AN ANALYSIS OF TECHNOLOGICAL CHANGE IN JUTE WEAVING IN BANGLADESH, 1954/55 to 1979/80

M. G. KIBRIA
C. A. TISDELL

A. *An Introduction to Technological Change in Jute Weaving in Bangladesh*

In jute manufacturing, the weaving process follows spinning[1] and consists of the stages from beaming to finishing. Weaving uses yarn, the finished product of spinning, as its input and results in the output of fabric, i.e., cloth. The purpose of this paper is to measure and examine alterations in production functions in jute weaving in Bangladesh that arise from (1) technological change, (2) learning-by-doing, and (3) related factors.

The jute weaving industry has been established in Bangladesh for only just over twenty years. Before its establishment, all raw jute (i.e., jute in unprocessed form) was exported for manufacture elsewhere, mostly to India. Three major types of jute goods are now produced in Bangladesh: sacking, hessian, and carpet backing cloth (CBC).[2] All the weaving mills in Bangladesh are nationalized. In mid-1981 there were seventy-six weaving mills engaged in producing the three major products just mentioned, and four specialized mills producing

---

We would like to thank the University of Newcastle, Australia, for financial assistance with this survey and all Bangladesh Jute Mills Corporation (BJMC) officials and personnel of the mills visited in Bangladesh for their cooperation. We would also like to thank Mr Ahsanul Habib for his help with calculations.

1 Spinning consists of the processes from "batching" to "winding" and yarn is its finished product.

2 Hessian, sacking, and carpet backing cloth (CBC) together account for about 95 per cent of the total output of the industry. Of these, hessian is a plain weave, lightweight fabric normally weighing between 7 and 12 ozs. per yard. It is generally produced from good quality jute and is used mainly in packaging, wrapping, and industrial uses. Sacking is a heavy, loosely woven cloth, either plain weave or twill, normally weighing between 12 and 20 ozs. per yard. Inferior quality jute, cuttings, tangled jute and mill wastes are used in the manufacture of sacking which are generally sold in the form of bags of various sizes. Carpet backing cloth, like hessian, is also a quality product of fine texture and is woven of very good quality jute. It is used as both primary or secondary backing for tufted carpets and also as backing for woven carpets.

The minor products include canvas, yarn and twine, carpets (significantly rising since the late seventies), mattings, wall-coverings, combination fabric (jute and cotton mixed fabrics), decorative fabrics, curtains, upholstery, floor-coverings, and various other laminated fabrics. There are only four mills with 115 looms in total presently engaged in production of these special products.

some minor products. About 80 to 90 per cent of the total production of these mills is exported.

The jute weaving industry in Bangladesh depends almost entirely on capital equipment embodying imported technology.[3] The average length of life of weaving equipment is very high—at least thirty to forty years. Consequently, since no weaving mill in Bangladesh is much more than twenty years old, each mill has its original equipment incorporating the technology available at the time of its establishment. Furthermore, expansion in the industry has occurred by adding mills rather than by expanding the size of existing mills. We can assume that once a mill has been established there has not been any change in the composition of capital equipment in that particular mill. Thus machine-determined technological change is an inter-mill and not an intra-mill phenomenon.

The loom is the main machine in the jute weaving process, and the final product, jute fabric, is produced entirely on such machines (unlike the situation in industries in which different parts of the final product are produced on different machines). Each loom, with its attendant labor and other variable inputs producing different types of jute cloth, is an identifiable unit of capital [1]. Thus a jute weaving mill can be viewed as a multi-unit plant, each loom constituting a unit. A jute mill may have looms of different types, sizes, and vintages and, depending on these characteristics each loom has a unique performance-rating. In the jute weaving mills of Bangladesh the main types of looms are narrow looms for the production of hessian and sacking and broad looms for the production of carpet backing cloth.

