The Use of Input-Output Analysis to Determine the Appropriateness of Technology and Industries: Evidence from Bangladesh*

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I. Introduction

Since the proportion of available capital to labor is low in LDCs compared to the developed countries, the most appropriate techniques for LDCs, from an economic point of view, are likely to be the labor-intensive ones. If we suppose that there is a single most efficient technique for each industry, and if it technologically requires labor and capital in fixed proportions, the most appropriate industries for LDCs are likely to be the labor-intensive ones. This is because of the close correspondence between industries and their technological requirements. On an international scale this appropriateness is given some support by the Heckscher-Ohlin theorem of international specialization in production. As is well known, this theorem indicates (subject to various assusmptions) that countries should specialize in the production of goods that make use of their relatively abundant factors of production.[1]

The aim of this paper is to identify appropriate industries for Bangladesh in view of the relative availability of labor and capital and taking into account the amount of labor and capital needed both directly and indirectly to produce output for each industry. Unfortunately, as specified below, a number of previous studies of appropriate techniques and industries have ignored the indirect requirements for labor and capital needed to produce the various intermediate products used in these industries. Interindustry analysis, based on the assumption that the adopted techniques require inputs to be combined in fixed

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proportions, is used in order to take account of these wider resource links.[2] It might be noted that even if the choice of technique is not based purely on economics and technology but involves sociological factors such as the supposed predilections of engineers in less developed countries for adopting Western-style techniques, the interindustry analysis can be applied assuming that the sociological bases of choices are continuing predictable phenomena and are specific to particular industries.

Once the viewpoint is adopted that industries require fixed capital-to-labor ratios for production (or will use techniques that require this), the next step is to consider empirically the capital/labor requirements of the industries within a country. Following the path-breaking analytical work by Eckaus,[3] this has been done by writers such as Stewart and Streeten,[4] Stewart,[5] and Pack.[6] However, the studies of these writers have only concentrated on the direct capital and labor requirements of individual industries in relation to value added within industries. This neglects the fact that the materials and intermediate products used in the production of each industry and supplied by other industries may have specific capital and labor requirements. Account can only be taken of these requirements by means of interindustry analysis of which input-output is one operational form. The use of direct capital-to-labor ratios to estimate the total (direct plus indirect) labor-capital intensities of industries can lead to significant biases and give rise to a misleading picture for planning purposes. Biases are most likely to arise when an industry uses a high proportion of intermediate products or materials in relation to the value of its output. Errors arise if the proportion of capital to labor embodied in these inputs differs significantly from that in the purchasing industry. Bias is likely to be lowest in primary industries that buy few inputs and in service industries that also buy few inputs. Manufacturing industries (especially where they involve important inputs that have gone through various earlier manufacturing stages) may be prone to bias when direct, rather than total, capital and ratios are considered.

This paper addresses the issue of appropriateness of Bangladeshi industries in terms of total (direct and indirect) factor requirements and proportions and is based on an input-output framework that takes account of the structural interdependence of industries. To measure the effect of an alteration in sectoral final demand, one should take into account both direct linkages as well as indirect impact.[7] Input-output analysis reveals total input requirements, which are the sum of direct requirements of production from a particular sector plus the indirect requirements that include the input requirements for intermediate products (such as electricity, chemicals, raw cotton, steel, etc.) consumed by the sector. The indirect effects are important in that, depending on the strength of intersectoral linkages, it is quite possible for a

sector to show greater need for output and input elsewhere within the economy than within the sector itself or greater need than is apparent from direct linkages.

We made use of the latest available 47-sector input-output table to consider the appropriateness of Bangladeshi industries,[8] given their labor/capital requirements and the relative availability of labor and capital in Bangladesh. Bangladesh, like all LDCs, is characterized by a low ratio of available capital to labor. For Bangladesh, to maintain or expand industries requiring higher ratios of capital to labor than available overall in the economy can add to unemployment or underemployment and reduce output available to satisfy final demand. Furthermore, where industries have similar relative factor intensities, some may be more efficient than others in supplying production to satisfy final demand.

Following an outline of the analytical framework adopted, we discuss the data used for determining output, capital, and labor requirements (both direct and indirect) for a unit expansion in final demand of each of the Bangladeshi industries specified in the 1976–77 input-output table. We indicate how capital and labor availability has been estimated for Bangladesh, and this is followed by the presentation of empirical results. After discussing the degree of dependence of each industry or sector on inputs from outside the industry or sector, the factor intensities of different industries in producing a unit of final demand are outlined. Comparing these intensities with ratios of available as well as employed labor and capital, industries with inappropriate factor proportions can be identified. The paper identifies systematic errors that arise in the Bangladesh context when direct rather than total K/L (capital-to-labor) ratios are used to estimate required capital/labor for industry production.

II. Analytical Framework

The analysis is based on a Leontief open input-output model.[9] Basically, the technology of each industry is assumed to be such that inputs are required in fixed proportions and constant returns to scale prevail. These are limiting assumptions but may hold at least for small changes in the economy. The usual limitations of static input-output analysis apply, and one has to be cautious in interpreting the results. Nevertheless, it is still possible to obtain significant pointers from an input-output overview that takes account of production interdependence in the economy as a whole.

We employ the open static Leontief model to determine the total (direct and indirect) output and input (labor and capital) requirements to satisfy a unit increase in sectoral final demand. The basic model is as follows:

A. Total Output Requirements
Define

$$Q = (I - A)^{-1} = (Q_{ij}), \tag{1}$$

where A is the matrix of technical coefficients. In the technology matrix, A, the elements a_{ij} represent the value of the commodity i required to produce one unit (by value) of commodity j. Each column of this matrix specifies the commodity-input requirements for one unit of output of the particular industry corresponding to the column.[10] The component $(I - A)$ is the "Leontief matrix" that can be used after it has been inverted, as has been done in equation (1), to determine the overall production required from each of the industries of the economy to produce one unit of net output by industry j to satisfy final demand. To be more precise, $\Sigma_i Q_{ij}$ measures total (direct and indirect) output required to satisfy a unit increase in the final demand for the output of sector j.

