of intensive interviews among Kenyan manufacturing firms. To my surprise these interviews suggest that, at least in this economy, many widely accepted views of the output-employment relation miss the mark in a number of important dimensions.

The plants visited are quite labor intensive. For the most part these factories use rather simple technologies and it is quite easy to observe activities in which more capital intensive methods could be used. Moreover, there is enough factory to factory variation to permit the observation of slightly more mechanized processes in some and older methods in others.

The labor intensiveness of production may be demonstrated in a number of ways. First, we use data on individual firms from a number of countries provided in a recent set of U.N. publications.[2] Information on these firms for 1964 include estimates of output, labor inputs, capital (at estimated replacement cost), number of shifts and so on. I have analysed this data in considerable detail elsewhere;[3] for the purposes of this paper two simple comparisons are useful. Among the branches of manufacturing analyzed in Kenya for which considerable U.N. profile data are available are paint production and cotton spinning. Tables 1 and 2 present data for Indian , Japanese and Israeli plants in the two industries.[4]

Table I

Equipment-labor Ratios in Paint Production

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

Sources: For countries other than Kenya, UNIDO, Profiles of Manufacturing Establishments, Volumes I and II. For Kenya, personal interviews.

Table II

Equipment-Labor Ratios in Cotton Textiles

	U.S. Dollars (1971)
India - Plant 1	2072
India - Plant 2	1484
India - Plant 3	2212
India - Plant 4	1722
India - Plant 5	6120
Israel	8318
Kenya (average of several plants)	2044

Sources: Same as Table I.

In both industries, capital-labor ratios have been adjusted to correct for differences in the number of shifts since two plants with the same capital stock will have different effective capital-labor ratios if one is used on a three shift basis and the other on a one shift schedule. In paint production, the Kenyan plants are considerably less capital intensive than the Israeli and the capital intensive Indian plant. On the other hand, even more labor intensive methods seem to be available as indicated by two of the Indian plants and the Japanese plant.[5] In textiles, the capital-labor ratios of the Kenyan plants rank toward the middle of the Indian spectrum, but considerably below both the highly capital intensive Indian plant (number 5) and the Israeli plant.

A comparison may also be made with a recent analysis of the costs of establishing integrated cotton textile plants by the Economic Commission for Latin America.[6] The capital-labor ratios for a 1950, 1960, and 1965 technology were estimated. The capital estimates include plant and equipment and working capital, and the capital-labor ratios were $6700, $12,700 and $20,700 respectively. Assuming half of these amounts are non-equipment costs, the estimates suggest that current equipment-labor ratios in Kenya are below those viewed as best practice in 1950.

Thus, comparative data on capital intensity indicate that Kenyan production is relatively labor intensive--on a par with many Indian plants, though the latter face lower wage rates. Comparisons in other industries lead to similar conclusions.

Apart from cost data it is possible to examine suggested methods of production in engineering textbooks.[7] The current descriptions in such books of desirable production techniques are of interest chiefly for their complete absence from most Kenyan plants.

Section I below describes some salient aspects of the observed production processes at some length. The industries described cover a considerable range within the manufacturing sector including *inter alia* all branches of food processing, paints, shoe polish, soap, shoe production, cement production, textiles, metal and plastic containers and home toiletries. In total, 42 plants were visited, all of which had more than 50 employees. Firms of this size accounted for 82 percent of manufacturing value added in 1967 and the industries represented in my sample did not differ greatly from the overall pattern. Most of the following is applicable to all branches: exceptions will be noted explicitly. Section II suggests some generalizations on the evolution of labor productivity based on the evidence of Section I. In Section III the implications of the existence of widespread excess capacity are considered. Section IV discusses a number of other issues related to factor substitution.

I CURRENT PRODUCTION METHODS - Processing by Stage

All plants can be characterized by five basic processes: material receiving, material processing, (primary processing) material handling among processes, packaging, and storage of the finished product.[8] Considerable emphasis in the literature has usually been placed upon the possibilities of substitution in the actual processing operation. However, in most plants a relatively small percentage of the labor force is involved in this operation. Thus, in a large fruit processing plant employing over one hundred workers, the actual processing of jam or the oooking of other fruits is done in a vat into which three workers pour ingredients which have been mixed by hand. A more advanced process would involve automatic weighing of the ingredients and filling of the vat. Nevertheless, the three represent a small fraction of the total force and if they were replaced by automatic vat filling equipment requiring one person, total plant employment would decline by only two workers. The same feature holds in almost every industry considered except pineapple canning, textiles, and shoe production: in the latter two branches over three quarters of the labor force was engaged in the primary operation. Thus, most employment occurs in the auxiliary activities and it is there that the potential payoff to substitution of labor for capital is of the greatest significance.

More generally, where the primary production operation involves mixing and/or heating (e.g. paints, much of food processing, soap, shoe polish), the direct labor force involved in such operations is usually less than 30 percent of all production workers. In this stage of production, economically rational substitution of labor for capital appears to be limited. Where precise heat or chemical composition is of importance, reversion to older methods of human, rather than automatic control, is likely to reduce quality and uniformity, while adding only a small number of workers to the labor force. For example, a soap factory which recently introduced such equipment to insure better quality control experienced a decline of only two workers out of a total labor force of 60.[9] Most recent machine improvements are either of the quality control type or permit higher speed operations with machines of the same basic design (and similar cost) as older ones. Such improvements lower the capital-output (and labor-output) ratio but typically leave the capital-labor ratio about the same. This, of course may not be true of major innovations which permit fewer workers to mind a larger number of machines, as has been true in recent textile machinery innovation. But in most of the industries considered here the basic production process has been in use for a quite long period, and as just stated, most of the improvements are in speed and quality control.

None of this is meant to convey the image that existing Kenyan plants use only the most modern primary processesing equipment. Almost all plants, even those set up during the last five years, purchased at least some used equipment when production began and, in general almost all of the direct processing equipment was used. Moreover, even when purchasing new equipment, many firms purchase older, slower models where these are available. Nevertheless, such equipment uses only slightly more labor than the more modern equipment.[10] Thus, in primary production processes there are relatively limited substitution possibilities.

There were some interesting exceptions to the general rule of a lack of substitution possibilities in primary operations. One of the soap manufacturers, for example, used a detergent process which is completely different from the conventional one. Instead of soap "noodles" (the solid, wet soap which is produced by mixing) being dried in large metal towers by gusts of hot air, the alternative process utilizes a simple bin drying procedure. The equipment is a third as costly as spray drying. However, only three additional workers (out of a plant labor force of 0) are required as a result of the difference in process. Other cases of substitution can also be cited. For example, another soap factory used an old railroad, wood fueled, steam engine to obtain heat for the mixing of basic materials. This added two jobs in the plant for wood cutters.[11] Perhaps the most startling exception occurred in a factory manufacturing plastic containers in which six men we assigned to manually insert the of plastic caps. Although a machine exists for this operation, it is very fast and suitable for only a limited range of sizes. In the absence of large production runs for a given size, installation of such equipment was not calculated to be economically efficient.

