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ALLOCATIVE AND TECHNICAL EFFICIENCY: A STUDY OF RURAL ENTERPRISES IN BANGLADESH

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I. INTRODUCTION

THE importance of generating employment in off-farm sector in LDC has received considerable recognition in empirical and analytical literature.[1] Over the past decade increasing disenchantment with the pace of job creation in agricultural and large industrial sectors has shifted attention to the small industrial sector because this nonfarm activity has become a major source of income and employment for rural population in many LDC. Prima facie greater labor intensity in small enterprises has drawn widespread support for their promotion among the policy planners. While the labor intensity argument is fairly established fact, economic efficiency in production is still an area of concern because whether or not small enterprises are efficient mechanisms for employment creation also crucially depends on efficiency in allocation of primary inputs like labor, capital, and other tangible materials, i.e., allocative efficiency, and efficiency management, i.e., technical efficiency.

The term technical or X-efficiency was first introduced by Leibenstein [6] and later methodological improvements were initiated by Farrell [5]. Farrell coined the concept of the "frontier" or the "best practice" production function which represents a set of observations from which the maximum output is achievable from a given stock of measured inputs. The amount by which measured output is less than potential output is customarily defined as technical or X-inefficiency.[2] Although the issues of allocative efficiency of small industries received intensive treatment in empirical literature, research on technical or so-called X-efficiency for this sector has remained relatively scanty. The ambiguity of the basic concept and paucity of relevant micro-economic data are the most

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[1] For instance, Yotopoulos [21] and Sahota [16] with respect to farm sector and Liedholm and Chuta [11], with reference to off-farm sector.

[2] Such studies essentially employ a frontier production function. The amount by which measured total factor productivity deviates from the potential (from the standpoint of frontier) is usually defined as technical inefficiency. See [5] [18] [2].

visible problems for empirical tests of technical efficiency. Scholars seem to be in general consensus that technical efficiency basically stems from failure to produce at the outer-bound of firm's production surface. Studies aiming at measuring magnitudes of losses from technical inefficiency are useful for identifying factors and policy measures to improve management. Moreover, insightful implications for ranking, selecting, and appraisals of projects can be obtained from such exercises since sensitivities of project returns can also be assessed with regard to variations in technical efficiency.

The purpose of this paper is mainly to identify empirically the links between capital intensity and productive efficiency with data from a comprehensive survey on rural industries in Bangladesh. Essentially, the paper seeks to explore whether allocative and technical efficiency in production positively correlate with capital intensity. In addition, the sources of variations in productive efficiency in the sample enterprises will be investigated. This paper begins with a neoclassical production function in Section III which would give clues of efficiency in allocation of primary inputs and economies of scale in production. Second, for additional insights of productive efficiency, total productivity ratios, and economic profits, generated by these enterprises will be estimated. Finally, in Section IV on the basis of probabilistic "frontier" Cobb-Douglas production function, variations in technical or X-efficiency will be explicated.

The data for the present study have been gathered from a two-phased survey on rural industries constituting small, cottage, and some medium variants in eleven different thanas (counties) of Bangladesh. Phase I is the census of 60,000 enterprises containing basic information on size, location, establishment dates, and the like, while phase II comprises 1,207 individual enterprises selected randomly from the census for indepth case studies. The units of inquiry for the present exercise are these 1,207 individual enterprises.