Now

$$\begin{aligned} Q = (I - A)^{-1} &= (I + A + A^2 + \ldots + A^n) \\ &= (I + A) + \sum_{\theta=2}^{n} A^{\theta}. \end{aligned} \tag{2}$$

The first term in equation (2) refers to the direct effect, while the second refers to the indirect effect. Thus for the jth sector, direct effect (say, α_j) of a unit change in final demand is given by

$$\alpha_j = \left(1 + \sum_i a_{ij}\right), \tag{3}$$

where a_{ij} is an element of A. The indirect effect measures the further variation in production required from industries to support the direct demands on production as a result of change in final demand.

B. Total Capital Requirements
Define

$$K = (\hat{k})(I - A)^{-1} = (K_{ij}), \tag{4}$$

where $\hat{k}$ is the diagonalized matrix of capital coefficients. Then $\Sigma_i K_{ij}$ measures total (direct and indirect) capital required to sustain a unit increase in the final demand for the output of sector j. For the jth sector, direct-capital requirement (say, β_j) of a unit increase in final demand is given by

$$\beta_j = \left(k_j + \sum_i k_i a_{ij}\right). \tag{5}$$

This expression indicates that the direct-production requirements from each industry need to be multiplied by capital/output ratios (coefficients) for each industry to estimate direct capital requirements stemming from final demand for an industry's production.

C. Total Labor Requirements

Define

$$L = (\hat{l})(I - A)^{-1} = (L_{ij}), \tag{6}$$

where $\hat{l}$ is the diagonalized matrix of labor coefficients.

Then $\Sigma_i L_{ij}$ = total (direct and indirect) labor input required to sustain a unit increase in the final demand for the output of the jth sector. The direct requirement of labor input from this sector (say, γ_j) of a unit increase in final demand is given by

$$\gamma_j = \left(1_j + \sum_i l_i a_{ij}\right). \tag{7}$$

In order to estimate direct labor requirements stemming from final demand for an industry's production, the direct production requirements from each industry need to be multiplied by the labor/output ratios (coefficients) for each industry. The indirect output and input requirements can be derived as residuals from their respective totals once the direct effects are known.

The model assumes two primary inputs (labor and capital) and allows for interdependence between industries in production. Total output (Q), total capital (K), and total labor (L) requirements so derived can be employed to find both total and direct relative-factor intensities and input requirements. To examine how far the factor-use pattern is consistent with factor proportions, ratios of (a) total available capital to total employed labor, and (b) total available capital to total available labor need to be considered. They are respectively defined as $\Sigma k_i x_i / \Sigma l_i x_i$ and $\Sigma k_i x_i / N$, x_i being the output of sector i and N the total available labor in the economy.

III. The Basic Data

For the purpose of the present analysis, the latest available 47-sector input-output table has been used.[11] It relates to 1976–77 and provides data on sectoral output and capital coefficient vectors. The methods used to estimate the capital coefficients are discussed by the Bangla-

desh Planning Commission (BPC).[12] By multiplying sectoral outputs by the capital coefficients, we obtain the estimates of the amount of capital used in each of the sectors. These estimates of the quantity of capital used in each of the sectors are set out in table 1 together with output levels. The aggregate amount of capital stock employed in the economy in 1976–77 is estimated to be Tk 223,658 million.

The employment figures used to derive sectoral labor coefficients were estimated by Alauddin from a number of sources.[13] This was necessary because estimates did not accompany the 1976–77 input-output table. Without going into the controversies surrounding conceptual and measurement issues, labor employment is defined to include only those persons who were actually engaged in various sectors of the economy. Labor requirements for the agricultural crop sectors were estimated by using per acre labor requirement data for various crops from BPC.[14] This required a consideration of distribution of acreage by variety of crops and use of irrigation by techniques, and details of these variables were obtained from Bangladesh Bureau of Statistics (BBS).[15] Estimation of labor requirements for livestock, forestry, and fisheries sectors posed special problems, since information was not available from the previously mentioned sources. The 1976–77 employment figures for these sectors were estimated by taking the 1975–76 estimates of Clay and Khan.[16]

The derivation of employment figures for the sectors within the nonagricultural complex involved approximation and arbitrariness to a certain degree. This was unavoidable because employment data according to the sector-classification scheme used in the input-output table were not directly available from any official source. Various bodies provide employment data on the basis of broad categories of economic activity,[17] for example, industry (large and medium, small and cottage), construction, services, transport, finance and banking, and so forth. Industrial employment was estimated to be in the vicinity of 1.2 million man-years.[18] It consists of employment in large and medium firms (about .4 million), in handloom industries (.2 million), and in small and cottage industries (about .6 million). The Census of Manufacturing Industries employment figures (for large and medium industries) available from the BBS were used as they broadly conform with the sector classification of the input-output table.[19] Small and cottage industry figures were allocated to different industries according to the proportion of their value added except for those industries where the small and cottage industry category was known to be nonexistent. These included sectors such as fertilizer, petroleum products, cement, and basic metals.[20] For mill-made cloth, jute textiles, and cotton yarn, no addition was made for small-scale and cottage-produced goods as it was included in the handloom sector. For the other nonagricultural sectors, construction (.4 million), trade (.99 million), finance and bank-