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

Paint and soap production yield other examples of the lack of mechanization even in receiving. Whereas in the U.K., ingredients are delivered directly into storage drums and are then pumped through pipes automatically when paint is to be mixed, in Kenyan plants drums are unloaded by hand and kept in the factory, to be carried to mixers as needed. One plant is about to introduce automatic handling equipment but it is an anomaly among Kenyan firms. In general, then, receiving is a quite labor intensive process in most plants, exceptions occurring because of quality control requirements.

In intrafactory material movement among primary machines, there is little further scope for increasing labor intensity. Although we expected to find considerable reliance on the use of conveyors, there were only a few in use. Even quite heavy jobs where automatic methods might be profitable (if batches were large) are done manually. For example, after paint ingredients are weighed, they have to be raised to a platform from which they are emptied into a mixer. In all plants except one this was done by hand, two men carrying the drum rather than using either an electric hoist or, as is done in advanced processes in western countries, piping the ingredients to the platform. To take another example, in a medium size (30 employee) meat processing plant, after meat has been trimmed and sliced, it is typically put into bins which are then moved by hand to the next processing stage, rather than sent along a conveyor.

Filling operations generate major amounts of employment in many of the plants visited. Rather than automatic filling operations which are conjured up by statistics of productivity growth, one finds relatively primitive operations. It was by no means uncommon to find something like the following sequence. After a product is processed it is brought by hand to the filling area and hand ladled or tipped into a filling machine. The machine is then operated by a foot lever - at the press of a foot some of the flour or other product is dropped into a bag held by the operator, who in turn puts it on a table from which the next worker takes it. The second worker weighs the package and if the weight is not correct, uses a spoon to obtain the correct amount. The package is then given to a sealer who closes it with a simple device, e.g., a stapler. Variants of such simple packaging procedures are common. In a number of paint plants the mixed paint was poured into cans by tipping the vat and using a funnel. In pineapple plants, crushed pineapple is hand filled into cans. In toothpaste production, though some semi-automatic filling is utilized, much of the operation, such as putting the cans on then putting tubes into cartons, is still done by hand using a considerable amount of labor. This operation was mechanized over 20 years ago in western factories. Labor intensive methods also extended to labelling, which in most plants follows the filling activity. For the most part labels are attached by hand though automatic labelling is the rule in equivalent western plants.

It was true, however, that every manager interviewed suggested that automatic filling (and labelling) was one of the easiest operations to introduce. The reason for the failure to do so was that typically output levels were so small that such equipment, given its productivity, would lie idle much of the time. Reinforcing this was the fact that many products are produced in small batches and require different container sizes while most automatic machines have limited size flexibility. Thus, one machine might be needed for each size, but given the small total output, its purchase would be uneconomic. At considerably higher output levels, estimated between three and ten times current levels, it was argued that automatic filling machines would be profitable to introduce regardless of the level of wages. In plants where filling is the major operation (e.g. carbonated beverages) and relatively long production runs of a limited number of items are typical, automated filling is the rule, though there is adaptation, e.g., stacking of bottles into cartons being done by hand, though this has long been automated in western countries.

Though there was almost universal agreement about the economic irrationality of automatic filling machines at low volumes, there was similar unanimity about its desirability at high volumes. All realistic calculations of the combined labor and capital cost per unit of output indicated that, regardless of wage rates, the speed and labor saving nature of such machines warranted their adoption.

Not only are the unit cost levels lower for more capital intensive processes, but increasing returns characterize these processes. Thus filling machines with 16 heads cost only 50 percent more than those with eight heads. Even in some cases in which volume is less than these critical levels, automation may still be warranted since hand operations require much more floor space than automated processes of equivalent capacity. This suggests substitution between labor and buildings (and land) may become important at increased volume; indeed, the constraint of factory floor space was repeatedly cited as a strong incentive to adopt automated devices in activities other than filling. Interestingly, this phenomenon was much less pronounced in areas outside of Nairobi where both land acquisition and construction costs are lower. In these areas a number of plants have in fact duplicated existing production lines rather than automate.

Finally, consider the storage process. The conventional expectation is one of fork lift trucks being used to stack the final product in warehouses. However, in only 10 percent of the plants was such a device used and in most of these it was due to the heavy weight of drums,[12] or, more rarely, to a desire to increase the height of vertical storage, thus postponing the need to acquire further warehouse space. Though vertical stacking using hand methods is possible, where platforms are required hand methods become self defeating given the need for additional space. Again this suggests the possibility of a building (space)-labor tradeoff.

It is instructive to consider a numerical illustration of some of the preceding observations. A not atypical example of the economic rationality of continuing to use labor intensive peripheral processes is provided by the operation of stacking toothpaste tubes into cartons. Although the following data apply to one operation within one firm, other examples yield similar results. At present stacking is done by three men who take filled tubes from a table at the end of the semi-automatic filling machine and manually put them into cartons. An available machine could replace two of the men and the remaining man and machine would be three times as productive per shift as the three men. The price of a used machine of this type is Ŀ 2500 and that of a new one Ŀ 4000. The production characteristics of the two are the same and the expected life with either is at least 10 years, the firms current planning horizon. Differential maintenance costs are viewed as a minor consideration. Thus the relevant question for the firm is the choice between the current, completely manual operation and the adoption of the used machine. The company opted for the manual operation and the correctness of its choice can be demonstrated. The relevant data are shown in Table III.

Table III

Cost of Production (shillings)

	Capital cost per annum*	Labor cost per annum	Total Cost	Unit Cost $Q_k = Q_m$	Unit Cost $Q_k = 3Q_m$
Used equipment	9960	3960	13920	1.3920	.4640
Manual process	0	10080	10080	1.0080	1.0080

*Derived from the annuity formula $Z = \frac{A}{d}[1 - (\frac{1}{1+d})^n]$ where Z is the purchase price, n the expected life, d the discount rate and A the annual cost.

A 10 year life and a 15 percent cost of capital are assumed. The average monthly wage of these workers is 330 shillings and there are no skill differentials as the machine could be operated with very small training costs by one of the three workers currently employed. Labor costs on the manual operation are assumed to vary directly with output though in reality there are likely to be some discontinuities in hiring. To compare unit costs we set potential one shift output with the labor intensive process (Q_m) equal to 10,000 and express one shift output with used equipment (Q_k) as a multiple. When $Q_k = Q_m$ the former process is more expensive while at full utilization of its potential ($Q_k = 30Q_m$ unit costs are .43 of the manual process. If wages were to remain constant then the output level at which unit costs are equal is $1.38Q_m$ (1.392/1.008) i.e., at an output level 38 percent greater than that producible by full utilization of the hand process. Under these conditions it is rational to delay introduction of equipment until the required volume is approached. However, this calculation disregards one factor which is likely to affect the investment decision, namely, that the current one shift stacking output could be increased by 25 percent if greater demand existed. This implies that the equal unit cost volume ratio of 1.38 represents a 72 percent increase above current output assuming that labor input on the manual operation increases in proportion to output. At an optimistic growth rate of physical output of 8 percent per annum, the introduction of equipment of current specification and cost would not be justified for another nine years. The emphasis on quantity and the higher productivity of machine processes thus seems warranted. Moreover, this is an industry in which output per capita is, by Kenyan standards, quite high as toothpaste is one of the earliest "modern" commodities to enter consumption baskets.