By way of background, let us consider the history of adoption of weaving looms in the Bangladesh jute weaving industry. This study concentrates on the twenty-five year period 1954/55 to 1979/80. Only one mill was established before this period.[4] Of the different types of looms mentioned above, sacking looms use heavy yarn for weft and light yarn for warp, while hessian and CBC looms use light yarn for both. The distinction between narrow hessian looms and broad looms lies only in their width, broad looms, in general, being 110 inches wide and hessian looms standardized at 40 inches. Like the structure of the looms, the texture of the product is more or less the same for these two types of looms, the only thing differing being the width of the cloth produced. Sacking, on the other hand, is quite different from hessian and CBC, being coarser in texture, heavier in weight and on the average 44 inches wide.

During the interval 1954/55 to 1961/62 mostly old LEFCO and ULRO-type weaving looms were adopted for the production of both sacking and hessian, but

3 In the seventies a few new looms of domestic make (Gulfra-Habib) were added to the existing looms in the mills where the operational capacity of the weaving units fell short of that of the spinning units. Contrary to the usual practice in developed countries, jute mills in Bangladesh, almost invariably combine both spinning and weaving operations on the same premises, and hence, imbalance between these productive operations is not uncommon.

4 This was established in 1952 using second-hand machinery (old LEFCO type) purchased from India.

sacking was dominant in overall production in this period [10]. The other types of weaving frames adopted during this period, and not much different than the old LEFCO and ULRO types, were the FLCB and WLB.

Nineteen sixty-two marked the beginning of a technological breakthrough with the emergence of newer LEFCO, FLTM, and WLB-type looms for both sacking and hessian. All were of the same general type and all became available the same year. Having the choice of these advanced technologies, most of the mills established during the period 1962/63 to 1969/70 imported the new LEFCO, closely followed by the FLTM. But by the mid-1960s, the situation was reversed, i.e., the share of FLTM outstripped that of LEFCO. The WLB type also had a significant share while the ULRO type totally disappeared from the scene after 1962. There was also a notable change in the production structure during this period—hessian taking up a relatively rising share of the increase in production (peaking in 1969) relative to that of sacking [10]. The other striking feature of the development of the weaving industry during this period was the establishment of the first broad loom for weaving carpet backing cloth in 1964. The demand for CBC started to undergo a steady growth, especially in the United States and Western Europe during the late sixties [9].

The continuous expansion of demand for CBC led to the establishment of a number of weaving mills in Bangladesh for producing it in the seventies. Hence, the majority of looms adopted during this period were broad looms, and most of them were of the newer FLTM type. Some SULZER-type looms (the most efficient of all the types available to date) were also imported. Furthermore, a small percentage of domestic looms made by Gulfra-Habib (a government-owned manufacturing establishment at Chittagong, Bangladesh) were installed, making the introduction of domestically produced looms in Bangladesh's jute manufacturing industry.[5]

B. *Purpose of the Study*

The main purpose of the present study is to examine changes that have occurred in the production functions of jute weaving mills in Bangladesh as a result of technological change, learning-by-doing, and related factors. To what extent has change been capital intensive? How have economies of scale altered? Of what significance, if any, is learning-by-doing in this contenxt?

In order to resolve these questions data were collected (as explained in the next section) from a large number of weaving mills in Bangladesh in 1981 and these data were used to make estimates of Cobb-Douglas production functions of the type

$$Q=AL^{\alpha}K^{\beta}, \qquad (1)$$

where Q=quantity of fabric output, K=quantity of capital, L=quantity of labor, and α and β represent the elasticity of production in relation to labor and capital respectively.

[5] It has recently been the Bangladesh government's policy to encourage indigenous manufacture of looms for jute mills in the country.