II. THE CONCEPT, PRODUCTION FRONTIER, AND STATISTICAL PROBLEMS

A brief discussion on the concept of technical efficiency, relevant production function, and its inherent statistical problems is useful before attempting to analyze the data in the next section. In accordance with Farrell's interpretation [5], technical efficiency is the ratio of (a) the firm's observed (measured) output and (b) the maximum possible (potential) output, i.e., on the frontier, given its observed factor utilization. The maximum technical efficiency is accomplished when the ratio equals one. Now, in the cross section of producing firms there are potentials of differences in their input-output and input-input ratios. Such differences, resulting from differences in (a) technical efficiency, (b) price efficiency, and (c) economic environment can be explained conveniently with neoclassical production functions. But estimation is not straightforward because of the concurrent existence of (a), (b), and (c), which introduces simultaneous equation bias.[3] Lau and Yotopoulos [7] proffered an alternative method which uses dual

[3] Numerous authors from Hoch [7] to Zellner, Kmenta and Dreze [23] dealt at length with the potentials of simultaneity.

cost or profit function for measuring relative economic efficiency. But direct profit data in our sample are not straightforward; data we have here are deduced from input-output file, so analysis through a profit function is not done. Although Farrell-type analysis to measure allocative and technical efficiency is useful, we did not employ this because (a) the technique is not robust to extreme observations whereas extreme observations are used to estimate frontier, (b) nonconstant returns to scale is not taken into account of, and (c) it does not take into account of uneconomic areas of production function where efficiency index is clearly undefined. To circumvent these limitations, Aigner and Chu [1] and Timmer [18] introduced quadratic and linear programming methods respectively with a view to estimate frontier production function. For our purpose we have employed the linear programming approach [18] because it is less affected by extreme values compared to Aigner and Chu's quadratic method. Moreover, quadratic programming is appropriate in the case of estimating simultaneous equations. Since there are no such equations, linear programming procedure turned out to be the obvious choice.

Finally, the problem of separating a stochastic measurement error from the efficiency error has been discussed rigorously by Aigner, Lovell, and Schmidt [2], where they decomposed the disturbance term into a stochastic and one-sided efficiency component. Because the stochastic frontier production method does not permit firm specific measure of technical efficiency with cross sectional estimates, we have not attempted this here.

III. ALLOCATIVE EFFICIENCY

A. *Production Function Analysis*

For the present context the traditional two-factor Cobb-Douglas and CES production functions proved to be most appropriate in providing the essential indicators of allocative efficiency.[4] Products were divided into three more homogeneous groups in light of wide variations of technology used among the sample enterprises. The relevant groups can be gleaned from column 1 of Table I. Labor was converted into number of hours worked throughout the year 1979–80. The measurement of capital, particularly its user cost, posed a distinct problem.[5] It was decided to measure capital in stock terms by adding present values of the buildings, machines, tools and equipment (T & E), and other fixed assets. In addition, at the end of the reference period, the present value of working capital and output as reported by the proprietors were calculated in similar way.

[4] Not only because of its simplicity, comparability, and widespread usage in empirical literature, but also valuable insights concerning returns to scale, marginal productivities of labor and capital, etc., can be gathered from the estimated parameters of the production functions. Moreover, for all categories of firms, CES and translog functional forms were estimated to measure technical efficiency by OLS; neither of them produced superior estimates to those with Cobb-Douglas specification.

[5] Compounded by the heterogeneity in building types, machines, T & E used by different enterprises with differing life spans, and depreciation at the time of operation.

TABLE I
PRODUCTION FUNCTION ESTIMATES
(Specification: $\ln Y = \ln A + \alpha \ln L + \beta \ln K + u$)

Industry Category	Parameter Estimates			
	A	$\hat{\alpha}$	$\hat{\beta}$	R^2
I	3.08	0.556* (0.044)	0.297 (0.023)	0.96
II	2.14	0.765* (0.076)	0.203 (0.057)	0.94
III	3.44	0.692* (0.065)	0.266 (0.071)	0.98
IV	3.96	0.609* (0.157)	0.342 (0.109)	0.93
All	3.35	0.628* (0.033)	0.322 (0.025)	0.95

Notes: 1. Industry category:
I = all cottage industries;
II = cottage industries requiring meager capital (up to 1,000 taka per worker) or no capital;
III = cottage industries requiring capital from 1,001 to 4,000 taka per worker; and
IV = small industries requiring capital more than 4,001 taka per worker.
2. Values in the parentheses are standard errors of estimates.
* Significant at 1 per cent level.