The preceding calculations ignore the role of wage growth. If it is assumed that wages grow at their historical rate of 6 percent per annum, the unit costs of the two processes will become equal during the fifth year. On the other hand, to the extent that disembodied productivity growth is possible, then still further postponement of the equipment process will occur. It will be suggested below that such productivity growth is more likely to be derived if labor intensive techniques are chosen.

Thus the stacking activity which is typical of many non-primary activities allows a considerable range of production method, at least at low volume. High wage levels would weaken such choice as does exist, e.g. at current volume an increase of 63 percent in wages would make unit costs identical for the two processes. However, the magnitude of this increase confirms the relative insensitivity of many peripheral operations to wage growth at current output levels. On the other hand even at the volume of full utilization of equipment, i.e., ($Q_K = 3Q_m$) almost four times current volume, the manual operation would yield the same unit cost if the wage were 110 shillings, about one-third the current wage, but arguably the shadow price of labor to the urban sector.[12b]

In contrast to peripheral operations, primary ones are less likely to afford efficient substitution possibilities. A dramatic example can be found in a juice extraction process. The data for a current operation using manually controlled extractors and a semi-automatic substitute are given in Table IV. The semi-automatic operation is capable of 5 times as much output per shift, though employing 3 workers rather than 20. The discount rate and the investment horizon are again 15 percent and 10 years respectively.

Table IV

Cost of Production (c)

	Capital Cost per annum	Labor Cost per annum	Total Cost
Semi-automatic Process	797	504	$1301/Q_K$ for $Q_K \leq 50_m$
Current	60	3360	$3420/Q_m$

Even at the one shift output of the manual process, the unit cost of the capital intensive process is only 38 percent of that on the labor intensive one. At capacity of the semi-automatic process, its unit cost is only 7.5 percent of the manual process. In fact, the wage at which the labor intensive process would yield equal unit cost even at current output levels is 4 shillings per month. Though choice exists in the sense that less labor per unit of output requires more capital per unit of output, the lower productivity of the labor intensive process is such that its adoption cannot be rationalized.[12c]

II The Employment-Output Relation

The above material raises two general questions in analyzing the relationship between employment and output growth. First, what are the factors which influence the initial choice of technique? Second, once this is chosen, what are the implications for future employment growth?

From the descriptive material of Section I it should be clear that there appears to be considerable ex-ante choice of capital intensity in most manufacturing branches. The major scope for substituting labor for capital is in peripheral activities and these account for a major part of the work force in most plants. Nevertheless, it is important to remember that efficient substitution is possible, even in peripheral activities, only at low volumes (relative to those in the developed nations). As most LDCs seem to be characterized by low volume because of both limited domestic markets and substantial internal transportation costs in the case of larger countries, it seems safe to ignore the dilemmas which will eventually be introduced as volume grows. For most countries, the decisions over the next decade are unlikely to be influenced by large volume production.

The cost of labor was undoubtedly a major factor determining the initial technique in peripheral operations. While it is difficult to derive precise answers to the questions of the critical wage level which would have induced more automated operations, most plant managers estimated that only a doubling or tripling of the actual wage would have motivated consideration of faster or more mechanized operations. The implied arc elasticity of substitution in the peripheral process is thus a bit strange. A doubling or tripling of the wage-rental ratio would have no impact and a zero elasticity holds for changes of this magnitude.[13] But at some critical wage, the elasticity becomes extremely high. It may be argued that the discontinuous nature of substitution is not quite correct: if wage rates continue to increase (whether such increases represent the social conscience of employers or the strength of unions), firms beginning production or planning new investment may mechanize in anticipation of further wage growth.[14] While there is little discernible evidence of such deleterious effects in recent Kenyan experience, continued wage growth may well have such an impact, though the considerable idle capacity likely to result from the great productivity of these machines makes me reluctant to predict the inevitability of their adoption even if wage growth continues.[15]

So far we have taken a mechanistic view of the substitution problem: if factor prices are "correct", labor intensive peripheral operations are adopted. But there is no deus ex machina at work, translating factor prices into correct choice of technique. Rather, it is a plant manager or director who performs this function. Correct translation of factor prices into production techniques depends critically on their abilities and perception of the world.

A useful typology in analyzing the role of managers is to divide them into two categories: those with technical training or a background in production and those without such education or experience. The technically trained understand why operations are performed the way they are and the possibility of using other methods. It is possible for them to envision a production flow which takes the output from a high speed processor and divides it among several hand filling operations, rather than simply directs it into a high speed filler and wrapper. Instead of copying a U.K. process, they are able to make the small, but important, adaptations which allow a more labor intensive process to function properly. In contrast, managers with sales or finance experience and training or those who have extended wholesale and retail operations backwards toward manufacturing appear to lack this ability. They often duplicate the western process <u>in toto</u>, following the advice of consultants and machine salesmen. Technical adaptation is only part of the role of "good" managers. Typically they are also responsible for searching the international market for appropriate equipment, whether used primary processing equipment or low speed new equipment. This involves examining the specifications in the listings of used machinery dealers as well as the catalogs of new equipment producers.[16] Those without technical background rely on capital goods salesmen--with predictable results.

Thus, we would argue that in the absence of particular characteristics of management, appropriate relative factor prices may be of limited efficacy in achieving socially appropriate factor proportions[17] (or profit maximizing ones for the given firm). The effect of such expertise may be envisioned as extending the effective isoquant out of which a firm chooses techniques. In Figure I the unit isoquant is drawn in two sections--the solid one reflects the typical range of alternatives actually in use in advanced countries. The dashed part indicates the technically feasible range if older peripheral equipment and other adaptations are implemented. The "existence" of this part

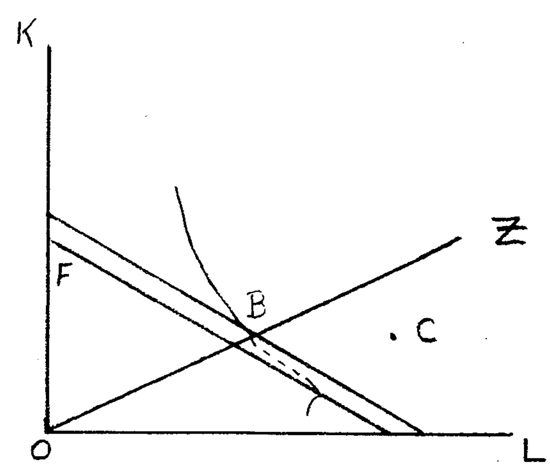

Figure 1

of the isoquant is determined not only by the physical feasibility of the process, but by the ability of managers to discern and implement this part of the isoquant. This implies that the textbook isoquant has little meaning--the range of real world options is nowhere conveniently laid out. One of the major roles of management is to "discover" this part of the isoquant[18] and successfully produce with these techniques. The benefit to the firm of such extension is the realization of cost level FF rather than F'F' (for the given output level), as the firm can now produce at point A and achieve a tangency with the extended isoquant, whereas in the absence of the extension it would produce at point B. With the same relative factor prices prevailing, the extension of the isoquant permits a higher labor-capital ratio to be achieved. The benefits to a national economy from such a process are simply viewed as an aggregate one, a labor force-capital endowment (point C) to the right of OZ[19] which, in the absence of adaptation implies unemployment of EC, is now consistent with full employment; moreover a gain in output also is achievable as C will lie on a higher isoquant than D.