TABLE 1

OUTPUT, CAPITAL STOCK, AND EMPLOYMENT BY SECTOR: BANGLADESH, 1976–77

Number	Sector Name	Output (in Million Taka)	Capital (in Million Taka)	Employment (in Thousands of Man-Years)
01	Rice	33,700.1	32,470.143	6,910.272
02	Wheat	694.1	684.868	65.508
03	Jute	3,218.6	1,373.377	732.512
04	Cotton	1.1	.394	.368
05	Tea	650.0	586.430	24.480
06	Other crops	11,197.4	1,700.885	827.968
07	Livestock	8.941.5	939.752	1,143.560
08	Fisheries	9,232.7	6,870.976	631.960
09	Forestry	1,956.5	484.038	111.872
10	Sugar	3,410.1	574.602	104.983
11	Edible oil	1,221.3	157.792	23.511
12	Salt	849.6	23.789	74.812
13	Tobacco	2,379.1	97.305	20.965
14	Other food	2,681.6	106.996	110.523
15	Cotton yarn	1,562.5	1,092.188	44.905
16	Cloth: mill-made	725.1	422.153	16.885
17	Cloth: handloomed	4,812.0	1,275.180	200.000
18	Jute textile	2,995.5	2,814.572	184.062
19	Paper	604.1	833.054	8.992
20	Leather	3,400.3	775.604	70.780
21	Fertilizer	893.5	2,256.981	5.042
22	Pharmaceuticals	870.2	1,194.089	11.475
23	Other chemicals	1,492.5	2,048.009	29.659
24	Cement	450.9	1,173.061	2.305
25	Basic metals	2,319.4	1,065.532	8.504
26	Metal products	968.8	1,000.770	28.249
27	Machinery	912.9	1,129.075	14.071
28	Transport equipment	473.1	454.838	8.920
29	Wood	894.1	132.237	43.076
30	Miscellaneous industries	5,059.3	3,930.064	155.031
31	Urban house building	2,575.4	217.106	74.840
32	Rural house building	2,640.9	101.411	67.720
33	Nonresidential building	1,296.4	153.105	37.120
34	Construction: electricity and gas	1,183.1	48.625	45.760
35	Construction: transport	1,209.2	52.358	53.360
36	Other construction	986.0	25.537	121.200
37	Petroleum	2,026.9	1,185.736	.456
38	Electricity	555.5	5,322.134	4.863
39	Gas	162.4	1,268.376	5.137
40	Transport service	7,052.3	22,506.709	400.000
41	Trade service	10,039.7	15,597.678	990.000
42	Housing service	10,219.7	85,163.820	1,196.900
43	Health	1,253.6	1,953.610	103.100
44	Education	2,191.3	3,307.548	281.100
45	Public administration	3,835.4	5,774.194	369.800
46	Banking and insurance	1,578.4	2,776.406	70.000
47	Other services	4,974.1	10,534.646	659.000
Total			223,657.750	16,095.124

ing (.07 million), electricity and gas (.01 million), transport (.4 million), and services (2.61 million), employment figures were allocated for different component sectors according to the proportion of their value added in the broad category of economic activity to which they belonged. The amount of labor employed in each sector is set out in table 1. The total amount of labor actually employed in the Bangladesh economy in 1976–77 is estimated to be 16.095 million man-years.

The total available supply of labor exceeds that actually employed. Bangladesh population figures for 1976–77 were utilized to estimate total available labor supply.[21] The size of the civilian labor force was calculated assuming a 33.9% participation rate.[22] The figure so derived was converted into standard units on the basis of the age and sex composition of the labor force in the 1974 census.[23] A conversion factor of 0.50 was used for laborers in the 10–14 and over-55 age groups. Female workers were converted into standard man units using a conversion factor of 0.75. Taking all these into account, the total available labor for 1976–77 is estimated to be about 24.41 million man-years. It should be noted that other available estimates do not take into account the age and sex composition of the labor force.[24] Despite arbitrariness in our assumption concerning the conversion into standard man-units, this aspect cannot be ignored. If no conversion factor is used, the total amount of available labor in 1976–77 is (using Clay and Khan's suggested participation rate of 33.9%) 28.03 million man-years. Undoubtedly it is difficult to estimate precisely the total amount of labor willing to work in the economy. The two estimates could provide the lower and upper limits of the actual labor force available for work. However, available labor is considerably in excess of that actually employed. Our estimates using conversion factors indicate involuntary employment or underemployment equal to at least one-third of the total available labor force, but this rises to over 40% if conversion units are not used. The basic argument is not affected by the precise proportion of the labor force unemployed or underemployed. Even allowing for errors of approximation, some industries are clearly inappropriate for Bangladesh given the labor-capital availability. These industries can be identified.

IV. Empirical Results

Input-output analysis is well placed as a technique to highlight production interdependence between sectors of an economy, and the 1976–77 input-output table for Bangladesh indicates that some sectors depend heavily on resources from other sectors, whereas others show little dependence on other sectors. Using the estimates of proportions of direct to total requirements of output, capital, and labor to sustain a unit of final demand, industries based directly on living resources (agriculture, fisheries, and forestry) and the service industries show little

relative dependence on other industries for inputs in producing output to satisfy final demand. They also require relatively little employment of labor and capital in other sectors. However, the construction and energy industries are relatively heavily dependent on other sectors for inputs, whereas manufacturing industries show an intermediate degree of dependence. However, sectoral linkages or dependence (or independence) of sectors are not the main concern in this paper. This has been discussed elsewhere.[25] The main purpose of this paper is to consider the appropriateness of various industries to Bangladesh in the light of capital-labor ratios required in the industries and the availability of capital and labor in the economy.