Lastly, output has been measured in conventional terms, i.e., value added in taka. Regressions were run on the estimated values of the relevant variables for the population rather than the sample, as the sample proprietors for various products were quite uneven. The estimated results are presented in Table I, which reveals that 96 per cent of the variation in value added is explained by the variations in labor and capital utilization. Further, the sum of the estimated coefficients are less than unity but not discernibly different from unity, reflecting that there is no increasing return to scale in production in the rural industries of Bangladesh.

A comparison of marginal productivities of labor and capital from the production function can provide useful insights about their allocative efficiency. An initial clue of allocative efficiency of the sample rural industries can be secured by comparing marginal productivity of labor with the wage rate of the labor and similarly marginal productivity of capital with interest rate. The estimated values of marginal productivities of labor (MPL) and capital (MPK) for different types of industries are reported in Table II. The MPL is higher in small industries compared to cottage industries. For the rural industrial sector as a whole, the estimated MPK is 0.67 taka for 1.00 taka of investment; hinting that return at the margin on capital investment is 67 per cent. If bank interest rate at the time of survey is taken as 12 per cent, the result implies that the expansion of

TABLE II

MARGINAL PRODUCTIVITY ESTIMATES

Industry Category	$MPL=\alpha Y/L^a$	$MPK=\beta Y/K^a$	Wage Rate (Per Hour)	Interest Rates (Per Year)
I	1.13	0.89	1.25	140[b]
II	0.66	2.08	0.72	n.a.
III	1.24	0.71	1.32	n.a.
IV	3.12	0.28	1.79	n.a.
All	1.18	0.67	1.33	135[c]

Note: Industry categories are the same as those in Table I.

[a] Labor and capital per hour and per taka of capital, respectively.

[b] Interest rates paid by enterprises located in rural areas for loans obtained during the reference period.

[c] Interest rates paid by enterprises located in urban areas.

this sector will insure allocative efficiency. However, it is worth pointing out that MPK is overestimated as it is applicable to the existing industries only and if one accounts for higher failure rates, say, 15 per cent, the values of MPK are likely to drop by, say, 25 per cent. Thus, for more insights on efficiency one may tempt to argue that larger sample of enterprises including ex-post evidence on those that have failed and those that have succeeded, should be accounted for.[6] But if MPK is so high as in the present case, the failure rates should be low and the nonexistent firms in one's calculation of MPK seems irrelevant. Although the rate of return on capital is high, it may not be profitable to invest by borrowing capital since most of the industries have meager access to institutional credit; so they resort to non-monetized sector which changes excessively high interest rates. The enterprises having better access to the organized credit markets get cheaper capital which inspires them to invest on relatively more capital-intensive ventures. Others who lack that access are forced to remain satisfied with an investment at a below optimal level. Such a dualistic nature of capital market creates distortion and promotes inefficiency in allocation and utilization of scarce factors.

It is instructive to note that the MPL for all industries is 1.18 taka per hour, which is nearly 90 per cent of the wage rate. It ranges from 0.66 taka per hour for cottage to 3.12 taka per hour for small industries requiring heavier capital. The MPL is not markedly different from the wage rate paid by the cottage industries; reflecting a more efficient utilization of labor by these industries. In small industries, the MPL is much higher than the wage rate; indicating that employment in these activities is at a suboptimal level. Additional employment can be generated by introducing more labor-intensive technology. Because of the paucity of information on actual interest rates, marginal productivity with respect to mean values was not calculated.

[6] Skepticism is widespread. But studies on the causes of mortality of small enterprises are extremely rare. One shining exception in this regard is Itao's article [8].

