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INDUSTRIAL EFFICIENCY AND TECHNOLOGY CHOICE

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INTRODUCTION

This paper has its origins in the need to make informed choices about the desirability of proposed industrial projects in developing countries. The past fifteen years have seen an enormous growth in the literature suggesting precise analytic methods for evaluating an individual project whose operating characteristics are known.[1] Nevertheless, one of the most important elements of the decision process - the establishment of a plausible range for these characteristics - has been largely ignored in most formal discussions. It is generally believed that manufacturing plants in developing operate at lower levels of productivity than those in developed countries, but relatively little is known of the current magnitude of the difference, its evolution over time, or its sources. Although a few authors, notably Leibenstein, have called attention to this phenomenon, it is still most often treated as a curiosity, outside the mainstream of development thought. Yet the large difference between productivity in industrial and developing countries is inextricably related to such major concerns as the choice of technology and the validity of special support for infant industries. Productivity differences between technically similar plants in different countries are of interest in themselves for the insight they provide into the industrialization process; they

[1] The most recent summary of this extensive literature is that of Squire (1989).

also suggest that there may be high social rates of return from industrial projects that improve performance.

Section I introduces a number of issues in industrialization whose clarification depends on precise knowledge of the link between technology choice and productivity. Spinning and weaving are used to provide a detailed illustration of these issues. Section II provides comparisons of the performance of plants in Kenya and the Philippines with those in developed country mills equipped with identical equipment. Section III examines the nature and sources of the deviation of actual from best practice productivity, information that provides the guidelines for the design of a productivity-improving project as well as indicating the values that should be assumed for critical variables in carrying out a benefit-cost analysis of new plant capacity. Section IV presents the magnitude of a number of productivity-depressing factors that account for the divergence between actual and best practice productivity. Based on the results from the Philippines, a benefit-cost analysis of a project designed to augment productivity is presented in section V. A brief discussion of the results bearing on the choice of technology is provided in section VI. Policy issues are discussed in section VII.

I SOME ISSUES IN INDUSTRIALIZATION

A comprehensive approach to the design of industrial projects requires consideration of the optimal choice of technology or capital-labor ratio in a new plant if the correct

benefit-cost ratio from additional capacity is to be obtained. Because optimal capital intensity depends partly on the productivity with which specific equipment is employed under actual operating conditions, the choice of technology and the level of productivity are closely related.

Most analyses of technology choice rely on labor and capital productivities that apply only in advanced countries or solely in developing countries. The productivity assumptions embedded in feasibility studies, for example, particularly when equipment of advanced design is one of the alternative technologies, often reflect idealized working conditions in industrialized countries that have had long experience in the manufacture of a particular product. Although the standard input coefficients presented by consulting engineers or machinery producers may offer a useful guide to prospective equipment purchasers in Lyons, Antwerp, or Raleigh, the typical producer in a developing country will fall short of the envisaged productivity. Sophisticated equipment that exhibits a lower unit cost of production (at developing country factor prices) than more conventional machinery in feasibility studies that assume high productivity for both, may result in greater cost when the production parameters used are more realistic for developing countries. The unit input requirements in a developed country do not necessarily translate into similar ones when the technology is transferred to a different setting. The calculation of the least-cost technology is sensitive to the specific set of productivities used; the choice of technology and differences in productivity between

operating developing country plants and best-practice ones are inextricably linked.[2] Input coefficients specific to the developing country must be used if realistic rather than fanciful project evaluations are to be obtained

Productivity Comparisons in the Literature

There have been two types of comparative international productivity studies of specific manufacturing branches, and they have drawn mainly on evidence from developed countries.[3] The first uses sectorwide measures of output and input to derive comparisons of labor productivity, whereas the second compares one or two plants in an industry in each of two or three countries. Both sets of analyses typically investigate sectors or firms in developed countries and consider labor productivity differences; they provide little guidance on the probable range

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[2] This point was first emphasized by Hirschman (1958), who hypothesized that industrial production methods in which both worker and management effort is determined by the speed and sequential demands of "machine-paced" operations will exhibit greater productivity than those in which the process can be segmented into individually paced activities. Continuous-process activities, such as most chemical production, would thus exhibit higher relative productivity than metal working, in which individual tasks are subject to considerable latitude in timing. In spinning and weaving, the sector considered in this paper, the production process is largely machine paced regardless of technology, so this characteristic of the production process cannot explain observed differences between firms.

[3] A comprehensive survey is provided by Kravis (1976).

of results in developing countries or on differences in total-factor productivity (TFP).[4] There have also been a few comparisons of developed and developing countries with respect to differences in TFP at a point in time.[5] In contrast, the present study analyzes data from a large group of individual plants in Kenya and the Philippines and compares their total-factor productivity with that of best-practice plants in a developed country using identical equipment. Knowledge about the performance of a large number of factories in each developing country permits the measurement and analysis of intracountry as well as international productivity variations. In this and other respects the present study is closer to the emerging literature on frontier production functions than to the studies cited in the preceding footnote or those surveyed by Kravis.[6]

The main empirical question considered in past analyses of the choice of technology has been whether a choice in fact exists or whether the newest technology dominates older ones in the sense of requiring less of both capital and labor per unit of output. A substantial body of work has shown that in many

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[4] A useful survey and a analysis of what is known about labor productivity in developing countries is provided by Horton and King (1981).