In competitive equilibrium, the firm equates its marginal rate of technical substitution of the factors to the price ratio of the factors. Thus equation (1) implies that, for a perfectly competitive firm, capital and labor are combined in such a manner that

$$\frac{W_L}{W_K}=\frac{\alpha K}{\beta L}, \tag{2}$$

where W_L represents the price of labor and W_K that of capital.[6] It follows from equation (2) that the optimal value of K/L varies inversely with α/β if the ratio of the prices of factors is constant. Other things being equal, the higher is β/α, the more capital-intensive technology tends to be optimal for the firm. Variations of α/β or β/α can be used to help ascertain the degree of capital intensivenesss involved in technological change. An upward movement of β/α indicates technological change with a capital-using bias, whereas a fall in the ratio indicates a change with a labor-using bias.

Variations in the ratio $\alpha/(\alpha+\beta)$, the proportion of total output attributed to labor divided by the proportion of total output attributed to both labor and capital, can also be used (as has been done by Brown and Popkin [3]) as a measure of alterations in the relative importance of capital in contributing to output. Changes in the relative contribution of capital to production may arise because of embodied technological change. Alternatively, one can use the ratio $\beta/(\alpha+\beta)$, the contribution of capital to total factor productivity, as an indicator of technological change. Alterations in both of these ratios—as well as in α/β—will be estimated for the Bangladesh jute weaving industry.

In addition, trends in returns to scale of operations, defined as the proportional change in output resulting from an equi-proportional change in the quantity of the factors used, can also be a useful indicator of the nature of technological change in an industry. Returns to scale, given the Cobb-Douglas function in equation (1), are indicated by $(\alpha+\beta)$, the sum of the output elasticities of labor and capital.

In order to consider the possibility of productivity changes due to learning-by-doing,[7] particular attention will be paid to alterations in parameter A, the autonomous multiplicative factor in equation (1). The higher the value of A, other things being equal, the greater is the productivity of inputs. Given the same techniques, an upward trend in A over time would indicate the presence of learning-by-doing.[8]

In order to estimate equation (1) for Bangladesh jute weaving mills, the practice has been followed of using the natural logarithmic form of the equation, viz.:

$$\ln Q=\ln A+\alpha \ln L+\beta \ln K. \tag{3}$$

The collected data were fitted to this equation by the least squares regression method, thereby enabling A, α and β to be estimated. Using the logarithmic

[6] See, for example, [4, pp. 373–74].

[7] For further information and references on learning-by-doing see, for example, [5, pp. 48–50].

[8] But A may also alter for other reasons as discussed in this paper.

form, an increase in A leads to a parallel upward shift in the isoquant corresponding to any level of output if α and β are constant.

C. *Survey Data and Data Used*

The data for our estimation were obtained for fifty-one out of the seventy-six weaving mills (all nationalized)[9] in Bangladesh through direct interviews by one of the authors, M. G. Kibria, during the period March–July 1981.[10] Of the three major regions in Bangladesh, the survey included nineteen mills in the Dhaka area, twelve in the Chittagong, and twenty in the Khulna zone. Care was taken to ensure that the sample, which is a relatively large one, was representative: mills of all sizes and from all regions were represented in it. The mills surveyed accounted for just under two-thirds of all the looms in the Bangladesh jute weaving industry. Together the surveyed mills accounted for 15,410 looms (5,084 sacking, 9,275 hessian, and 1,051 CBC looms) out of the industry's total of 25,877 (9,009 sacking, 14,463 hessian, and 2,405 CBC).

Data were collected mostly by direct examination of the records of individual mills and through interviews with key personnel. Individuals interviewed included project heads, production managers, quality control officers, accountants, statisticians, shift-supervisors, weaving sardars (foremen), and some weavers themselves.

Data were also provided by the Secretary, Ministry of Jute; directors and section heads of Bangladesh Jute Mills Corporation (BJMC); and directors of Bangladesh Jute Research Institute.

For each mill surveyed the following data were assembled for each year since its foundation; its annual output of cloth (fabric) measured in tons (weight), the number of looms operating each year, and the annual total number of hours for which all weavers were employed. These data were used to make various estimates of production functions of the type indicated in equation (1). Q was represented by the annual jute fabric output in tons, K by the number of operating looms in a given year and L by thousands of labor hours used in weaving. The rationale for using these measures is discussed in the next section.