TABLE III
ESTIMATES OF CES PRODUCTION FUNCTION

Industry Category	Parameter Estimates			
	A	$\hat{\beta}$	$\hat{\gamma}$	R^2
II	0.41	1.034 (0.036)	−0.625 (0.623)	0.97
III	0.68	0.945 (0.081)	−1.175 (0.419)	0.92
All	0.94	0.989 (0.414)	−1.377 (0.281)	0.94

Notes: 1. Industry categories are the same as those in Table I.
2. Standard errors are in the parentheses.

The issue of factor substitution remains essentially unexplored if one considers the Cobb-Douglas production function only.[7] A CES specification seems a more suitable choice. However, estimation of all parameters of CES is quite complicated, as they can only be estimated by the maximum likelihood procedure. Following Wallis [20] an enlightened indirect formulation of the same which can be estimated by OLS procedure has been applied:

$$L = AQ^{\beta}W^{-\gamma}, \tag{1}$$

where L=labor, Q=value added, W=real wage rate, γ=measure of elasticity of factor substitution and also gives the wage elasticity of demand for labor when output is held constant, and β=elasticity of labor demand with respect to change in output when real wage rate is constant, i.e., it measures the percentage change in demand for labor arising from given percentage change in output.

Due to very negligible amount of capital, fixed technology, and very few hired labor in the cottage industries category I, factor substitution is naturally expected to be insignificant and, therefore CES function has been estimated for cottage industries category II and small enterprises. The results of equation (1) have been reported in Table III. In cottage industries category II, there is little scope for labor-capital substitution while the elasticity of substitution is higher in the small industries. The results apparently suggest that higher interest rates relative to wage would promote more employment in small industries compared to cottage industries as a whole. On the other hand, the values of the elasticity of employment with respect to output is higher in cottage industries II reflecting that an increase in output will generate more employment in these industries than their small-scale counterparts. Overall, the estimated results are, by and large, consistent with underlying production technologies.

[7] As elasticity of factor substitution is assumed unity, i.e., $\sigma=1$, $Y=Y_0K^{\alpha}L^{\beta}$, the MRS of L and K are $\text{MRS}=\partial K/\partial L=(\partial Y/\partial L)/(\partial Y/\partial K)=\beta K/\alpha L$. Thus, $\log(\text{MRS})=\log(\beta/\alpha)+\log(K/L)$, $\log(K/L)=\log(\text{MRS})-\log(\beta/\alpha)$.

B. *Productivity Analyses*

Two alternative indicators of allocative efficiency, viz., total productivity ratios (TPR) and economic profits (EP) will be invoked in this section.[8] A product-level classification which is the lowest-level disaggregation has been employed as opposed to homogeneous grouping of industries in the previous section. Occasionally, such a classification provides useful clues for ascertaining factor intensity, sector of origin as well as investment projects.

1. *Total productivity ratio*

A comparative investigation of efficiency in resource use among various activities cannot be performed with respect to labor or capital alone.[9] It is illuminating therefore to use total productivity ratio (TPR), which expresses the value added as a proportion of the weighted sum of labor and capital, the weights are respectively the scarcity prices.[10] The TPR is quite useful in ranking the products according to their economic utilization of both labor and capital and thereby it may be called the "efficiency index" (E_i) which is calculated as follows:

$$E_i=\frac{V_i}{wL_i+rK_i}, \qquad (2)$$

where V = value added by the ith product, L = labor hours worked for producing the output, K = amount of capital invested in the product, w = marginal productivity of labor (MPL) for the rural industrial sector, and r = marginal productivity of capital (MPK) for the sector. The numerator of the above equation shows the amount that the industry has actually produced. The denominator shows what the ith enterprise can produce given its L and K, if the MPL and MPK realized are the same as the rural industrial sector as a whole. If the ratio is greater than unity for a particular enterprise, then it is earning more on its L and K than the sector as a whole.[11] The relative efficiency in the use of L and K estimated for the cross section of products is reported in Appendix Table I. The most inefficient group of enterprises are those which either use no capital or are highly capital intensive, e.g., jute baling, hosiery, and job printing. The most efficient enterprises rank middle with respect to capital intensity. The role of appropriate and relatively less capital-intensive technology in promoting the sector is clearly demonstrated by these estimates.