[5] Arrow, Chenery, Minhas, and Solow (1961), Daniels (1969), Pack (1984). These and studies of the growth of productivity in developing countries are surveyed in Pack (1988).

[6] A review of the use of frontier production functions in developing countries is contained in Pack (1988).

industrial processes the technology permits considerable substitution of labor for machinery and that, in general, newer technologies do not dominate older ones.[7] The analysis of the cotton textile sector presented in the following sections confirms these earlier findings. Comparison of the most modern technologies and currently available conventional technologies for both spinning and weaving shows that the former have higher production costs at market prices for the factors of production; the discrepancy would be greater at shadow prices. The magnitude of the cost difference between the technologies varies with the productivity with which each technology is used in particular developing country settings.

Evidence about productivity differences and their evolution is critical for evaluating industrialization strategies and methods for effecting the successful transfer of industrial technologies to developing countries.

PRODUCTIVITY DIFFERENCES AND THE TRANSFER OF TECHNOLOGY

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[7] There have been two generations of studies of empirical substitution possibilities, beginning with the estimation of the constant elasticity of substitution production functions in the 1960s and continuing with a number of studies based on engineering and microeconomic information. Four extensive survey articles of the second group of studies are Acharya (1974), Stewart (1974), Morawetz (1974) and White (1978). Surveys of the first set include Gaude (1975), Morawetz (1976), and Nerlove (1967). For a recent and comprehensive set of CES estimates, see Behrman (1982). An estimate of the aggregate quantitative importance of the correct choice of factor proportions is provided in Pack (1982).

It has often been asserted that the establishment of manufacturing capacity behind tariff or quota barriers enables individual firms to improve their productive abilities gradually and to move toward best practice.[8] Although firms do not need to attain best practice to compete internationally - lower prices for some factors can offset some productivity disadvantage - it is nevertheless of considerable interest to determine how close to best practice are the textile firms in the highly protected economies of Kenya and the Philippines. Although it was not possible to obtain adequate time-series data of technical coefficients from the firms, the data collected do permit an analysis of the nature of the gap still to be closed fifteen to thirty years after production started in each country.

The approach followed in this paper, particularly the disaggregation of the sources of productivity differences between operating developing country plants and best-practice plants in developed countries, permits the analysis of issues that standard criteria of competitiveness do not consider. In particular, estimates of effective protection rates or domestic resource cost cannot discriminate between a number of microeconomic factors that generate the summary measures. A firm may have successfully mastered its own technologies according to its expectations and

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[8] Such a prospective move does not provide the basis for infant industry protection; in the presence of perfect capital markets, a firm could finance its own learning, later reaping the rewards. For a full discussion of infant industry arguments, see Corden (1974).

may come close to best engineering practice, for example, but may still not be able to match the total-factor productivity of better developed country firms because of excessive product variety - which in turn stems from the particular market structure that has evolved, perhaps in response to protection. A high rate of measured effective protection cannot differentiate between this possibility and substantial technical inefficiency within the firm, yet the two phenomena may have different implications for the success of infant industries.

Disaggregated analysis of the sources of productivity differentials also permits detailed analysis of policy questions with respect to improving industrial sector performance. Much effort has been expended on measuring the level of effective protection but little on finding out why firms (and industries) need such protection. Although there is clearly some validity in the view that protection itself is a source of inefficiency,[8] it is possible that the removal of protection alone will not provide a magic corrective to existing deficiencies; some specific technological intervention or effort at rationalizing the organization of industry may also be required. These questions are discussed in the conclusions.

The Analytic Model

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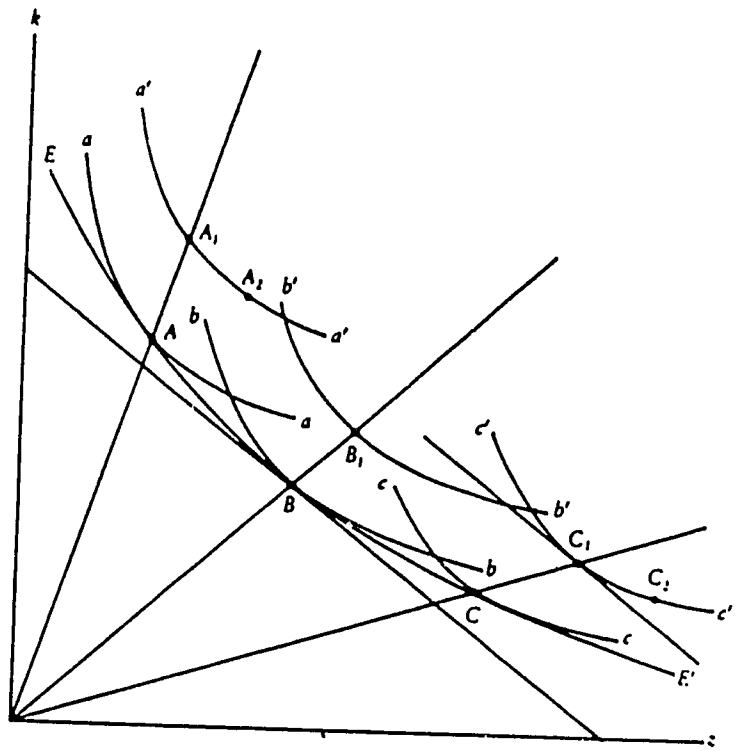
[8] As has been noted by Corden (1974), however, this outcome is not necessary. For a complete analysis see Martin (1978).