D. *Organizing the Data for Estimation Purposes*

Physical data were collected because of their ready availability and in order to avoid the indexation problems inherent in monetary data.[11] The relative homogeneity within the jute weaving industry renders this a reasonable approach. Weaving mills established in the same period have adopted almost identical machinery so that the number of looms employed by a mill is a useful index of the amount of capital employed by it. The quantity of all capital employed is assumed to vary proportionately with the total number of looms used. Only the annual labor time (in thousands of hours) of weavers is used to measure labor

9 No private weaving mill exists so far in Bangladesh.

10 Specialized mills engaged in producing minor products are excluded from this sample.

11 For a full discussion and justification of the use of physical data in production functions, see [8, Sect. 8.3].

TABLE I
CLASSIFICATION OF WEAVING MILLS BY PERIOD IN WHICH ESTABLISHED (VINTAGE A, B, C) AND PERIOD IN WHICH OPERATED (0, 1, 2)

Period of Operation of Mill	Period in Which Mill Established (Vintage)		
	1954/55 to 1961/62 (A)	1962/63 to 1969/70 (B)	1970/71 to 1979/80 (C)
1954/55 to 1961/62	A0		
1962/63 to 1969/70	A1	B0	
1970/71 to 1979/80	A2	B1	C0

input. This is reasonable if the quantity of all other labor employed varies in proportion—or almost so—to the number of hours worked by weavers. The use of any other variable inputs such as yarn input is implicitly assumed to vary proportionately with the total output of cloth.

Even the cursory outline of technological change in the jute weaving industry given in Section A makes it clear that input-output relationships are heavily influenced by the vintage[12] or type of technology embodied in looms. The production functions corresponding to different weaving technologies need to be established separately.

As outlined in the first section, different types of looms were adopted in Bangladesh in the three distinct periods, 1954/55 to 1961/62, 1962/63 to 1969/70, and 1970/71 to 1979/80, which we identify separately as periods A, B, and C, respectively. Depending upon when it was established, each mill is assigned to category A, B, or C, which indicates the vintage of its looms.

Production functions were estimated for A-vintage mills for the period 1954/55 to 1961/62 using cross-section data, namely, the average annual output of each mill in this period (for the time it operated), its average number of operating looms and its average hours of labor used in weaving. This exercise was then repeated for the same group A mills for the periods 1962/63 to 1969/70 and 1970/71 to 1979/80. A similar exercise was undertaken for group B mills for the periods 1962/63 to 1969/70 and 1970/71 to 1979/80, and for group C mills for the single period 1970/71 to 1979/80. Table I identifies the six possibilities. The initial letter identifies the vintage of the plant and the following numeral, the period for which the production function is being estimated.

Production relationships for sacking were also separated from those for hessian so that distinct production functions could be estimated for both. On the other hand, the nature of the production of both hessian and CBC being the same and the nature of direct input requirements, i.e., the yarn, being identical (in both cases light yarn, the only difference being in width), the capital for CBC (i.e., all broad looms in our study) have been converted to hessian loom equivalents by using an appropriate multiplier (2.75, the width of CBC divided by the standard width of hessian).

Changes in production functions between groups A, B, and C may be ascribed

[12] For some discussion of vintages, see [11].

TABLE II
REGRESSION RESULTS: SACKING

Group	A	α	β	$\alpha+\beta$	β/α	$\frac{\alpha}{\alpha+\beta}$	$\frac{\beta}{\alpha+\beta}$	R^2	F-ratio
A0	2.973	0.307 (0.081) (3.775**)	0.686 (0.069) (9.878**)	0.993	2.235	0.309	0.691	0.908	74.292**
A1	3.138	0.264 (0.047) (5.58**)	0.721 (0.041) (17.614**)	0.985	2.731	0.268	0.732	0.968	224.410**
A2	3.095	0.288 (0.074) (3.906**)	0.654 (0.063) (10.407**)	0.942	2.271	0.306	0.694	0.916	81.617**
B0	3.259	0.196 (0.106) (1.843)	0.738 (0.118) (6.236**)	0.934	3.765	0.210	0.790	0.927	102.055**
B1	3.174	0.222 (0.113) (1.961)	0.712 (0.126) (5.653**)	0.934	3.207	0.238	0.762	0.918	90.042**