[8] See [3] and [14] for a discussion.

[9] Because products usually with high value of labor productivity have a low value of capital productivity and vice versa. The rank correlation coefficient between L and K productivity among cross section of products is -0.81, reflecting that activity which economizes L does so by using relatively more K.

[10] One may consult [12].

[11] Brown [4] and Nadiri [12] provided a lucid discussion on measurement of total productivity.

2. *Economic profit*

The TPR, examined in the previous section, focuses primarily on the static efficiency of allocation of resources. But as far as economic development is concerned, the question of augmentation of resources (dynamic) is as important as the question of allocation of resources (static). And there is often a dichotomy between static and dynamic efficiency. The most important paradigm that comes to one's mind immediately is the optimal growth literature.[12]

The prospect of generation of profit and its reinvestment for capital accumulation constitute a vital criterion for augmentation of investible resources. Frequently, it is argued that even though efficient small-scale labor-intensive industries exist, large and capital-intensive industries ought to be chosen because they accrue more profits and assist faster accumulation of capital which is beneficial in the long run.

To test the validity of this argument, profit per unit of capital generated by various rural enterprises has been estimated. In addition, qualitative information from the sampled industries on the mode of utilization of profits was collected. Profits have been calculated directly from information on input-output and value of fixed assets assembled from the sample enterprises. First, family income was estimated by subtracting from value added the wage bill paid to hired workers, the rent paid for hired building, machinery, equipment, and the estimated value of depreciation of owned fixed assets. Profits were obtained by deducing from family income the imputed value of family labor. The problem of inaccurate measurement of depreciation of fixed assets remained high, particularly because of the large number of products with heterogenous capital items.[13]

Computing values to family labor is highly cumbersome. One obvious practice is to apply wage rates. But if the proportion of hired labor is quite negligible, as in the present case, the wage rates may not provide a reliable clue as to the cost of family labor. Hence family labor has been imputed by the wage rate for the products in which a discernible proportion (more than 10 per cent) of hired labor is employed and by prevailing agricultural wage rates (taka 1.25 per hour) for other products.

The economic return on the scarce factor i.e., opportunity cost, is our relevant parameter rather than the accounting profits. The estimates show that in the majority of cottage industries, both family income and profits are remarkably low (not shown). For a number of products, economic profits turned out to be negative; these include dhenki products, juice gur, basketary chatai making, pottery, and footwear repairing. Results indicate that enterprises of these products accept a lower rate of return on their family labor compared to even the agricultural wage rates. It may be recalled that in these activities no capital is used and laborers are mostly landless or near landless. The rate of profit, i.e.,

12 For an excellent discussion of the topic, see [17].

13 For simplicity, following values of life expectancy of capital assets with constant rate of depreciation were assumed: brick-built buildings 30 years, semi-brick-built 30, non-brick 10, all machines 20 (except printing press 50), and T & E 5.

TABLE IV

SIZE AND CAPITAL INTENSITY OF PRODUCT GROUPS CLASSIFIED BY PROFIT RATES

Product Groups with Profit Rates	Average Size of Enterprise			Capital per Worker (Taka)	Share of the Group in	
	No. of Workers	Size of Capital (Taka)	Value Added (Taka)		Total Employment	Total Capital
Negative	2.8	283	2,260	101	34.8	2.1
Up to 10%	8.4	328,990	73,325	39,165	0.6	15.1
10.1 to 50%	5.4	9,204	16,471	1,704	16.8	17.4
50.1 to 75%	4.5	9,174	22,390	2,039	31.6	48.6
75.1 to 100%	4.0	26,043	39,709	6,511	3.5	14.0
100.1% & over	4.0	4,342	14,821	1,086	13.1	2.8

profit per unit of scarce factor (capital) is, however, quite high for most of the products in which positive profits were found. One important result emanating from Table IV is that the rate of profit is low not only for small industries and industries with low capital, but also for those with high capital intensity. The profit rates are highest for the products which rank middle with regard to the scale of operation and capital intensity. The estimates of the TPR in the previous section and of the profits apparently reflected that there is no potential conflict between allocation and augmentation of resources in terms of generating profits. Attempts to gather information on proprietors' propensity to save and reinvestment rates out of profits were also made.[14]