A simple model can be used to analyze the implication of many of the issues that I have raised so far. In the following discussion, "technology" is used to describe a relatively homogeneous set of production methods that differ distinctly from each other; for example, a variety of looms used for weaving differ mainly in the principle by which the weft is inserted into the warp. Semiautomatic, automatic, and water jet looms are three of the many technologies available, though there are several relatively minor variations of the basic loom within each category, depending on the particular loom manufacturer. For any technology, a specific technique indicates the capital-labor ratio -- each type of loom can be used with varying amounts of labor, depending upon the wage-rental ratio facing the firm. The ex ante unit isoquant facing the firm about to purchase new equipment consists of the envelope of best-practice coefficients of each of the technologies, or EABCE′ in figure 1 in which the axes measure unit input requirements, k the capital-output ratio, and z the labor-output ratio. Once a particular technology has been chosen by a firm, for example, technology A, ex post variation in technique is possible. If the firm can achieve best practice, this variation occurs along aa. In developing countries, where plants typically exhibit total-factor productivity below that of best practice, ex post substitution occurs along $a'a'$. As drawn in figure 1, the ex post elasticity of substitution is less than that holding ex ante, the latter including as it does the possibility of choosing among different

Figure 1 . *The Effect of Productivity on the Choice of Technology*



technologies designed to be optimal for any given factor price ratio.

Given the preceding definitions and assumptions, we may identify three separate features that are compressed into one in most analyses of the choice of the optimal capital-labor ratio: (1) the choice between ex ante technologies, *A*, *B*, *C*; (2) the level of efficiency with which the chosen technology is operated (if each of the isoquants, *aa*, *a'a'*, and so forth depicts requirements for a unit of output, then efficiency relative to best practice is measured by OA/OA_1, and so forth; the lower the ratio, the lower is relative total-factor productivity [RTFP] in the developing country); and (3) the choice of technique within any technology (for example, operation along *a'a'* at *A* or A_2).[10] For any given factor price ratio, the three characteristics of production jointly determine the least-cost production method.

The remainder of this paper systematically explores the above-mentioned aspects of factor choice and productivity and takes the cotton textile sector in Kenya and the Philippines as the concrete setting. The questions addressed include the appropriate ex ante choice of factor proportions at current relative factor prices, both when current productivity generates the relevant set of choices and when developing country firms are

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[10] There is no reason to expect RTFP to be the same for every technology. A noted above, the Hirschman hypothesis that machine-paced operations are more likely to exhibit greater relative productivity is not apposite here, as most of the processes in spinning and weaving are machine paced.

postulated to realize productivity close to that on the best-practice frontier. The ex ante choice of technologies includes: (1) the most technologically advanced equipment currently available; (2) machinery currently being manufactured that is of modern but conventional design; (3) used modern machinery that differs from new versions mainly in price and expected useful life; (4) new or used machinery whose design dates back forty years or more. In analyzing the optimal ex ante technology choice, it is necessary to obtain both current operating productivity and estimates of feasible productivity. If developing country productivity that has been realized with alternative technologies is the only basis for calculation, technology C shown in figure 1 is superior to B, as C_1 yields a lower unit cost than B_1; if best-practice coefficients could be realized in the developing country, however, B would yield a lower unit cost. Existing studies utilize either information about best-practice alternatives (aa, bb, cc) or observations from current developing country operations ($a'a'$, $b'b'$, $c'c'$)[11]

The preceding analytical framework is also useful for assessing productivity improvement projects. The potential cost reductions to be obtained from improved performance in existing plants are twofold: those arising from a movement from low current productivity levels (for example, $c'c'$) to best practice

[11] For an example of the former see Pack (1975); for the latter approach see Rhee and Westphal (1977) and Stewart (1975). A complementary investigation of textile production is also to be found in Ranis and Saxonhouse (1978).

(cc) as well as from an improved choice of the amount of labor to be employed with machines already installed (the move from C_2 to C_1). The cost reductions realized do not represent net gains to the firms or the economy, because some costs will typically have to incurred to realize better practice. Thus the economic optimality of a program to enhance productivity must be established through careful appraisal of benefits and costs. Such an effort is undertaken in below.

Whereas, the typical industrial project that international lending institutions and LDC industrial development banks undertake is one that allows the borrower to establish or expand a factory, many borrowers already have a significant amount of industrial capacity. These plants may be inefficient and significantly greater output could be obtained if firms could eliminate part of the gap between their current productivity and that realized by the better plants in other countries. The existence of a gap between actual and best practice productivity suggests the possibility that a desirable industrial project may be one devoted to partially or completely eliminating the current discrepancy. The additional output obtained from such an "improvement" project may eliminate the need for additional physical investment in a particular industry. Indeed, any proposed industrial project to expand output in a sector with existing capacity should be viewed as implying an alternative project against which it should be compared, namely, an improvement project for the sector in question, and more generally, for other sectors as well. The choice of the optimal

project must then be based on a comparison of the social benefit-cost ratio of the capacity expansion project versus that of the productivity-enhancing one.