More technically, the extension of the isoquants is equivalent to an increase in the elasticity of factor substitution. The importance of this for an economy in which potential labor supply is growing more rapidly than capital is that an increased elasticity is equivalent to a (Hicks) labor-using (capital-saving) innovation and allows the growth rate of output to be higher than it would be in the absence of such innovation.[20] In a country in which research explicitly designed to use labor (and save capital) is extremely difficult both to finance and implement, this relatively costless achievement of biased innovation is of considerable importance. The availability of the type of manager described earlier is a potential substitute for investment in research capability.

Some Dynamic Implications

The fact that the initial process chosen is relatively labor intensive has interesting implications for future growth. In the existing development literature, the analysis of the dynamic effects of choice of technique has been limited to the question of the impact of such choices on the national saving rate.[21] Little, if any, attention has been directed to the productivity implications of such decisions, yet it is apparent from the plant interviews that those effects may be quite significant.

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

It is quite clear in the Kenyan context that substantial productivity growth has taken place simply as a matter of re-organization of production and better training and supervision.[22] A typical change involved a simple rearrangement of the position of two processes within the same plant. A worker who had formerly been idle half of the time (evenly spaced over the day) was more fully employed when two processes converged on him. In addition to these types of completely disembodied change, there were some that could be called slightly embodied insofar as they were implemented with internally produced "equipment" containing material and labor worth less than £50; nevertheless they increased productivity noticeably. The archetype of such innovation occurred in a fruit processing plant in which crushed fruit had formerly been packed into cans one by one. The manager had the machine shop bore 12 holes, each the size of a can top into a sheet of metal. This was installed at the end of the processing line. As the crushed fruit came down onto this metal, one worker shoved the fruit through the holes until the cans were full. The manager estimated that this increased output per worker at this point fourfold and this was undoubtedly true when the older process was observed in another plant. Many similar tales about very simple reorganization and inexpensive, internally generated devices could be spun.

These descriptions suggest that productivity raising innovations are more easily achieved because of the existing labor intensive nature of the technology. Thus, the initial benefit from the choice of a low capital-labor ratio is augmented by total factor productivity gains which accrue from simple innovations. While such gains are also realizable when more capital intensive methods are used, they are likely to be of an embodied type, thus utilizing scarce investment funds (and probably foreign exchange as well) and may tend toward labor saving bias as they emanate from the developed countries.[23]

Thus, given the initial choice of production technique (in the augmented section of the isoquant) one may view the impact of managerial innovation as permitting an increase in the level of total factor productivity; this increase being greatest at low capital-labor ratios and becoming progressively more difficult as the industries become mechanized or, if no capital deepening occurs, more difficult with the passage of time as innovation possibilities become exhausted.

This point can be illustrated geometrically. Assume a productivity index A(t) which has two components, a and z. The former reflects all types of productivity augmenting factors other than the type of innovations described above. Thus a may reflect learning by doing, increasing labor force education, etc.;[24] z indicates the impact of pure organization and the type of exceedingly low cost innovation.[25] Assume $\frac{\dot{a}}{a}$ occurs at a constant rate and $\frac{\dot{z}}{z}$ at a declining rate as time passes (or if capital deepening occurs, as K/L grows); then $\frac{\dot{A}}{A}$ will have a shape such as that in Figure II.[26]

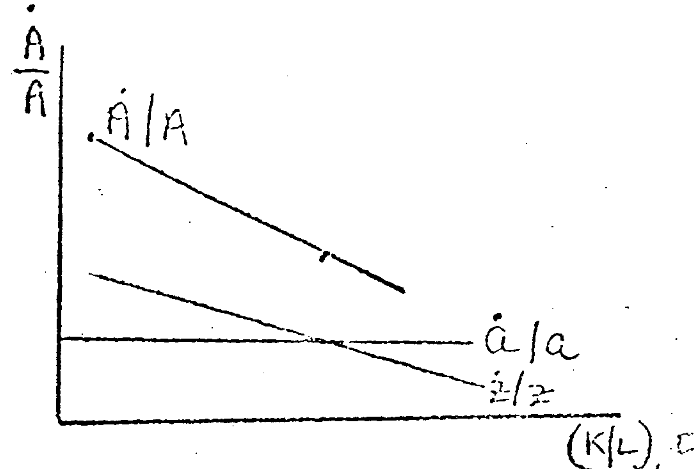

Figure II

The total productivity index, A, will, of course, be growing overtime as in Figure III.

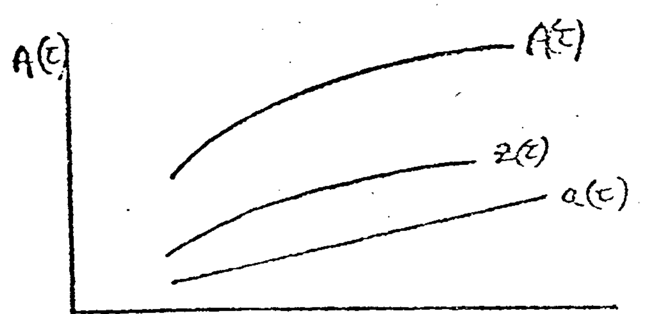

Figure III

What these figures suggest is that in early stages of development, with unexplored reorganization possibilities and low levels of mechanization, the rate of total productivity growth $\frac{\dot{A}}{A}$ may be substantial, but this is likely to slow since opportunities for such innovation decline as reorganization is effected and mechanization grows, i.e., $\frac{\dot{z}}{z}$ declines. Whether $\frac{\dot{A}}{A}$ actually declines, of course depends on whether changes in $\underline{a}$ can offset the postulated decrease in $\underline{z}$.

An implication of this analysis is that during early stages of growth, employment is likely to lag behind output growth even if capital deepening does not occur. In a sense, low labor absorption may be an inevitable accompaniment of the growth process under conditions such as those in Kenya, particularly, low initial mechanization combined with considerable innovative ability of managers. On the other hand, such disembodied productivity growth clearly has limits; there is an exhaustible set of innovative opportunities and as these are exploited further output growth will require both more labor and capital.

That growth in total factor productivity is likely to lead to a slower growth of employment than of output can be demonstrated as follows. The growth of average labor product (assuming no bias in innovation) is[26a]

(I) $Q^* - L^* = A^*(1 - \sigma) + \sigma w^*$

where w^* is the rate of growth of wages and σ is the elasticity of factor substitution. Assuming $w^* = 0$, average labor product will increase if $A^*(1 - \sigma) > 0$. For existing firms, those in which technical progress is occurring, σ is likely to be below unity on installed capital-though the *ex-ante* elasticity of substitution may have been high, post-installation flexibility is likely to be limited. Thus, even if wages remain constant, employment will grow more slowly than output. In fact, wage growth under the conditions described here is likely to occur. Thus even if $A^* (1 - \sigma)$ were negative, $Q^* - L^*$ would still be positive if $\sigma w^* > /A^*(1 - \sigma)/$. If wages grow by some proportion of A^*, say $w^* = \lambda A^*$, (1) can be rewritten as

$$\text{(II')} \quad Q^* - L^* = A^*(1 - \sigma) + \sigma\lambda A^*$$

$$= A\ (1 - \sigma(1 - \lambda))$$

and $Q^* - L^*$ will increase if $\sigma < \frac{1}{1-\lambda}$. If $\lambda < 1$, a plausible assumption in the Kenyan context, unless σ is sufficiently greater than unity, employment will grow more slowly than output.