The average propensity to save in the rural industries did not vary significantly by location. Separate estimates (not shown here) indicate that the proprietors of rural industries saved nearly 20 per cent of their profits as against 26 per cent of their urban counterpart. But the rate of reinvestment of savings in proprietors' own enterprise is lower in rural (29 per cent) compared to urban enterprises (72 per cent). For maximization of surplus and capital accumulation from a given investment we need to look for marginal savings (not average) and reinvestment rates. It is worth pointing out that a high average savings and reinvestment rates in comparatively more capital-intensive enterprise may stem from high family income of the proprietors. They save a smaller proportion of their incremental income. In order to shed some light on this issue, the following regressions were run from which one can estimate the marginal savings and reinvestment rates:

$$S_i = \alpha_0 + \alpha_1 Y_i, \tag{3}$$

$$R_i = \beta_0 + \beta_1 Y_i, \tag{4}$$

where S = annual savings per enterprise in an industry (it is calculated by multi-

[14] Our primary objective is to provide a suggestive picture. It is indeed difficult to obtain such data since a large number of sample proprietors have other occupations and it is problematic to isolate savings from industrial income and savings from other sources of income.

TABLE V
ESTIMATED MARGINAL SAVINGS AND REINVESTMENT RATES BY CAPITAL INTENSITY OF RURAL INDUSTRY

Capital Intensity	Dependent Variable	Constant	Income Coefficient	R^2	Average Savings/ Reinvestment Rates	Marginal Savings/ Reinvestment Rates
1,000 taka and less per worker	Savings	−373	0.180 (0.026)	0.62	8.1	18.0
	Reinvestment	−397	0.159 (0.028)	0.58	6.1	15.9
1,001–4,000 taka per worker	Savings	−4271	0.561 (0.045)	0.90	24.8	56.1
	Reinvestment	−3424	0.436 (0.036)	0.89	18.6	43.6
4,001 taka and above per worker	Savings	−4467	0.408 (0.102)	0.61	27.2	40.8
	Reinvestment	−3784	0.365 (0.106)	0.54	25.1	36.5

Note: Values in the parentheses are standard error of estimates.

plying the saving rate as reported by the proprietors by the family income Y, estimated from the input-output data); R = amount of income reinvested in the enterprise (it is estimated in the same way); and the estimated values of coefficients α_1 and β_1 give the marginal rates of savings and reinvestment respectively. The results are presented in Table V. A little reflection shows that the average savings and reinvestment rates are the highest for relatively capital-intensive products, while the marginal savings and reinvestment rates are highest for the products with medium capital intensity. This implies that although capital accumulation can be maximized by priorities set by the economic rates of returns to investment, the same can also be accomplished by giving priorities in allocation of investments to products with medium capital intensity.

IV. TECHNICAL EFFICIENCY

Because of the obscured definition, empirical examination for the existence of technical or X-inefficiency remained comparatively limited. Leibenstein did not precisely define the concept and as a result various interpretations have been advanced. However, recent literature generally suggest that technical inefficiency, if it actually exists, is nothing but a failure to produce at the outer-bound of the firms' production surface and this failure has common terrain with the allocation of efforts. Following Farrell's original notion of "frontier" or best practice production function, a battery of methodological works focusing on estimation and specification has appeared.[15] The frontier production posits an

[15] For excellent reviews of frontier production functions see [1] [9] [22] [18].

outer boundary in output space over a given range of observed inputs. To facilitate the basic elements of the frontier production function, let us consider a structure of production function of the following form:

$$Y=F(X;\beta)+u, \tag{5}$$

where

Y = a vector of observations on output,
X = a matrix of observations on inputs,
β = a vector of parameters of production function, and
u = a vector of error terms.