II. RELATIVE PRODUCTIVITY DIFFERENCES

Best practice is defined as the technical operating characteristics achieved by the plants at the upper quartile of productivity in a developed country. It is of interest as a standard that provides a target that can be aimed for though it will require a considerable effort by workers and managers and changes in government policy. Available evidence indicates that deviations from best practice are larger and more frequent in newly-industrializing countries than in developed countries and that such shortfalls have occasionally led firms begun with highly profitable forecasts to go bankrupt or require considerable propping up by subsidization or tariff protection.

Visits to all of the major textile plants in Kenya and to a large percentage of the plants in the Philippines allowed the collection of very detailed data necessary to pursue productivity questions in concrete detail: the type of equipment employed, its specifications, the quantity and types of operatives, power consumption, raw material usage, and a large number of engineering variables which are particularly useful in examining the probable causes of deviation from best practice productivity. Some summary descriptive statistics of the productivity of plants

in Kenya and the Philippines relative to best practice in the United Kingdom are shown in Table I.

Three productivity measures are presented and all are expressed relative to best practice: the output per unit of labor where labor is measured as hours worked by all operatives; output per spindle or loom hour; and total factor productivity. The last measure combines labor and equipment productivity into a single comprehensive measure and is, for many purposes, the most enlightening one. It is useful because loom productivity, for example, can always be increased by assigning more workers to a given group of looms; such an increase in the weaver-to-loom ratio will reduce "machine interference," the average time a loom remains idle before a yarn break is repaired and the loom restarted. While this procedure increases output per loom hour, it simultaneously reduces labor productivity; hence the two are inextricably related and there is a need for a summary measure such as total factor productivity. This measure also provides a good approximation of the magnitude by which unit cost (average cost) of production will differ among firms that pay similar prices for their inputs.

Table 1 shows the average output per unit of labor and capital relative to best practice plants as well as total factor productivity relative to such plants. In both textile processing activities, the productivity of each factor is less than that in a comparably equipped developed country best practice plant. The

TABLE 1

Productivity Relative to Best Practice

	Output per Unit of Labor*	Output per Spindle*	Total Factor Productivity*
Spinning			
Kenya	.28	.93	.70
The Philippines	.49	.78	.73
Weaving			
Kenya	.22	.95	.68
The Philippines	.23	.65	.51

*Average of underlying firm data.

fact that the output per unit of capital (spindles or loom) is relatively greater than that per unit of labor reflects the much greater utilization of labor per unit of equipment. The total factor productivity measure that explicitly takes account of differences in relative factor proportions between the LDC and best practice plants shows that in spinning the LDC plants obtain about 70 percent of the output of best practice plants using an identical bundle of labor and capital. In weaving, the Kenyan plants manufacture 68 percent, the Philippine mills 51 percent, as much as their best practice counterparts. Put somewhat differently, if factories in both countries could, on average, achieve 85 percent of the total factor productivity of best practice plants, the resulting increase in output from exiting labor and equipment would range from 16 to 67 percent, depending on the activity and the country (see Table 2).

Potential sector-wide gains of such magnitude clearly demand consideration of the economic benefits and costs of their realization. However, without a more detailed analysis of the sources of the shortfall from best practice, it is difficult to move toward a policy-oriented analysis of the types of intervention that should constitute the elements of a productivity-enhancement project. As a preliminary step to such policy formulation, it is thus necessary to inquire into the sources of the deviation of current from best practice productivity levels.

TABLE 2

Increase in Output Obtainable
From Realization of Total Factor Productivity
Equal to 85 Percent of Best Practice

	Spinning	Weaving
Kenya	21	25
The Philippines	16	67

III. SOURCES OF PRODUCTIVITY DIFFERENTIALS

To account for the failure of individual plants to attain best practice it is convenient to place the causes along a spectrum ranging from those beyond the control of individual firms, such as national economic policies, to those at least potentially remediable by the plant concerned, such as poor quality control. The quantitative importance of each productivity depressant will vary across economies; in some countries the national economic environment engendered by existing economic policies as well as the inadequate quantity and quality of the physical infrastructure loom large; in others the major hindrance to effective technical performance may be found in the lack of "technological mastery" possessed by individual firm managers or the absence of sufficient attention to non-production activities such as recruitment, training, and incentive payment programs. More specifically, a firm's productivity will be affected by conditions determined at the national or economy-wide level, by special industry conditions, by the managerial capacities of the firm, and finally, by the task level productivity of individual workers. The following paragraphs provide a short introduction to some of the potential

sources of deviation from best practice productivity. Section IV provides numerical measure of the quantitative impact of these productivity depressants.

A. The National Economy

If productivity is evaluated for a given time period such as a year, some features of the national context in which the firm operates will inevitably affect it: breakdowns in the transportation system that delay the arrival of raw materials, failures in electricity supply that reduce the percentage of hours during which equipment is operating, and other intermittent sources of stoppages in production will lead to lower than best practice rates of capacity utilization. Failure to incorporate those lapses in the provision of social services that are unlikely to be corrected during the period in which the planned capacity is to operate imparts an optimistic bias to all project evaluations. It will also typically provide a too favorable assessment of capital-intensive relative to labor-intensive plants, since the expense of "downtime" is greater the larger the amount of capital lying idle.