Note: Standard errors in first parentheses, t-values in second parentheses.
** One per cent level of significance.

to the adoption of new weaving machines incorporating changed technology whereas changes in production function that occur within groups (for example from A0 to A1, A1 to A2) may be ascribed to learning-by-doing or similar time-dependent influences.

E. *The Estimates*

Estimates of the production function for the vintages and periods set out in Table I are given in Table II for sacking and in Table III for hessian and CBC. As mentioned earlier, least squares linear regression was used to estimate the parameters in equation (3). However, no estimates have been given for sacking production for C vintage because the sample for 1970/71 to 1979/80 is too small. Only two of the mills established in the period 1970/71 to 1979/80 produced sacking.

F. *Interpretation of the Estimates*

The estimates need, in part, to be interpreted against political changes in Bangladesh that have affected the jute industry as they have everything else. The first of our periods, 1954/55 to 1961/62, was relatively stable from a political viewpoint and the second period, 1962–69, was politically very stable. However, the period 1970/71 to 1979/80 witnessed a great amount of political instability. Political unrest occurred in 1971, to be followed by the war of liberation from Pakistan. In 1972, with the emergence of the new nation of Bangladesh, the whole of the jute manufacturing industry was nationalized. This led to initial problems of organization because a considerable number of managers and skilled workers left the country (in many cases for Pakistan), new and not infrequently

TABLE III
REGRESSION RESULTS: HESSIAN AND CBC

Group	A	α	β	$\alpha+\beta$	β/α	$\frac{\alpha}{\alpha+\beta}$	$\frac{\beta}{\alpha+\beta}$	R^2	F-ratio
A0	1.987	0.369 (0.091) (4.034**)	0.609 (0.086) (7.091**)	0.978	1.65	0.377	0.623	0.961	183.453**
A1	2.196	0.316 (0.086) (3.698**)	0.645 (0.081) (7.936**)	0.961	2.041	0.329	0.671	0.966	210.064**
A2	2.071	0.337 (0.106) (3.18**)	0.596 (0.1) (5.972**)	0.933	1.769	0.361	0.639	0.943	124.207**
B0	2.224	0.220 (0.113) (1.944)	0.746 (0.116) (6.453**)	0.966	3.391	0.228	0.772	0.867	58.63**
B1	2.139	0.262 (0.107) (2.457*)	0.756 (0.109) (6.957**)	1.018	2.885	0.257	0.743	0.890	72.993**
C0	2.282	0.147 (0.104) (1.417)	0.830 (0.14) (5.909**)	0.977	5.646	0.150	0.850	0.881	33.357**

Note: Standard errors in first parentheses, t-values in second parentheses.
** One per cent level of significance.
* Five per cent level of significance.

inexperienced administrators were appointed to some mills, and trade unionism grew in strength and disrupted jute manufacture.[13] But return to stability (from the viewpoint of the industry) seems to have started towards the end of the seventies, with its peak in 1979/80 when profit earnings of the jute industry exceeded even those of 1969/70, the peak year before liberation [2].

It would obviously be improper to compare the performance figures for the periods 1962/63 to 1969/70 and 1970/71 to 1979/80 at face value. Group A2 and its chronological equivalents, B1 and C0, could be expected to show reduced productivity on account of political instability, independently of any changes stemming from the adoption of new technology or learning-by-doing that might have been continuing during the period. Thus our results need to be interpreted with this in mind.