The traditional production functions provide estimates of average production function for the given set of observations while frontier estimator requires that all observations either lie on or below the frontier, i.e.,

$$\begin{aligned}\ln Y &= \ln f(X)-u \\ &= \beta_0+\sum_{i=1}^{n}\beta_i \ln x_i - u,\ u\geqslant 0,\end{aligned} \tag{6}$$

where, one-sided error term forces $Y \leq f(X)$. The elements of vector of β_i parameters can be estimated either by linear programming or quadratic technique. For our purpose we elect the linear programming to measure a probabilistic frontier production function first developed by Timmer [19] which can be written as:

$$Y=f\,(x_1, x_2, \ldots, x_m;\ y_1, y_2, \ldots, y_n), \tag{7}$$

where x_i = measurable inputs like labor, capital, and other observable materials required for production and y_i = non-measurable inputs essentially related to management like technical knowledge, managerial efforts, etc. Since y_is are non-observable, production function estimates from measured inputs are likely to be biased resulting in an unexplained residuals. Consider the Cobb-Douglas production function as,

$$Y_{jt}=\prod_{i=1}^{m} x_{ijt}{}^{a_i}\cdot e_{jt}. \tag{8}$$

The estimated form of which is,

$$\log\hat{Y}_{jt}=\log\hat{A}+\sum_{i=1}^{m}\hat{a}_i \log x_{ijt}+\log e_{jt}, \tag{9}$$

where

$\hat{Y}_{jt}$ = predicted output of enterprises j;
$\hat{a}_i$ = estimated factor elasticities or the parameters of the frontier production function; and
e_{jt} = error term.

Using linear programming a Cobb-Douglas variant outer-bound production func-

TABLE VI

ESTIMATED COEFFICIENTS FOR FACTOR ELASTICITIES OF THE FRONTIER AND AVERAGE PRODUCTION FUNCTIONS OF THE SAMPLE SMALL AND COTTAGE INDUSTRIES

Industry Category	Constant	Labor	Capital	R^2
II	1. LP_{100} 2.12	0.510	0.185	
	2. LP_{95} 1.92	0.532	0.199	
	3. OLS 1.83	0.758*	0.235*	0.92
		(2.61)	(2.34)	
	N=46			
III	1. LP_{100} 3.01	0.497	0.291	
	2. LP_{95} 3.11	0.507	0.301	
	3. OLS 2.88	0.567*	0.269*	0.95
		(2.11)	(2.72)	
	N=55			
IV	1. LP_{100} 3.22	0.576	0.266	
	2. LP_{95} 3.15	0.589	0.275	
	3. OLS 2.81	0.633*	0.295	0.93
		(3.08)	(3.19)	
	N=60			

Notes: 1. Industry categories are the same as those in Table I.
2. The t statistics are in the parentheses.
3. Due to sampling variations, coefficients of the average production functions are slightly different from those in Table I.

* Significant at 1 per cent level.

tion can be secured by restraining all residuals to be positive. The estimated form thus employed for the present case is,

$$\log \hat{Y}_j = \log \hat{A} + \sum_{i=1}^{m} \hat{a}_i \log x_{ij}. \tag{10}$$

The condition for an efficient production function is that given firm's input levels the actual output Y_j be equal to the predicted output Y_j and the ratio of $Y_j/\hat{Y}_j \leqslant 1$ gives the index of technical efficiency. For explaining the variations in technical efficiency this production function provides an attractive options.