Even if transient disturbances are ignored and attention is concentrated on productivity per hour of actual production, characteristics of the national economy affect individual firms. For example, the structure of economic incentives that arise from decisions on tariffs, import quotas, and preferential loans from the financial system may exert an important influence on the desire of (and necessity for) firms to strive for high

productivity. A firm operating with partial or total immunity from international competition has limited incentive to undertake the often expensive steps that are necessary to obtain greater output per machine or worker hour. Where the higher costs resulting from low productivity can be passed forward to consumers in the form of higher prices, the realization of best practice standards is not a probable outcome.

B. The Industry

Industry-wide features that affect a plant's productivity include the evolution and organization of the constituent firms. In many countries the growth of firms is artificially encouraged by import restrictions and excessively generous support from the financial system. The productive capacity of firms often exceeds the absorptive capacity of the domestic market, yet firms are incapable of producing at sufficiently low cost to export. Enterprises find themselves with excess capacity and, in an effort to increase the rate of plant utilization, expand their product range. Each mill finds itself producing a very large range of yarns and fabrics, an outcome that substantially reduces productivity.

C. The Firm

A large number of operational skills at the firm level affect productivity. Consider, for example, weaving. A critical determinant of weaving productivity is the quality of the yarn employed. This depends on the ability of the firm's own spinning department in integrated textile mills and the technical

capacities of other spinning firms where the sector exhibits vertical specialization. Among the technical factors that are important in obtaining high quality cloth from a given yarn are the following: good humidity control; an appropriate sizing mixture (the liquid used to add strength to yarn before it undergoes weaving); the use of quality control testing throughout the process; and quick identification and correction of production errors accounting for defects. Inadequate knowledge or implementation ability with respect to these and other aspects of production engineering lowers loom, labor, and material productivity.

Another firm level skill that can exert a major influence on productivity is the ability to insure an adequate supply of spare parts. Although this is seemingly a simple task, some firms do not carry a satisfactory inventory of spares, mainly because of the complexity of ordering and storing them, but also to avoid the carrying charges. Instead, they maintain a small stock and order replacements as equipment fails. However, the long shipping time from many foreign suppliers may result in a sustained inability to operate spindles or looms at their potential utilization rate. The better managed firms in Kenya and the Philippines have developed the requisite inventory control abilities, incur the necessary interest expenses (which are considerably less than the value of the output lost from shortages), or successfully develop local suppliers, often

working with them to insure correct specifications and high metallurgical quality.

D. Task Level Productivity

Finally, task level productivity (TLP) may be defined as the output produced by a worker assuming that the firm is successful in maintaining its equipment in good working order, raw materials are of adequate quality, and no interruptions occur due to intermittent failure, for example, of the electricity grid. TLP depends on operative skills and motivation, which in turn are affected by the work atmosphere within the textile factory and the incentive structure established by the firm to reward high productivity, and by the quality and intensity of supervision. Frequently, concern with low industrial productivity focuses on task-level productivity. As will be seen below, however, this is not a quantitatively important source of low productivity in the textile sectors that have been examined in this study.

The preceding are conceptual categories which are not mutually exclusive. They provide an initial framework with which to structure a number of important issues.

IV. THE SIZE OF PRODUCTIVITY DEPRESSING FACTORS

In giving operational context to the several productivity-reducing factors, extensive use is made of both the production theory usually employed by economists and textile engineering principles. Data on variables collected from plants such as

spindle speed, twist multiples, and loom and spindle efficiency (or utilization rates per hour) are compared to those in best practice plants, and permit the proximate determination of firm-specific sources of the deviation of actual from best practice productivity. The impact of the major industry-wide feature affecting LDC productivity, the extent of product specialization, is determined using engineering-based studies as well. However, no attempt has been made to estimate the impact of productivity depressants that stem from deficiencies at the national level. The effect of some of these such as an inadequate electrical grid and occasional service interruptions is transient, while the focus here is on productivity per hour of normal operation. Insofar as nationwide shortcomings such as an inadequate vocational training system or a poor incentive system impinge on normal productivity, the effect is likely to be manifest in one of the depressants actually measured. In this sense, the measured sources of deviation from best practice are proximate, not ultimate. Eliminating some of the measured productivity shortfall may require intervention not only at the level measured (the firm) but at a more macrosopic level as well.

In Tables 3 and 4 task level productivity is calculated as a residual and is not based on direct measurement of worker productivity, such as would be contained in time and motion studies. As a result, errors in measurement of other factors that determine productivity or omissions in calculating the productivity depressants affect measured task level productivity.