Table 2 sets out the estimated capital-labor ratios of the sectors of the Bangladesh economy in descending order of total (direct and indirect) capital-labor requirement per unit of final demand. It is very difficult to determine precisely which industries are inappropriate in terms of their capital-labor ratios. However, the ratio of capital to employed labor in the economy is estimated to be 0.0139. Industries requiring capital and labor in a higher ratio than this certainly appear to be inappropriate. However, available labor exceeds that employed. If such labor happened to be employed, the capital-labor ratio would be 0.0092, using conversion factors, or 0.0080, if conversion units are not used. In any case, sectors such as electricity, gas, petroleum, cement, fertilizer, housing and transport services, paper, and basic metals involve higher capital-labor ratios in terms of techniques used than seem appropriate to factor availability in the economy.[26] When considered in terms of direct relative-factor intensity, the rankings change very little as indicated by the value of the rank correlation coefficient (0.9713). Nevertheless, if the dividing line of $K/L = 0.0139$ is applied, industries such as tobacco, rural house building, and transport-related construction, which seems to be clearly inefficient if the total relative-factor intensity criterion is used, do not appear to be so if one uses the direct criterion. Thus, if the direct capital-labor ratio criterion is used, some sectors will appear appropriate that are not so when the total criterion is used.

To pursue the point of identifying appropriate industries in terms of total as well as direct capital ratios, we have employed a linear regression estimate to relate the observed direct ratios to the observed total ratios. The total K/L and direct K/L values for the 47 Bangladeshi industries listed in table 2 are plotted in figure 1. The following line gives the best fit to the data for Bangladesh:

$$\text{Total } K/L = 0.01508 + 0.4281 \text{ Direct } K/L, \text{ with} \qquad (8)$$

$$R^2 = 0.8420, \; t\text{-value} = 15.487.$$

Since the first term of equation (8) is close to zero, the actual direct K/L

TABLE 2

CAPITAL-LABOR RATIOS (Total and Direct Requirements) FOR FINAL DEMAND BY SECTORS: BANGLADESH ECONOMY, 1976–77

Number	Sector	Total	Rank	Direct	Rank	Difference	Difference (%)
38	Electricity	.2339	01	.6214	01	−.3875	−165.67
39	Gas	.2049	02	.2287	02	−.0238	−11.62
37	Petroleum	.0945	03	.1712	03	−.0767	−81.67
24	Cement	.0774	04	.1105	04	−.0331	−42.76
21	Fertilizer	.0715	05	.0997	05	−.0282	−39.44
42	Housing service	.0666	06	.0691	06	−.0025	−3.75
40	Transport service	.0605	07	.0566	09	.0039	6.45
19	Paper	.0558	08	.0570	08	−.0012	−2.15
25	Basic metals	.0507	09	.0571	07	−.0064	−12.62
27	Machinery	.0438	10	.0477	10	−.0039	−8.90
22	Pharmaceuticals	.0387	11	.0441	11	−.0054	−12.24
26	Metal products	.0373	12	.0349	14	.0024	6.43
28	Transport equipment	.0369	13	.0362	13	.0007	1.90
46	Banking and insurance	.0366	14	.0365	12	.0001	.27
30	Miscellaneous industries	.0299	15	.0281	17	.0017	5.69
23	Other chemicals	.0298	16	.0317	15	−.0019	−6.38
05	Tea	.0291	17	.0244	18	.0047	16.15
33	Nonresidential building	.0275	18	.0198	20	.0077	28.00
31	Urban house building	.0255	19	.0171	22	.0084	32.94
35	Construction: transport	.0251	20	.0124	28	.0127	50.60
34	Construction: electricity and gas	.0250	21	.0150	25	.0100	40.00

43	Health	.0236	22	.0203	19	.0033	13.98
45	Public administration	.0196	23	.0176	21	.0002	10.20
32	Rural house building	.0188	24	.0108	32	.0080	42.55
13	Tobacco	.0176	25	.0123	29	.0053	43.08
41	Trade service	.0174	26	.0166	23	.0008	4.60
47	Other services	.0162	27	.0161	24	.0001	.62
16	Cloth: mill-made	.0159	28	.0301	16	−.0142	−89.31
08	Fisheries	.0146	29	.0132	27	.0014	9.59
02	Wheat	.0136	30	.0117	31	.0019	13.97
18	Jute textile	.0126	31	.0095	33	.0031	24.60
44	Education	.0126	32	.0120	30	.0006	5.00
14	Other food	.0120	33	.0084	34	.0031	25.83
17	Cloth: handloomed	.0115	34	.0150	26	−.0035	−29.17
11	Edible oil	.0113	35	.0075	36	.0038	33.63
20	Leather	.0106	36	.0087	35	.0019	17.92
10	Sugar	.0103	37	.0072	37	.0031	30.10
29	Wood	.0088	38	.0067	39	.0021	23.86
36	Other construction	.0080	39	.0030	45	.0050	62.50
09	Forestry	.0078	40	.0069	38	.0009	11.54
15	Cotton yarn	.0076	41	.0061	40	.0015	19.74
06	Other crops	.0069	42	.0054	41	.0015	21.74
01	Rice	.0059	43	.0052	42	.0007	11.86
12	Salt	.0052	44	.0041	43	.0011	21.15
03	Jute	.0043	45	.0034	44	.0009	20.93
04	Cotton	.0035	46	.0025	46	.0010	28.57
07	Livestock	.0029	47	.0023	47	.0006	20.69