It might be noted that equation (3) provides a good fit to the data in terms of R^2. All the R^2 values are high. The F-ratios enable us to reject the null hypotheses at either the 1 or 5 per cent significance level, and the t-values indicate that we can have a high degree of confidence in the parameter estimates.

1. *Variations in coefficient A and learning-by-doing*

The multiplicative factor, A, in the Cobb-Douglas production function tended

[13] For further background on historical developments, see [1] and [6]. The latter publication stresses the disruption to management following nationalization of the Bangladesh jute manufacturing industry. See also, [7].

to rise in the period following the introduction of new vintage machines, except when this period coincided with the liberation war, nationalization and managerial dislocation. Take sacking for example: The A-value corresponding to A-vintage machines or mills is 2.973 in period 0, rises to 3.138 in period 1 and, although it falls slightly to 3.095 in period 2 (which coincides with the war of liberation and other disruptions), it is still above the A0 figure. In the case of vintage B mills, the A-value is 3.259 in the initial period, but falls in the subsequent period to 3.174 (the period that coincides with the independence war and other disturbances).

Similar trends in A-values can be observed for hessian and CBC manufactures. However, here there is also some evidence for A-vintage mills or looms. In the initial period, the A-value for A-vintage mills is 1.987 and rises to 2.196 in the subsequent period (falling to 2.071 in the next period).

Making allowances for the liberation war and associated disturbances, the results are consistent with an A-value that rises at first and then declines. In the absence of disturbing factors, the A-value appears to peak in the period following the initial introduction of a new vintage loom and then to decline. This appears to be a unimodal function of the time for which a particular set of machines has been used.

The initial rise in A may reflect the contribution to output that comes as a result of learning-by-doing. The subsequent decline in A may reflect the fact that the machines are losing efficiency due to wear and tear and/or that some skilled management tends to be attracted to newer mills with more modern machines.

2. *Changes in capital intensiveness and the contribution of capital to production*

The capital intensiveness of both sacking and hessian/CBC as indicated by β/α has tended to rise over time. So also has the share of capital in total production due to labor and capital (as determined on a marginal productivity basis), that is, $\beta/(\alpha+\beta)$. This can be seen by considering changes that occur in production functions when new vintages of looms are installed.

In sacking production, β/α is higher for the initial use of vintage B machines than for the initial use of vintage A machines. In the former case, the ratio is 3.765, while it is 2.235 in the latter. This comparative position, however, is not maintained for the second period of use of these machines, although it may be appropriate to ignore this because of the disturbing influence of the war of liberation.

For hessian and CBC production, during the initial phase of production using a new technique, β/α is greater the later the vintage of the looms. Thus for A vintage it is 1.65; for B 3.391 and for C 5.646. Capital intensity therefore rises with the adoption of later techniques.

Capital's proportionate contribution to the share of total output (explained by the marginal productivity of labor and capital) has tended to rise with the adoption of machines of later vintage. For A-vintage sacking machines, $\beta/(\alpha+\beta)=$ 0.691 for the initial period whereas for B-vintage machines the corresponding value is 0.790. Comparison of the other phases is complicated by the war of liberation. As for hessian and CBC, the proportionate share contributed by capital in the initial period of its use rises consistently with the vintage of machines. The ratio $\beta/(\alpha+\beta)$ for A, B, and C vintage mills is respectively 0.623, 0.772, and 0.850. Allowing for the implications of disruption caused by the war of liberation, an upward trend in $\beta/(\alpha+\beta)$ is also present for later techniques when other phases of use are compared according to vintage.

Within vintages there seems to be a tendency for $\beta/(\alpha+\beta)$ to first rise with time and then to fall. In the absence of political disruption, this ratio tends to be higher for each vintage in the second period than in the first period of use and then appears to decline. The pattern is, therefore, somewhat similar to that observed for coefficient A. The proportion of total output attributed to capital seems to rise at first with the installation of new machines and then declines. This implies that the proportion of output attributable to labor at first falls after a new machine is installed, but that after a time the share due to labor begins to rise.