TABLE 3

Productivity-Reducing Factors: Spinning

	Industry (lack of product specialization)	Firm				
		Spindle Speed	Twist Multiple	Spindle Efficiency	Total (2)x(3)x(4)	Task Level
	(1)	(2)	(3)	(4)	(5)	(6)
Kenya	.85	1.09	.89	.96	.93	.90
	(.15)	(.09)	(.14)	(.05)	-	(.12)
The Philippines	.79	1.00	1.00	.91	.91	1.03
	(.09)	(.24)	(.01)	(.01)	-	(.26)

Note: coefficient of variation in parentheses; - Not applicable

TABLE 4

Productivity-Reducing Factors: Weaving

	Industry (lack of product specialization)	Firm			Task Level
		Yarn Quality	Loom Efficiency	Total (2)x(3)	
	(1)	(2)	(3)	(4)	(5)
Kenya	63	1.00	.98	98	1.11
	-	(0)	(.08)	-	(.14)
The Philippines	70	.96	.78	75	1.03
	-	(.05)	(.09)	-	(.14)

Note: coefficient of variation in parentheses; - Not applicable

Analysis of the probable impact of such errors and omissions suggests that, if any bias results, it is one that understates task level productivity in Kenyan and Philippine mills relative to that in best practice plants.

The tables should be read as follows: in Kenyan weaving, for example, productivity is reduced to 63 percent of best practice by excessive product variety, to 98 percent of best practice by poor yarn quality, and so on. Note that task level productivity is 11 percent greater than best practice. These factors are multiplicative, so that total factor productivity relative to best practice is .63 x .98 x 1.00 x 1.11 = .68, which is the value shown in Table 1, column 3 for Kenyan weaving. Although their effect is multiplicative, each of the productivity depressants exerts an effect that is independent of the others--thus the adverse impact of product diversity will lower total factor productivity even if firm and task level productivity match that of best practice plants.

Two aspects of the data are of interest, namely, the absolute level of each of the productivity-depressing factors, and their dispersion as measured by the coefficient of variation (the standard deviation divided by the mean). A low absolute value of a depressant indicates that, for the entire sector, there are substantial potential benefits to be obtained from redressing the problems leading to the measured deficiency. The dispersion indicates the evenness of diffusion of the

capabilities necessary to obtain high performance in a given dimension; thus, the high coefficient of variation of speed in Philippine spinning suggests that a significant number of firms do not possess the capacity to match the good sector-wide performance. The dissemination of abilities among firms, usually assumed to be a major externality of intensive industrialization, has not materialized. Interventions to narrow the variability of performance as well as to improve the average may thus become an important policy option. Three aspects of the numerical results stand out.

(1) The major source of low productivity in both Kenya and the Philippines is insufficient product specialization;

(2) In spinning in both countries and in Kenyan weaving, firm-specific technological ability (Table 3, column 5 and Table 4, column 4) is fairly high. Nevertheless, potential increased output of about 10 percent in spinning and 33 percent in weaving could be realized in the Philippine plants solely from improvement in this dimension. Among the technical problems that would have to be overcome are poor quality control early in the spinning process and inadequate inventories of spare parts, particularly for looms.

(3) Performance by individual workers of given tasks is a significant source of low productivity only in Kenyan spinning, though there is considerable interfirm variation in this

dimension. The obstacle to efficient industrialization most often emphasized does not appear to be important in the textile sector in these two countries. The potential additions to output in existing plants shown in Table 2 can now be seen to be contingent on realizing improved performance in a number of dimensions suggested by the categories shown in Tables 3 and 4. Moreover, such progress, unlike the technology improvement contained in traditional economic models, will not be derived from a costless invisible generator of productivity growth. Rather, it can be obtained only from changes in economic policy combined with purposive technological effort. A combination of a liberalized trade regime, rationalization of the product structure of the industry, and technical aid at the firm level must be pursued, though not necessarily simultaneously.

The fact that, in both spinning and weaving, Kenyan firms using the same spinning or weaving equipment as those in the Philippines, display higher total factor productivity provides some potential clues into the nature of technology transfer and the requisites for efficient industrialization. Since the Kenyan firms are newer, they might have been predicted to exhibit lower productivity. The surprising proficiency in Kenya is almost certainly due to the presence of international managers of high quality who have been able to implant the procedures accumulated by some of the better firms in India, Japan, and Western Europe. These abilities, embodied in five to twenty expatriates per firm, have been a critical factor in Kenyan

success as manifested in the high level and limited variation in most determinants of total factor productivity. In effect, for most of the Kenyan firms the marginal cost of acquiring additional technical or organizational skills was close to zero once these expatriates were present, and the marginal productivity of such knowledge was high. Where technical information was not obtained within this staff, they knew where to identify relevant sources quickly and cheaply, and how to incorporate such information productively within the plant--hence the closeness to best practice and limited interplant variation in most dimensions.

In contrast, the textile sector in the Philippines has not benefited from a similar infusion of international expertise. Although a few firms have employed, on an ad hoc basis, two or three managers (on fixed-term contracts) from other countries, most plants have relied on domestic managers whose training has rarely included sustained exposure to international best practice. Should an unusual production problem arise, it is more easily rectified internally within the Kenyan firms. Where external help is required, the search process is almost surely quicker and less expensive than in Philippine firms. Whether it is unusual spare parts or the evaluation of the utility of a new process, the Kenyan firms also have a better idea of the appropriate price, whereas the Philippine firms may be discouraged from an action by an initial high quote that is merely a bargaining price. An infusion of foreign technical

expertise thus appears to offer a possible path to rapid and fairly efficient industrialization though it raises other well known questions.