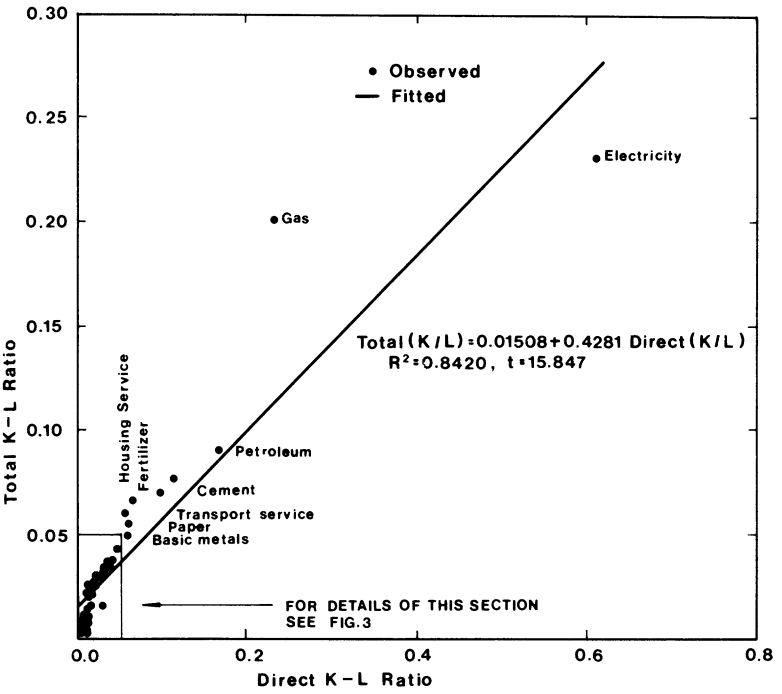

FIG. 1.—Direct K/L ratios and total K/L ratios for 47 Bangladeshi industries listed in table 2.

values tend to *overestimate* the total K/L values—that is, total K/L values are a fraction of the direct K/L values. This can be seen more clearly by taking the difference between the total K/L and direct K/L figures. The differences are shown in figure 2. Fitting a linear regression to the observations, we obtain:

$$\text{Difference } K/L = 0.01508 - 0.5719 \text{ Direct } K/L, \text{ with} \qquad (9)$$
$$R^2 = 0.9049, \; t\text{-value} = 20.687.$$

This indicates that for a direct K/L value of greater than 0.0264, direct K/L underestimates the total K/L, and the underestimate becomes larger as direct K/L rises. For direct K/L values less than 0.0264, direct K/L overestimates the total K/L values. For large direct K/L values, total K/L is significantly underestimated by direct K/L, whereas it is overestimated for very low direct K/L values. The error that arises in the use of direct K/L values as estimates of total K/L values rises with the size of direct K/L. Taking the absolute difference between total K/L and corresponding direct K/L values, and fitting a linear regression line to the scatter, the following results emerge:

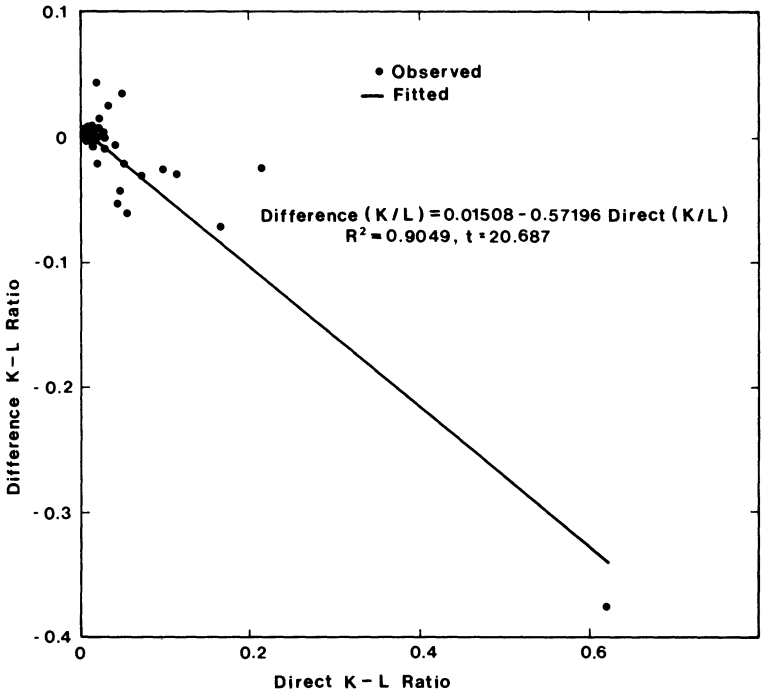

FIG. 2.—Difference between direct K/L ratio and total K/L ratio as a function of direct K/L ratio for 47 Bangladeshi industries listed in table 2.

$$\text{Absdiff } K/L = -0.00997 + 0.55765 \text{ Direct } K/L, \text{ with} \quad (10)$$

$$R^2 = 0.8904, \; t\text{-value} = 19.123.$$

It is clear that direct K/L ratios can be poor indicators of total K/L ratios, and (at least, in the case of Bangladesh) systematic errors that vary with the size of direct K/L appear to be present. The size of the absolute error term tends to be less for primary industries than for manufacturing, construction, and energy industries.

In the critical area for choice of industries or techniques, use of the available amount of capital in relation to the direct K/L values, rather than total values, can give rise (as illustrated below) to misleading results. However, if one merely wishes to exclude industries with the *most* unfavorable K/L ratios, even direct K/L ratios will appear to give an adequate guide to these. For example, industries ranked by total criterion from 1 to 17 in table 2 would be inappropriate on either the basis of total K/L ratios or direct K/L ratios.