Implicitly, this formulation assumes that Q^* is exogenously determined by a fixed rate of growth of demand. However, an increase in productivity, if translated into a decrease in (domestic and export) prices could increase Q^* itself, (this depending on the relevant demand elasticities), further augmenting the demand for labor.

Let us summarize the argument up to the present point. The existence of low wages and a special type of managerial ability lead to the choice of initial production processes in which the labor-output ratio is higher (and the capital-output ratio lower) than in similar processes in more advanced countries. Once this process is installed considerable productivity growth of a disembodied type is likely to be realized, managerial skill being the critical catalytic factor. These points suggest two observations on the existing literature. First, it is far from clear that the usual assertion that companies in LDCs use excessively capital intensive processes is valid. Most such statements proceed from a priori reasoning or are based on inferences from aggregate data.

Second, observed growth of labor productivity in the Kenyan context is influenced by realized efficiency gains which are more easily achievable in labor intensive regions of the isoquant. Thus, slower growth of employment than of output would be observed even if no capital deepening were occurring. To infer capital deepening from the growth of labor productivity is, at best, a questionable procedure unless supported by strong microeconomic evidence.

Finally, it should be emphasized that there is no evidence that companies using labor intensive methods suffer from lower efficiency or increased costs. Although some do exhibit domestic prices which are not competitive with c.i.f. prices of imported goods, this was most often attributable to a low volume of production and the inability to exploit increasing returns. In the presence of excess capacity and yet to be exploited scale economies, measured rates of effective protection are at best a weak guide to potential efficiency. Nevertheless, many of these firms are competitive, as indicated by the low rates of effective protection (in their industry) according to the Phelps-Wassow[27] computation and the existence of considerable exports to areas other than the East African Community.

III The Role of Excess Capacity

Until now, in the interest of simplicity of presentation, one characteristic of Kenyan manufacturing which is of great importance in understanding the process of employment absorption has been omitted, namely the existence of widespread excess capacity. A systematic examination of the determinants of of this phenomenon is beyond the province of this paper. However, two factors emerged in the interviews which appear to be extremely important in determining utilization levels. First, indivisibilities in the primary processing machinery implied inevitable underutilization of such equipment until demand had increased sufficiently. In many operations even equipment designed for low volume operation has potential output considerably in excess of local demand.[28] Second, in some firms, particularly those established since 1967, larger than minimum size equipment had been installed in anticipation of high and growing demand in the East African common market. However, recent difficulties in exporting to both Uganda and Tanzania have falsified such expectations and only limited efforts have been made to switch to other markets.

Whatever the reasons for current levels of excess capacity, it is clear that in almost all firms a continuing increase has occurred in the level of capacity utilization, measured as the number of hours per week of effective use.[29] As might be expected, few firms have added any substantial equipment after their initial setting up period, though purchases have occurred where additional product lines have been introduced. Thus, in most firms much of the current value of equipment represents the initial investment.

To a smaller extent, excess capacity also characterized the labor force. As suggested in Section II, the initial labor intensive choice of technique was made out of a substantial spectrum of ex ante possibilities. Once this choice was made there was relatively limited post-installation flexibility in labor-machine ratios; for example, a filling machine operated at any positive number of hours will require four workers in attendance. Even if it is used for half of one shift, the same number of men are required. Thus labor of this type, which may be designated "semi-fixed",[30] will also be subject to increasing utilization as output grows. Employment in both primary processing and filling is likely to grow less than in proportion to output as the utilization of one full shift is approached.[31] Although more workers will be hired in storage and material movement as demand approaches such utilization, here too there is likely to be a less proportional increase in the labor force as some members of the initial labor force were not fully employed. Once one full shift is operated, then further output growth will require a replication of the initial minimum size labor force on the second shift.

Thus, as demand grows, both capital and labor utilization increase. Output growth can then occur with little, if any, change in nominal (or measured) labor input: hence productivity, measured as output per employed worker, will grow rapidly despite the absence of any capital deepening.[32] It is obvious that if measures of effective labor input (hours utilized) were available, the growth in average labor product would be considerably slower than when the denominator is measured as numbers employed. However, even if the labor input were measured correctly, labor productivity would grow if the rate of increase of utilized capital exceeded that of utilized labor, resulting in more capital employed per manhour.[33] Thus, the growth of the number of persons employed in individual firms is likely to be slow after an initial burst of hiring, even if labor intensive methods are adopted (one might say especially if labor intensive methods are chosen in view of the link with future productivity gains). Obviously, as a firm approaches one full shift and then switches to a second shift, the employment growth process just described will be duplicated. A relatively full complement of second shift workers will be hired, but only a fraction of second shift capacity (of labor and capital) will be utilized initially. As demand growth continues, both capital and labor utilized increase and measured labor productivity will again grow. Employment growth may thus lag that of output even where there is little capital deepening in terms of equipment per worker due to substantial increases in productivity over time resulting from increasing capacity utilization (and the type of innovations previously discussed). The firms' data support this view. Our calculation suggests that in most companies 70 to 90 percent of the growth in labor productivity as conventionally measured was unaccounted for by capital deepening. The equation used was

(1) $Q^* - L^* = \alpha(K^* - L^*) + a,$

where α is the assumed elasticity of output with respect to capital, Q^* is the growth rate of output, K^* the growth rate of the nominal capital stock (not adjusted for changes in the utilization rate) and L^* is the rate of growth of the measured labor force.[34] A residual, a of 70 to 90 percent implies that almost all growth in productivity of labor was attributable to the innovation (and greater utilization rates). However, when the capital variable is redefined to reflect increased utilization rates over time, so that capital per nominal worker increases, the importance of the residual, a, is reduced to a much lower range and conversely, the contribution of "capital deepening" rises to a range of 40 to 70 percent of the growth of labor productivity. In addition, L^* can be redefined to allow for changes in its utilization, though the estimates here are much shakier. The role of capital deepening when the labor adjustment is made is lower than in the previous calculation but higher than the first calculation which had no adjustments of the nominal data.[35] The productivity enhancing effects of reorganization are thus augmented by the impact of increasing utilization of both capital and labor, leading to a rapid growth in output, accompanied by a much slower growth in the numbers employed.