V. THE BENEFITS AND COSTS OF A PRODUCTIVITY IMPROVEMENT PROJECT

Given the type of shortfalls from best practice shown in Tables 3 and 4, a project that will result in large benefits, particularly in the Philippines, is one that would improve specialization as well as firm-level production engineering. Moreover, despite the high average task-level productivity, many individual firms have poor performance in this dimension and would benefit from relevant expertise. Before specifically addressing the types of policies required, benefit-cost ratios that could be obtained from a productivity enhancement project are presented.

The benefit-cost calculation has been implemented using the data obtained from individual Philippine firms. The numerical benefits (shown in Table 5) are derived by computing the reduction in cost that would be obtained, at the prevailing output level, if each firm could increase its total factor productivity to 85 percent of best practice in both spinning and weaving and adjust its use of labor on existing equipment to conform to labor-equipment ratios exhibited by the best Philippine firms. Benefits are calculated as the present

TABLE 5

Potential Benefit/Cost Ratios Stemming from

Productivity Enhancement Project

	Benefits Included	
	(1)	(2)
	50%	100%
Sector-wide benefit/ cost ratio	2.30	4.33
Coefficient of variation of individual firm values	.26	.36
B-C ($ millions)	26.10	71.10
Percentage of firms with B/C > 1	83	92

discounted value of the total reduction in cost over ten years, assuming a ten percent discount rate.[12]

Two benefit-cost ratios are presented; the first includes all benefits, the second only half. The smaller estimate is relevant if some of the reduction in cost to the domestic economy could be obtained simply by a decrease in tariffs or removal of import quotas; however, an effort to do so without providing aid to firms that perceive themselves unable to meet international competition will usually encounter significant political opposition. Given this constraint on liberalization, it seems likely that a country will obtain either none or all of the benefits from a productivity enhancement-cum-rationalization program. The less inclusive benefit-cost ratio is provided as a benchmark for those more optimistic than I about the political economy of liberalization.

The more inclusive measure (Table 5, column 2) yields a sector-wide benefit-cost ratio of 4.33 and absolute net benefits (B-C) of $71 million. The narrower calculation, comparing half of the benefits and all of the costs, yields a sector-wide ratio of 2.30. Both ratios are quite high when compared with those projected in most industrial project evaluations and are more robust as the activities envisaged are narrower in scope than the

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[12] The formal analytic derivation of the benefit-cost ratios in terms of producers' and consumers' surplus is presented in Chapter 8 of Pack (1987).

major uncertainties encountered in establishing an entirely new plant.

The underlying data allow more complex calculations. But the results of the simple exercise shown in Table 5 provide a sufficient case for careful consideration of productivity-augmenting projects--rarely do new projects generate such high benefit-cost ratios.

VI THE CHOICE OF TECHNOLOGY

As noted in the introduction the determination of the appropriate capital-labor ratio for manufacturing a given product has several components: the choice of machinery from the range of models that are currently manufactured, the choice between new and used machinery of the relevant type, and the choice of the amount of labor to be used with whatever machinery is finally decided upon. Detailed analysis of the cost of production with various equipment confirms that none of these choices can be analyzed simply by using the input coefficients supplied by machinery producers or those characterizing best practice plants in developed countries. Neither can one rely on input coefficients observed in operating developing country plants because these may obscure some cost-minimizing choices that would be relevant if greater productivity could be achieved in individual plants. Rather, two alternative calculations are appropriate: the economically efficient technology if the productivity prevailing in the LDC is maintained; and the

efficient alternative if it is possible to obtain productivity that approaches best practice.

Three broad conclusions emerge from the underlying evidence.

1. At both current and high productivity, new conventional equipment offers a cost advantage over new machinery from either the highest or the lowest end of the capital-intensity spectrum; radically new or very old designs are not competitive within the economic environment of Kenya and the Philippines although in other countries, for example, South Korea, new semi- automatic looms have been shown to be cost efficient (Rhee and Westphal, 1977).

2. Comparisons between new and used conventional equipment demonstrate that the latter exhibits some cost advantage at current productivity levels; the advantage arises from its lower price and the greater productivity, relative to potential, achieved with it. At uniform high productivity relative to best practice, the cost advantage may lie with either new or used machinery, the margin of difference being quite small. Obtaining a good price on used equipment is more important than any inherent differences in operating characteristics if high productivity can be realized. Firm specific management skills are important in obtaining the cost advantages that exist, and the Kenyan multinationals achieve better results in this respect than locally owned Philippine mills.

3. Once a specific set of machines has been chosen, the correct choice of the amount of labor employed with them may result in a large cost saving. In the Philippines, for example, firms employ too much labor with a given group of machines in an effort to achieve output per machine hour that conforms to the standards of the industry in developed countries.

The existence of a substantial range of technologies that may allow a country to achieve both greater output and employment from a given investment level presents great opportunities for imaginative policy making. However, these issues extend considerably beyond the scope of this paper.[13]

VII. POLICY CONCLUSIONS

Three types of policies need to be pursued to improve low levels of realized productivity, namely, liberalization of the trade regime, explicit efforts to rationalize the fragmented production structure, and technical aid to firms to enable them to redress both narrow engineering and broader organizational problems. While each of these policies has precedents in some existing aid programs, the desirable time phasing and interactions among the components has received only limited attention. The following schematically outlines one approach to both the substantive programs and their timing.