In figure 3, we identify appropriate industries in terms of direct as well as total factor intensities. To avoid clutter we have not shown the sectors (ranking 01–09 in table 2) that lie clearly to the northeast of the rectangular OAMB region. The lines $\overline{OA}$ and $\overline{OB}$ mark the ratio of

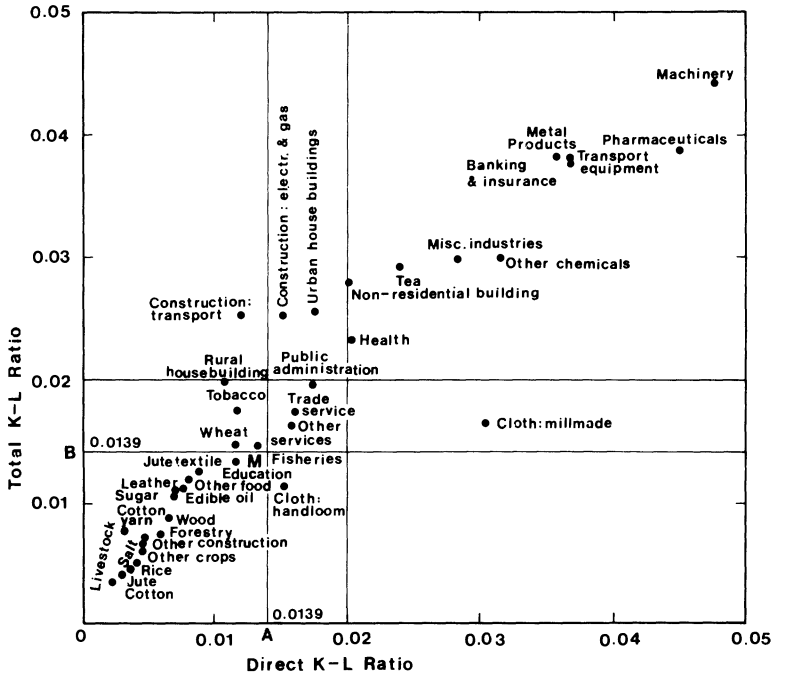

FIG. 3.—Total *K/L* ratios and direct *K/L* ratios for Bangladeshi industries with a total *K/L* ratio of less than .05. Appropriate industries can be selected using these industries and capital-labor availability in the economy.

available to employed labor (.0139). Figure 1 shows all the sectors. A total of 17 industries falling within the area circumscribed by OAMB appear to be appropriate in terms of either of the two ratios. On the total *K/L* criterion, four other sectors—namely, fisheries, tobacco, rural house building, and transport construction—seem appropriate. Handloomed cloth seems to be inappropriate on total *K/L* basis even though it appears appropriate in terms of direct *K/L*. Nevertheless, given unavoidable problems in the quality of the data, it may be wise to take a conservative view and only regard those industries requiring quite high capital-labor ratios as being inappropriate. Considering all these, if one sets an upper limit of .02 for both direct and total *K/L* ratios, we get the following picture of appropriate industries (in addition to those mentioned above): (1) appropriate direct *K/L* ratio: handloomed cloth, other services, trade service, public administration, electricity and gas construction, urban house building, nonresidential building, health; (2) appropriate total *K/L* ratio: fisheries, tobacco, rural house building, other services, trade service, mill-made cloth, public administration; (3) appropriate in total but not included in no. 1: rural house building, mill-made cloth; (4) inappropriate in total but included in no. 1: electricity and gas construction, urban house build-

ing, nonresidential building, health. We have already noted hand-loomed cloth to be appropriate on the basis of the total criterion and fisheries and tobacco on the direct one when the dividing line of $K/L = 0.0139$ is applied. In terms of table 2, capital-labor ratios are lowest in agriculture and highest in construction and energy. Broadly speaking, agricultural sectors and agroindustries are most appropriate for Bangladesh's available resources.

If one considers capital to be the factor that is basically in short supply in Bangladesh (the limiting factor to production) then it is instructive to consider the capital requirements (direct and indirect) of the sectors of the Bangladesh economy for fulfilling one unit of final demand. Table 3 shows the sectors in terms of descending capital requirements. Note that agricultural industries have a low capital requirment per unit of final demand satisfied. It could be argued that these industries should be given priority in investment. When the direct requirements of capital per unit of final demand is considered and sectors are ranked accordingly, the picture does not change much for the sectors within the agricultural and agroindustries complex. As a result, the coefficient of rank correlation is quite high (.8582). However, some significant changes in ranks of some sectors can be noticed. On the direct K/L criterion, petroleum, transport construction, and nonresidential building seem to have quite low capital requirements even though they rank relatively high in terms of the total requirement criterion. However, sectors like education, wheat, trade services, other services, and banking and insurance on the direct criterion show much higher ranking than on the total criterion.

It might be noted that if capital (K) required per unit of final demand is plotted against the capital/labor ratio (K/L) for each sector the scatter diagram in figure 4 emerges. A linear regression of the two variables gives the best fit line as

$$K = 1.0182 + 52.1724\ K/L, \text{ with} \qquad (11)$$

$$R^2 = .8403,\ t\text{-value} = 15.387.$$

As the K/L ratios of industries rise, there is a tendency for the amount of capital required per unit of final demand to increase. This would imply that industries with low K/L ratios tend to give a higher per unit return on capital invested (in terms of final demand satisfied) than those sectors with high K/L ratios. Thus in terms of attaining the highest returns on capital, a case can be made for directing the limited amount of capital toward industries with low K/L requirements per unit of final demand. From table 3 these can be seen to be the "agricultural" industries and agroindustries. It can also be seen that, on this basis, construction and energy industries ought to be avoided as investment outlets, except to the extent necessary to support favored industries.