How might the results of the process just described be interpreted by resort to a conventional econometric approach? First one observes a rapid growth in labor productivity. The most plausible explanation in terms of received theory is that an increase has occurred in the capital-labor ratio. However, lacking direct measures of this ratio, resort is had to a CES estimating procedure which requires observation of the real wage (nominal wage deflated by each branch's price level) and average labor product, similarly deflated. Although price deflators are scarce, the other variables are easily acquired and the bias attributable to the lack of proper deflators can be established. A logarithmic regression, $\log q = a + b\log w$ is estimated and b can be shown to be the elasticity of factor substitution.[36] Usually the results of such a procedure yield an estimate of b below unity, but significantly different from zero. The inference drawn from the estimate is that increasing labor productivity has been caused by capital deepening, which in turn is the response of (relatively competitive) firms facing a change in the real wage.

In Kenya such a procedure would have missed much of the underlying reality. Wage levels, as we have seen, influence the initial choice of technique especially in peripheral operations. Once installed, equipment is used increasingly intensively, as is overhead labor. Value added thus increases as demand grows, but if wages were constant, the profit share would grow radpily. In a highly unionized sector, also characterized by racial differences between workers and management, it is naive to expect that workers will not insist on a share in this increase in value added.

Even without explicit demands from labor, wage increases would be probable as many employers judge wage standards by western levels and express some guilt at paying only 20 English pounds per month. Thus, wages will follow the growth of measured labor productivity but one cannot infer from this correlation the existence of increasing capital-labor ratios (other than that reflecting changes in the utilization rates) which augment the productivity of labor.[37] This implies that the estimated elasticity of substitution is really a distribution (or bargaining) parameter rather than a rigorous production parameter. While it is perfectly possible to test elaborate lag structures, I think any set of procedures utilizing aggregate data and following the usual CES format will generate regressions which are more sensibly interpreted as wage determination equations than as implicit production functions. More generally, in the absence of capital stock data, continued reliance on indirect estimation procedures suggests that the policy inferences drawn from CES functions should be put forth with some discretion.[38]

In view of the preceding, the conventional estimates of the elasticity of substitution do not allow one to make statements about how many jobs have been lost due to growing wages. For a given industry, still not fully utilizing its initial investment, few, if any, jobs are lost as wages grow. New firms or older firms facing replacement or net investment decisions may opt for more capital intensive processes, but here the evidence on the relative insensitivity of the decision on peripheral equipment to even large wage increases should be recalled. (Also see footnote 13). Up to now, there is little evidence of such substitution in existing firms. This is not to say that no jobs have been lost through increasing wages, but rather that this has worked through a change in the set of industries which enterpreneurs perceive as viable--many potentially extremely labor intensive activities may never have been considered because of high wages.[39]

IV Other Considerations

(a) Managerial Ability

We noted above that the innovations making productivity growth possible were the result of the presence of one or more people at the managerial level who possessed a firm understanding of the technical aspects of the production process. Perhaps surprisingly, in view of the conventional wisdom that foreign owned firms (or those employing western trained technicians) will duplicate western methods, it was typically a subsidiary of a foreign firm which carried out labor intensive adaptations and was more willing to use older equipment. Thus, one of the plants visited, a local subsidiary of a U.S. producer, had almost no new equipment, indeed much of it was 25 to 40 years old, though it had been reconditioned. Although the machinery was obsolete by U.S. standards, it was more than serviceable. Strikingly, it was the parent company which had a department specially devoted to searching the used machinery market, arranging delivery, etc. It is unlikely that a purely local company would have been this successful.[40]

The adaptive behavior of technically oriented managers stands in contrast with that reported elsewhere.[40a] Such discrepancies are explainable in terms of specific characteristics of the Kenyan firms. First, the technically oriented management in Kenya has had limited formal education in engineering. Most have been trained in the production operation within a firm. Though quite versant with the most modern technology, they have observed the workability of older techniques. Thus they are less likely to think that the only possible method of production is the latest, the charge most often directed against graduate engineers. Moreover, since the "engineer" is usually the managing director he is forced to consider the financial implications of choice of technique: the artificial separation of the engineering and the economic aspects of such choice is effectively overcome. Even if the "engineer" wanted the modern, the non-schizophrenic managerial half is likely to impost financial discipline. The combining of the two roles is in my view a critical one in inducing adaptive performance. The relatively small size of Kenyan companies is also of importance. Most references to the advocacy of indiscriminate adoption of automated methods involve staff engineers who are divorced from the management side. So far there has been little need for a separate engineering staff in Kenyan companies: the director's own engineering time is sufficient.

To the extent that indigenous owners or managers had technical training, there was little difference between foreign and domestic companies. One of the most innovative plants had a local owner with a U.S. Ph.D. in engineering. But to the extent that foreign plants are more likely to be directed by those with considerable technical expertise, while locally owned ones are more likely to be run by owners who have extended their selling operations backward, foreign ownership, in this dimension, may well be desirable. This is not a brief for multinational corporations. On the other hand, to the extent to which such abilities are not available locally or through expatriates employed by local firms, the loss in adaptive ability should be weighed against the presumed costs of their presence.

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

The third exception to labor intensive processing was a food processing company that was locally owned. The owner had no technical training or experience in production and there was no staff with such background. The company had extended into manufacturing from a previous wholesaling operation. Not only was the plant almost entirely mechanized, but it was used for only part of one shift. Nevertheless the owner took great pride in the degree of mechanization.

(b) The Inducement to Innovate

Although almost all firms chose labor-intensive techniques to start with, there were differences in the intensity of effort to innovate once equipment was in place. This difference showed up to some degree in the residual by firm but much more convincingly in managers' subjective descriptions of their own concerns. Despite the fact that almost all firms possessed technical ability, there was a palpable difference in innovating effort and it is of interest to search for an inducement mechanism of a purely economic type that is helpful in discriminating among firms according to the intensity of their innovating effort. A widely used assumption is that growth in wages (per worker) will induce a search for labor saving innovation: a corollary being that a slower growth of wages will reduce the impetus to seek such innovations. This assertion, however, is open to doubt--firms will consider all possibilities for reducing costs; there is no reason to limit one's search to those of the labor saving type. A more plausible version put forward by Fellner[41] suggests that anticipated increases in wages will induce a search for labor saving innovation. This position is strengthened insofar as post-installation labor-machine ratios are relatively fixed. A machine-labor ratio which is an optimum one given initial relative factor prices, may not be a profit maximizing one over time if wages are increasing.[42] Unfortunately, such an inducement mechanism is of limited usefulness in discriminating among the firms in our sample as there is little variation in the rate of increase of wages among production workers in the various firms.

An alternative approach does throw some light on the difference in the zealousness with which firms examine the possibilities of productivity augmenting innovations. Firms in which material costs constitute a large part of total costs seem to be less painstaking in their attempt to innovate (and to some extent in their search for initial equipment). Reduction of the primary factor costs would reduce their total costs by a very small fraction whereas effort devoted to finding less expensive sources of supply or to convincing the Treasury to change the tariff category of such materials can result in major savings. Though such companies did use labor intensive peripheral processes, they were quite concerned with equipment design changes which would result in more accurate weights or other characteristics permitting raw material savings. Such behavior may not surprise those who remember the appropriate rule among Marshall's laws of derived demand for a factor of production, but concentration on the capital-labor nexus often forces that eminent piece of wisdom far back in the minds of most analysts of the employment problem.