While this may reflect learning-by-doing relationships, it is also possible that machinery reaches its greatest efficiency in terms of operational reliability in the second phase. In later phases of operation machinery may require much more care and more labor may be necessary to compensate for the declining technical efficiency of capital (though in our case, certain allowance should be made for the consequence of the war of liberation). Consequently, labor share in production may tend to rise once more.

A-vintage mills can be used to illustrate this tendency. In the case of sacking, the proportion of output attributable to capital in the initial period is 0.691, rises to 0.732 in the next period, but falls to 0.694 in the third period which is, of course, still higher than the initial period. In hessian and CBC, the pattern is the same, with the respective ratios being 0.623, 0.671 and 0.639.

3. *Economies of scale*

For all the production functions estimated, except in period B1 for hessian and CBC, $\alpha+\beta<1$, so decreasing returns to scale prevail, although they are not marked because $\alpha+\beta$ is not greatly less than unity. Decreasing returns to scale are more marked in sacking than hessian and CBC. For sacking, $\alpha+\beta$ tends to be in the range from 0.934 to 0.993 whereas in hessian and CBC production it exceeds 1—but only marginally (1.018)—in phase B1. There does not appear to have been marked change in economies of scale in the jute weaving industry in Bangladesh during the period covered by our study.

G. *Conclusions*

There is evidence that the multiplicative contribution to jute weaving output (indicated by coefficient A in the Cobb-Douglas function) rises for a new jute weaving mill (using new techniques) for some time after its establishment and then falls. This pattern may be explained by the combined influences of learning-by-doing, the eventual decline in efficiency of older machines, and the possibility that some of the experienced management may leave older mills to manage newer ones.

With the introduction of new looms incorporating newer techniques, the capital intensity involved in both the weaving of sacking and hessian/CBC in Bangladesh has tended to rise. Consequently, the labor intensity of weaving has tended to decline. This trend may be of interest to those who believe that labor-intensive techniques are more appropriate to developing countries than capital-intensive ones.

Furthermore, in terms of proportions of total output attributable to labor and capital, the share attributable to capital has tended to rise in Bangladesh with the introduction of new looms embodying new technology, while the share attributable to labor has tended to fall.

Economies of scale in the Bangladesh jute weaving industry appear to have altered little as a result of technological change. Although decreasing returns to scale do occur, they have remained close to constant.

REFERENCES

1. AHMAD, Q. K. "The Jute Manufacturing Industry of Bangladesh, 1947–74" (Ph.D. diss., University of London, 1976).
2. Bangladesh, Ministry of Jute. *Press Bulletin,* May 1981.
3. BROWN, M., and POPKIN, J. "A Measure of Technological Change and Returns to Scale," *Review of Economics and Statistics,* Vol. 44, No. 4 (November 1962).
4. CHIANG, A. C. *Fundamental Methods of Mathematical Economics* (New York: McGraw-Hill, 1967).
5. HAY, D. A., and MORRIS, D. J. *Industrial Economics: Theory and Evidence* (Oxford: Oxford University Press, 1979).
6. International Bank for Reconstruction and Development. *The World of Jute Economy,* Vol. 2, *Production in Bangladesh* (Washington, D.C.: International Development Agency, 1973).
7. ———. *Bangladesh: Survey of the Jute and Cotton Textile Industries* (Washington, D.C.: International Development Agency, 1976).
8. INTRILIGATOR, M. D. *Econometric Models, Techniques and Applications* (Amsterdam: North-Holland Publishing Co., 1978).
9. MUJERI, M. K. "The World Market for Jute: An Econometric Analysis" (Ph.D. diss., McMaster University, 1978).
10. MUSTAFA, G. "An Analysis of the World Jute Economy and Its Implications for Bangladesh" (Ph.D. diss., University of Exeter, 1978).
11. SALTER, W. E. G. *Productivity and Technical Change* (Cambridge: Cambridge University Press, 1969).