Table 4 ranks industries in direct as well as total labor require-

TABLE 3

TOTAL AND DIRECT CAPITAL REQUIREMENTS PER MILLION TAKA OF FINAL DEMAND: BANGLADESH, 1976–77

Number	Sector	Total	Rank	Direct	Rank	Difference	Difference (%)
38	Electricity	14.7699	01	11.3731	01	3.3968	23.00
42	Housing service	8.5894	02	8.3474	02	.2420	2.82
39	Gas	8.1783	03	7.9451	03	.2332	2.85
37	Petroleum	7.2518	04	1.2744	25	5.9774	82.43
24	Cement	5.9033	05	4.3663	04	1.5370	26.04
21	Fertilizer	4.7748	06	4.0653	05	.7095	14.86
40	Transport service	4.5351	07	3.4583	06	1.7068	23.74
19	Paper	4.2063	08	2.3857	07	1.8206	43.28
22	Pharmaceuticals	3.2724	09	2.3315	08	.0949	28.75
30	Miscellaneous industries	3.0339	10	1.7674	16	1.2665	41.74
23	Other chemicals	2.9549	11	2.2759	09	.6789	22.98
43	Health	2.9196	12	2.0153	11	.9043	30.97
16	Cloth: mill-made	2.8768	13	1.6195	20	1.2573	43.71
27	Machinery	2.8441	14	2.0021	13	.8420	29.61
18	Jute textile	2.8119	15	1.8094	15	1.0025	35.65
35	Construction: transport	2.7064	16	.7557	37	1.9507	72.08
33	Nonresidential building	2.6923	17	.9583	30	1.7343	64.41
31	Urban house building	2.4916	18	.8628	32	1.6288	65.37
45	Public administration	2.4498	19	1.9452	14	.5046	20.60
26	Metal products	2.4059	20	1.6074	19	.7355	30.57
46	Banking and insurance	2.2894	21	2.3315	12	.2745	11.99

28	Transport equipment	2.2747	22	1.6839	18	.5907	25.97
15	Cotton yarn	2.2611	23	1.3010	24	.9602	42.46
47	Other services	2.1829	24	2.1486	10	.0343	1.57
34	Construction: electricity and gas	2.1616	25	.7672	36	1.3944	64.51
17	Cloth: handloomed	2.1238	26	1.1323	28	.9915	46.69
25	Basic metals	1.9966	27	1.0638	29	.9328	46.72
05	Tea	1.9610	28	1.3256	23	.6353	32.40
41	Trade service	1.8735	29	1.7020	17	.1715	9.15
02	Wheat	1.7606	30	1.3762	22	.3844	21.83
44	Education	1.6855	31	1.5633	21	.1222	7.25
32	Rural house building	1.6319	32	.6300	38	1.0019	61.40
20	Leather	1.3846	33	.7970	34	.5876	42.44
01	Rice	1.3840	34	1.1732	26	.2108	15.23
08	Fisheries	1.3702	35	1.1544	27	.2157	15.75
14	Other food	1.5388	36	.7823	35	.5765	42.43
04	Cotton	1.3329	37	.8553	33	.4776	35.83
36	Other construction	1.2987	38	.4158	46	.8829	67.98
03	Jute	1.1366	39	.8744	32	.2622	23.07
11	Edible oil	1.1167	40	.5786	40	.5382	48.19
10	Sugar	1.0477	41	.5923	39	.4554	43.47
13	Tobacco	.9218	42	.4736	43	.4482	48.62
29	Wood	.8163	43	.5726	41	.2437	29.87
06	Other crops	.7175	44	.5318	42	.1857	25.88
12	Salt	.5681	45	.4339	45	.1342	23.62
09	Forestry	.5336	46	.4616	44	.0720	13.49
07	Livestock	.4785	47	.3645	47	.1140	23.82

TABLE 4

TOTAL AND DIRECT LABOR REQUIREMENTS PER MILLION TAKA OF FINAL DEMAND: BANGLADESH, 1976–77

Number	Sector	Total	Rank	Direct	Rank	Difference	Difference (%)
04	Cotton	375.520	01	342.082	01	33.438	8.90
15	Cotton yarn	297.166	02	213.675	04	83.491	28.10
03	Jute	264.813	03	256.514	02	8.299	3.13
01	Rice	236.296	04	227.809	03	8.487	3.59
18	Jute textile	222.320	05	191.365	05	30.956	13.92
17	Cloth: handloomed	187.244	06	75.461	23	108.783	59.04
16	Cloth: mill-made	180.704	07	53.785	32	126.919	70.24
07	Livestock	166.182	08	160.566	06	5.616	3.38
36	Other construction	162.791	09	136.962	07	25.830	15.87
47	Other services	136.528	10	133.416	08	3.112	2.28
44	Education	133.554	11	130.028	09	3.527	2.64
20	Leather	130.334	12	91.275	17	39.060	29.97
02	Wheat	129.467	13	117.207	11	12.260	9.47
42	Housing service	129.065	14	120.764	10	8.301	6.43
45	Public administration	125.236	15	110.281	12	14.956	11.94
43	Health	123.573	16	99.263	15	24.310	19.67
14	Other food	113.087	17	87.978	18	25.110	22.23
12	Salt	110.106	18	106.601	13	3.504	3.18
41	Trade service	107.702	19	102.636	14	5.067	4.70
35	Construction: transport	107.618	20	60.952	28	46.666	45.36
06	Other crops	103.894	21	97.627	16	6.267	6.03

10	Sugar	101.550	22	82.297	21	19.253	18.96
30	Miscellaneous industries	101.543	23	62.950	26	38.592	38.01
23	Other chemicals	99.317	24	71.761	24	27.556	27.75
11	Edible oil	98.829	25	26.853	22	21.976	22.24
33	Nonresidential building	97.747	26	48.332	36	49.415	50.55
31	Urban house building	97.620	27	50.502	35	47.118	48.27
08	Fisheries	94.137	28	87.549	19	6.588	7.00
29	Wood	92.861	29	85.054	20	7.806	8.41
32	Rural house building	86.826	30	58.336	29	28.490	32.81
34	Construction: electricity & gas	86.296	31	51.001	34	35.295	40.90
22	Pharmaceuticals	84.474	32	52.874	33	31.600	37.41
37	Petroleum	76.741	33	7.443	47	69.297	90.30
24	Cement	76.279	34	39.506	42	36.773	48.21
19	Paper	75.391	35	41.862	40	43.529	44.47
40	Transport service	74.995	36	61.063	27	13.932	18.58
09	Forestry	68.290	37	66.753	25	1.538	2.25
05	Tea	67.298	38	54.227	31	13.071	19.42
21	Fertilizer	66.780	39	40.787	41	25.993	38.92
27	Machinery	64.985	40	42.007	39	22.978	35.36
26	Metal products	64.437	41	47.890	37	16.548	25.68
38	Electricity	63.137	42	18.303	46	44.834	71.01
46	Banking and insurance	62.614	43	55.188	30	7.426	11.86
28	Transport equipment	61.576	44	46.500	38	15.076	24.48
13	Tobacco	52.249	45	38.428	43	13.821	26.45
39	Gas	39.909	46	34.747	44	5.162	12.93
25	Basic metals	39.393	47	18.438	45	20.755	52.69