Conclusions

The two major findings of this study are: (1) there is considerable variation in feasible efficient production methods, particularly in peripheral operations; (2) substantial gains in labor productivity without capital deepening occur due to the existence of considerable (disembodied) productivity gains and the gradual elimination of excess capacity of both capital and labor. The rapid growth of labor productivity is likely to result in reduced employment requirements for a given rise in demand. This phenomenon is likely to be transitional for two reasons. First, realization of the productivity gains for the type described here becomes more difficult as industries mature. Second, as the number of firms increases, the impact of increasing utilization in one or two firms will have a smaller effect on the labor productivity of an entire sector or, put differently, the average rate of capacity utilization in each branch will be higher. Thus, the employment-output relationship observed in the past should not be extrapolated far into the future. The mirror (and happier) image of the growth in productivity is the realization of reduced costs, with its potential benefits (if protection is reduced) to domestic consumers and expanded export opportunities.

Footnotes

1. A useful concise summary of many of the issues is given by Walter Elkan, "Urban Unemployment in East Africa," International Affairs, July 1970.

2. UNIDO, Profiles of Manufacturing Establishments, Volumes I and II.

3. "Capital-Labor Substitution--A Microeconomic Approach," in L. Goreux, editor, Capital-Labor Substitution and Economic Development (North-Holland Publishing Co., forthcoming).

4. As the Kenyan data were obtained during 1971, the replacement estimates given in the profiles were adjusted to a 1971 base using a variety of data sources.

5. There is probably some understatement of the Japanese capital intensity vis a vis other countries insofar as the yen was undervalued relative to the countries from which the non-Japanese plants obtained equipment.

6. Cited in UNIDO, Textile Industry (New York, 1969), p. 44.

7. For example, F.H. Slade, Food Processing Plant, Volume I (London, 1967).

8. A similar scheme was used by Harry Jerome in his Mechanization in Industry (New York, National Bureau of Economic Research, 1934). This monograph summarizes extremely careful studies of the process of substituting capital for labor in a number of industries. It has considerable relevance for the LDCs. I am indebted to Simon Kuznets for this reference.

9. The question of whether the added quality is warranted is of some importance. While it could be argued that for domestic consumption it is a luxury and heavy excise taxes should be levied to discourage such consumption, existing world export markets require the higher level of uniformity. This suggests obvious areas of mutual interest among LDCs to encourage intra-LDC trade.

10. However, the purchase of used equipment confers a substantial benefit insofar as its lower price requires less of scarce investment funds (and foreign exchange) to undertake a given level of production. This assumes that the decline in the price of equipment does not reflect physical depreciation or else the lower intitial price would simply reflect the shorter expected physical life and there would be no alteration in the capital-labor ratio from that in the advanced countries. Among the firms interviewed, used equipment was said to be fully as productive as new equipment and expected life was not different between the two. A useful analysis of many of the issues concerning the desirability of utilizing used equipment can be found in A.K. Sen, "On the Usefulness of Used Machines," Review of Economics and Statistics, August, 1962.

11. Of course, some indirect jobs may be created outside the plant in the timber industry. Whether this constitutes a net addition to total employment depends on the relative direct and indirect labor intensity of the various fuel sources including not only direct production, but transport and other stages. This suggests the importance of utilizing at least a semi-input-output method to assess the total employment impact of labor and capital intensive methods. This is far beyond what I attempt in this study.

12. It might be possible to break down drum size and thus avoid the need for a fork lift. In many cases it is not possible because of international export specifications.

12a. In an interesting paper for the ILO employment mission to Kenya, Charles Cooper performed similar calculations for two types of can selling processes.

12b. Arnold Harberger, among others, has suggested that the shadow price of labor should be the wage in the "informal sector" in urban areas. This is 100 shillings per month in Nairobi according to recent surveys. Harberger's view is set forth in "On Measuring the Social Opportunity Cost of Labour," in Fiscal Measures for Employment Promotion in Developing Countries, (International Labour Office, Geneva, 1972).

12c. In "Industrial Sector Labor Absorption" Yale Economic Growth Center Discussion Paper 116, Gustav Ranis shows that a number of measures such as increasing the speed at which machines are run can alter the realized capital-labor ratio with a given machine. Such equipment is, however, "efficient" to begin with, though less capital intensive than other types which are available.

13. It might be argued that this is an extreme interpretation--though zero elasticity may describe the peripheral process, aggregation across firms generates continuous substitution. While this is a theoretical possibility, it appears to me that the existing distribution of equipment and firms would not lead to smooth, neoclassical substitution at this stage of development of manufacturing.

14. See pages 32 and 33.

15. Of course, to maintain profit margins it might be necessary to take measures to reduce labor costs in other areas in which little equipment is used, such as storing. This might lead to the hiring of fewer workers and the extraction of more effort from those employed. For an entire firm this might yield a higher capital-labor ratio though no more equipment is utilized. This results from defining labor in terms of numbers of men, rather than effective hours. If the latter measure is used no substitution in the usual sense occurs.

16. As we will note below, multinational corporations are often extremely effective in these activities; indeed, some maintain special staff for this function, usually in the home office.

17. One reason, beside distortions in relative factor prices for the failure of "hothouse" import substitution to generate as much employment as had been expected, may be the absence of such "technical" entrepreneurs. One object of such programs is the development of entrepreneurs and this often utilizes those in trade as the "raw material."

18. The implication of this for the analysis of the sources of interemporal growth is pursued in my "The Contribution of Education to Growth: An Alternative Approach," Yale Economic Growth Center Discussion Paper 113. A set of unpublished papers by Richard Nelson and Sidney Winter, Jr. consider a wide range of questions concerning the "objective" existence of isoquants and its implication for the theory of the firm.

19. OZ may be thought of as a ridge line determined not by labor having zero marginal productivity because of the inherent physical properties of the production function, but as a result of the absence of the ability to search out and implement new processes. It may be thought of as representing the capital-labor ratio which almost all western firms exceed.

20. Hicks labor using (capital saving) technical change occurs if the ratio of the marginal product of labor (F_L) increases relative to that of capital, F_K. The rate of growth of these (ignoring technical change and its bias) is given by

$$(1) \quad F_K^* = \frac{-(1-\alpha)}{\sigma} k^*$$

$$(2) \quad F_L^* = \frac{\alpha}{\sigma} k^*$$

where an asterisk denotes rates of growth, k is the capital-labor ratio, α is the share of value added imputed to capital (or the output elasticity of capital) and σ is the elasticity of substitution. Differentiating (1) and (2) with respect to σ yields

$$(1a) \quad \frac{dF_K^*}{d\sigma} = \frac{(1-\alpha)}{\sigma^2} k^*$$

$$(2a) \quad \frac{dF_L^*}{d\sigma} = \frac{-\alpha k^*}{\sigma^2}$$

If $k^* < 0$, (1a) is negative and (2a) positive; thus an increase in σ is Hicks labor saving.