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[13] Estimates of the nature of the substitution possibilites, the magnitude of the benefits to be derived, and relevant policies to pursue are provided in the references cited in footnote 7.

The first component of a rehabilitation program should be an effort to improve production engineering and task level productivity by the assignment of perhaps ten individuals to a firm for sustained periods. This process is likely to have its greatest impact if these additional management resources are not accompanied by an attempt to rehabilitate even a small part of the existing equipment. Although such improvements may be necessary at some point, the argument against their early introduction is the likelihood that the management of the firm will be unable to absorb simultaneously both the non-embodied technology transfer and physical rehabilitation. If the objective of the restructuring effort is a permanent increase in the understanding of the importance of the potential benefits of improved use of existing resources, as well as the major gains from appropriate additions to the physical capital stock, their independent effects may be confounded by the potential beneficiaries. In particular, new equipment to alleviate bottlenecks or rehabilitation of older equipment may be viewed as the sole source of improved productivity and thus increase the propensity of firms to be believe, as many currently do, in the decisive role of reequipment. The contribution of production engineering and greater product specialization may be lost. Only after the marginal gains from efforts to improve productivity without additional equipment is estimated to equal the marginal costs of further such changes, is reequipment appropriate.

Before any new machinery is introduced, the two more macroscopic policies should begin, namely, efforts to liberalize the trade regime and reorganize the structure of production.

The liberalization effort should be designed to reinforce the learning program by enabling firms to obtain inputs at world prices. Firms would thus learn the extent to which they may become competitive simply from moving towards international productivity and facing international input prices; this should reinforce their desire for absorbing the ongoing technology transfer and increase their confidence that they could withstand the gradual lowering of the protection on their own production. To the extent that their existing equipment is, even at high productivity levels, incapable of permitting competitiveness even with inputs available at international prices, some firms may understand that they indeed face unpromising prospects and will be forced to assess their chances of becoming profitable in the period before loans for reequipment become available. A fairly long transition period before such loans become available provides an effective survival environment to encourage the scrapping of truly dated equipment. In contrast, if reequipment begins after a short period, firms with either dated equipment or poor management may be willing to sustain losses, in the hope that the soon-to-be-available machinery will save them.

Policies with respect to increasing product specialization are particularly difficult to formulate. It is possible to do

nothing explicit and to assume that liberalization in both output and input markets, combined with improved firm technical abilities, will inevitably result in an appropriate degree of interfirm product specialization. Unfortunately, there is little evidence on which to base such an optimistic prognosis either in developed country or LDC experience. Recently, the EEC countries engaged in cartelization of their textile industries specifically to obtain greater specialization. The Japanese have also engaged in specific government directed efforts to rationalize entire industrial sectors; included in their objectives has been a smaller diversity of products for each firm.

If there is to be an explicit concern with the range of products, there are two types of desirable outcomes: (1) a large country such as the Philippines might produce the entire range of products, each firm producing a very small subset of yarns and fabrics; (2) the entire industry would specialize and all firms would produce a similar small range of products, the industry thus being compelled to export, with non-locally manufactured products being imported. The relative merits of each outcome will not be set forth here. Rather, the important issue is the method for achieving whichever organization is thought desirable and its complementarity with other policies.

The case of each firm producing a different set of products is the more complex, the difficult issue being how product allocation is to be decided. In principle, the firms can decide

among themselves, basing their decisions on a presumably superior knowledge of their own comparative advantage across products. One difficulty is that firms that are currently considerably below best practice may not understand their ultimate relative costs among different products until they are fairly far along their learning curves. However, as much of the advantage among products reflects differences in equipment-embodied specifications, there is a good basis for initial speculation. Agreement on a narrowing of product range should be prerequisite for a firm's participation in any restructuring program. It also should occur at the beginning of the program, as a considerable part of the learning process could profitably concentrate on a small range of products.

The higher productivity realizable from increasing specialization should reinforce the confidence of firms that stems from improving firm level productivity and a lowering of input prices towards world levels. The inevitable lowering of protection on their own output will be seen as less of a threat. Simultaneously, such reductions of protection on final goods should prevent any monopolistic rents from being earned in the domestic market because of a limited number of suppliers of any given product.

The need to encourage product specialization also militates against the early provision of additional equipment or rehabilitation of the existing stock. The opportunities afforded

by machine product-specificity may deflect attention from the important task of improving productivity towards that of obtaining equipment that might allow rents to be earned in a specific market segment. Although the eventual reduction of tariffs on all products should serve to deter firms from such behavior, past experience of failed liberalization may make such options particularly attractive and subvert the productivity improvement program.

More generally, while the precise details of any industry restructuring will depend on country-specific circumstances including current macro-economic performance, it is likely to be the case that the provision of new machinery should be low on the agenda of planned industrial policies. The last two decades of development history and analysis convey many lessons; among the most important is the relatively minor role of simple physical capital accumulation, an inference confirmed by the evidence and analysis presented in this paper.

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