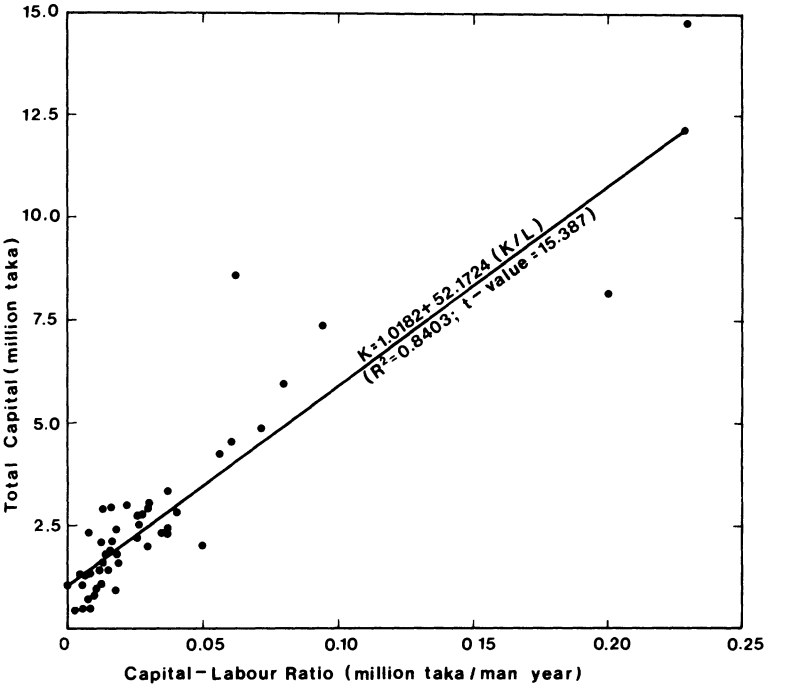

FIG. 4.—Relation between the total K/L ratios of sectors of the Bangladesh economy indicated in table 3 and their total capital requirements per million taka of final demand for 1976–77.

ments per unit of final demand. On either criterion, agricultural industries rank very high. The coefficient of correlation between rankings of industries is .8670. Despite this close association between the two attributes, some changes in rankings can be noticed. Considering total labor requirements, sectors like mill-made cloth and handloomed cloth appear to rank very high. Their ranks drop dramatically only if direct labor requirements are taken into account. In contrast, sectors like wood, forestry, and banking and insurance rank much lower in total employment generation than in direct labor requirements. A comparison of sectoral rankings in tables 3 and 4 indicates that sectors requiring higher amounts of capital are not necessarily those that generate higher employment. The rank correlation coefficient between total capital and labor requirements is $-.3017$, which shows little correspondence between employment creation and industrialization. The correspondence, if any, seems to be in the opposite direction.

V. Concluding Remarks

The analysis suggests that certain industries are relatively more appropriate than others. It seems that most agricultural industries are quite

appropriate to Bangladesh in terms of their capital-to-labor requirements. This indicates that there is a case for expanding these industries.

However, some limitations of the analysis should be kept in mind. We do not live in a two-factor world. All labor is not necessarily homogeneous and easily substituted. Furthermore, land and natural resources are important inputs in production from living resources. Expansion in agricultural, fishing, and forestry industries may, therefore, be subject to decreasing returns, and consideration needs to be given to whether expanded production is sustainable. Despite this, at least over a small range, there seems to be a case for expanding these industries.

Again, production in a particular sector may be either by a variety of techniques or by machinery of different vintages. Much capital is already embodied. It is possible that only new investment is free. Consequently, incremental output-capital ratios or capital requirements may differ from those estimated from existing capital stock. These limitations are inherent in input-output analysis and are a further reason for caution.

The analysis, despite its limitations, indicates sectors that might be given preference in Bangladesh for expansion in terms of the appropriateness of their K/L ratio as well as capital and labor requirements per unit of final demand. It seems that in the past there has been an urban bias, that is, a number of urban-located industries with inappropriate factor proportions (some of which are relatively inefficient) have been developed.[27] A case could be made on productivity grounds for expanding investment in several industries based on living resources. However, it could also be argued that measures that encourage urbanization and modernization help to reduce population growth rates and should be preferred as a long-run strategy.[28] A further complication is that greater emphasis on increasing resources in the rural sector, if it is associated with greater trade in primary products, may bring about structural dependence, economic risks, and problems of sustainability.[29]

Finally, the transition from total to direct criterion leads to a significant divergence in rankings for a few sectors even though this has apparently little impact on the overall sectoral rankings. But there is a clear need to draw a distinction between total and direct requirement criteria and trade-offs between more and capital-intensive industries. The total criterion is likely to provide a more realistic indicator of factor requirements. As the findings in this paper indicate, sectoral priorities assigned only on the basis of direct requirements of capital may lead to the promotion of sectors that are not consistent with a country's factor endowments and add to distortions in resource allocation. This is so despite the fact that direct K/L ratios may be sufficient to identify the most inappropriate sectors for a developing country.

Notes

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