The rate of growth of output (again ignoring technical progress) is

$$(3) \quad Q^* = \alpha K^* + (1-\alpha) L^*$$

If potential labor force growth, L*, exceeds K*, then an increase in $1 - \alpha$ will increase the output growth rate. To show this occurs when the elasticity of substitution increases is straightforward. The growth rate of α can be shown to be equal to

$$(4) \quad *\alpha = \frac{\sigma - 1}{\sigma} (1 - \alpha)\, k*$$

The derivative of (4) with respect to σ is

$$(4a) \quad \frac{d\alpha*}{d\sigma} = \frac{(1 - \alpha)}{\sigma^2}\, k*$$

which is negative if **k*** < 0.
The economic interpretation of the effect of increasing σ is that such a change reduces the rapidity with which diminishing returns sets in to the faster growing factor.

21. See the excellent discussion and synthesis in A.K. Sen, Choice of Technique, 3rd edition, (Oxford, 1967).

22. A similar finding is reported by Lloyd Reynolds and Peter Gregory in Wages, Productivity and Industrialization in Puerto Rico, (Homewood, Richard D. Irwin, 1965) particularly Chapter 6.

23. Many economists have argued that it is the capital intensive techniques which grow in productivity as these receive the most research attention. The implication, rarely fully articulated, is the desirability of adopting such techniques, despite their inappropriateness for typical LDCs. See, for example, Harvey Leibenstein, "Technical Progress, the Production Function and Dualism," Banca Nazionale del Lavoro Quarterly Review, December 1960).

24. Conceivably, such sources of productivity growth should be more properly recorded as augmented inputs, but this is not of interest in the problem at hand.

25. While it might be argued that such innovations should be more correctly included in capital stock, their low cost relative to the usual type of capital makes it more sensible to treat them as leading to purely disembodied changes.

26. Algebraically, these results can be described by a technical progress function

$$(5) \quad \frac{dA}{A} = a + \frac{b}{k_{0}e^{ft}},$$

where A is a (neutral) productivity index, a is an autonomous "manna", b is a constant, k_0 is some initial capital-labor ratio, and f is the rate of growth of capital intensity. The second term depicts the decreasing ability to innovate with capital deepening (or the passage of time). Integration of (5) and evaluation of the definite integral through period t yields

$$(6) \quad A = \exp\,[at + \frac{1}{f}\frac{b}{k_0}\quad (1 - e - ft)]$$

26a. See, for example, John C. H. Fei and Gustav Ranis, The Theory of the Labor Surplus Economy, p. 89. I have substituted $\frac{a}{\sigma}$ for their Φk.

27. M. Phelps and B. Wasow, "Measuring Protection and its Effects in Kenya," Institute for Development Studies (Nairobi), Working Paper No. 37.

28. Although exporting is a possibility considered by most managers, many of the newer plants had limited marketing organization and other non-production difficulties in exploiting export potential. Many complained of the difficulties in realizing drawbacks on imported raw materials as leading to noncompetitive international prices. This was true of a number of companies which claimed to be competitive and in which the Phelps-Wasow results indicated this was true.

29. Effective use reflects the firm's report of the number of hours during which the equipment was actually utilized. These are obviously rough and reflect, in some cases, only the fact that an additional shift was added. The answers are better in those industries, such as bottling, where only two or three machines are used. Where many machines are in use, such estimates reflect a rough average over all equipment.

30. This has no relation to Walter Oi's concept of a quasi-fixed factor which results from costs associated with hiring and training. See Walter Oi, "Labor as a Quasi-Fixed Factor," Journal of Political Economy, December 1962.

31. Clothing production, canvas products and shoes were exceptions as additional output required more direct production workers in proportion to output.

32. Henry Bruton has argued that change in capacity utilization is very important in analyzing the growth of total factor productivity in the Latin American economies. See his "Productivity Growth in Latin America," American Economic Review (December 1967).

33. If ex-post factor proportions are completely fixed this could not arise.

34. Physical output, gross sales, and value added were used as a measure of Q, depending on the type of information which firms were willing to divulge. In cases where the first two were provided, an effort was made to ascertain changes in the degree of internal production of inputs formerly purchased. When sales or value added were available, an attempt was made to adjust for price changes. Both changes in value added structure and prices have been relatively limited over the years analyzed, 1966 to 1972, the dates depending on particular company records.

Two values of the output elasticity were assumed, .4 and .6. These were used rather than factor shares (where available) as a number of recent studies have shown, not surprisingly, that the output elasticity of capital (and the implied marginal product) obtained from direct estimates of the production function usually exceed the measured share of capital. When neither factor is fully utilized and wages reflect a bargaining procedure which includes many noneconomic elements, factor shares are likely to be a poor measure of relative contributions to growth. For those who have confidence in neo-classical distribution theory, my values bracket the capital share of .47 shown in the 1969 survey of large firms as the average for all manufacturing, though in some industries the capital share does fall below .4.

The use of constant output elasticities over a short time period is not likely to do gross violence; however, if the innovations carried out after production began were non-neutral, then the weights would change during the period, this change depending on the bias of the innovation and on the elasticity of substitution. In this context these are second order magnitudes.

35. It may be helpful to explicitly set down the formulae for the calculations. The one without any adjustment of the nominal values of labor and capital is the one in the text. The other two are

$$\text{(1a)} \quad Q^* - L^* = \alpha(K^*_u - L^*) + a_1$$

$$\text{(1b)} \quad Q^* - L^* = \alpha(K_u - L^*_u) + a_2$$

where a <u>u</u> subscript indicates an adjustment for utilization. Equation (1b) indicates that a smaller labor productivity growth is to be explained than would be the case when labor is defined in terms of men.

36. We ignore explicit discussion of the other parameters which may also be obtained, as well as estimates of technical change and its bias.

37. The use of a time trend would not circumvent this problem as the growth of wages would catch much of the variance which should, in fact be attributed to technical change.

38. A recent study which does not rely on indirect estimates is J. Williamson, "Capital Accumulation, Labor Saving and Labor Absorption Once More," <u>Quarterly Journal of Economics</u>, February 1971. Williamson does not have utilization data and thus his estimate of the role of wage growth in inducing growing capital intensity and the loss of jobs may be overstated.

39. The reader may ask would it have been possible to keep wages down as utilization and productivity gains accrued and led to growing value added. Insofar as many industries received high rates of effective protection the answer is yes. Had nominal tariff rates been lowered (and hopefully unified) as demand grew, domestic prices could have been reduced and little additional value added (at current domestic prices) would have been created, where a u subscript indicates an adjustment for utilization. Equation (1b) indicates that a smaller labor productivity growth is to be explained than would be the case when labor is defined in terms of numbers of men.

40. The only other source known to me where this point is made is in Ian Little, Tibor Scitovsky and Maurice Scott, Industry and Trade in Some Developing Countries (London, Oxford University Press, 1970), p. 57. Strassman (op. cit., Chap. 7) and others have emphasized that foreign trained engineers are likely to imitate the advanced techniques of the developed countries.

41. William Fellner, "Two Propositions in the Theory of Induced Innovation," The Economic Journal, 1961. Also see S. Ahmad, "On the Theory of Induced Invention," Ibid. 1966.

42. A number of interesting exercises analyzing such questions, in a different context, are given by G. C. Harcourt, "Investment-Decision Criteria, Investment Incentives and the Choice of Technique," Ibid., 1968.