The results of the average Cobb-Douglas and the frontier production functions are reported in Table VI. Equation 1 in Table VI displays parameters estimated by fitting the frontier function to all observations. Since the estimated frontier is encompassed by a subset of data, they are quite sensitive to outliers. To permit some potential errors in extreme observations, equation 2 was fitted by deleting 5 per cent of most efficient observations from the sample of each industrial category. The rate of change with respect to exclusion of observation declined noticeably; therefore, the parameters are fairly stable. One would notice that the estimated coefficients for the factor elasticities between the frontier and average production functions are not phenomenally different. Technical efficiency is neutral as the values of the frontier intercepts lie above those of the average.

TABLE VII
OLS Estimates of Technical Efficiency Index Derived from Production Function

Industry Category	Constent	X_1	X_2	X_3	X_4	X_5	R^2
II	0.363	0.025	0.022	−1.61	−1.23	−0.178*	0.35
	(0.951)	(1.50)	(1.19)	(−2.31)	(−1.54)	(−3.17)	
III	0.971	0.153	0.018	−1.00*	−0.005	−1.03	0.49
	(1.70)	(1.77)	(1.33)	(−2.05)	(−1.52)	(−1.96)	
IV	0.778	0.146*	0.084	−1.13*	−0.017	−0.112*	0.57
	(1.21)	(3.45)	(2.17)	(−2.22)	(−1.15)	(−2.43)	

Notes: 1. Industry categories are the same as those in Table I.
2. The t statistics are in the parenthese.
3. X_1=dummy for education; 1=formally educated; 0=else.
X_2=ratio of migrated to native proprietors.
X_3=dummy for proprietors with no financial record keeping.
X_4=dummy for acquisition; 1=founded; 0=else.
X_5=dummy for proprietors with no prior training.
* Significant at 1 per cent level.

The LP and OLS estimates differ slightly and frontier estimates turned out to exhibit better capital productivity than the average enterprises in small- and medium-sized cottage industries, hinting that improvement in technical interms of X-efficiency is moderately capital augmenting in these industries, while in first category of industries capital has no apparent advantage in improving management. The output elasticity with respect to labor is lower in frontier production function than the average, which indicates that firms operating on the frontier tend to be less labor intensive than others. Table VII presents the estimated coefficients of an OLS regression of the LP efficiency index on five variables essentially linked with management. The results indicate that over half of the variations has been explained by these factors in the small industries while in other two categories the variations are 35 and 49 per cent. Formal education seems to influence efficiency for small enterprises while for more traditional enterprises education does not appear to be important. The values have positive signs but significant for small enterprises only.

The weak relationship between formal education and level of technical efficiency in cottage industries perhaps indicate the incipient nature of formal education among the proprietors. It also indicates that individuals with no prior education entered in these industries and the process became inter-generational. Indeed, findings from entrepreneurship study [15] suggest that the process has been a deliberate design of the proprietors and artisans to preclude wider spread of skill, they tend to retain skill within family without much attention to formal education.

The explanatory variable for migration was incorporated with the prior expectation that migrated proprietors manage their enterprises better than the natives. The signs are positive but statistically weak for all industries; reflecting that natives do have an edge over information of markets and resources than the migrants.

The dummy for record keeping appears to explain significant variations in the level of technical efficiency in all industries. Enterprises where proprietors have no bookkeeping have been found to be discernibly associated with low-level technical efficiency as expected. Thus, one of the viable inputs of managing and monitoring business is seldom practiced among the proprietors.

Nature of acquisition of the enterprise as a determinant of efficiency has not been significant across the cross section of cottage and small enterprises.

It was expected that those who founded the enterprise would work harder and manage their firms more seriously than those who had a windfall gains like gift or inheritance. The estimated coefficients are weak at 1 per cent suggesting that technical efficiency does not vary substantially among the inherited and founded activities. The dummy for prior training turns out to be low in all industries. Low level of training is thus associated with lower technical efficiency as anticipated. Overall, findings herein indicate that variations in management related inputs have salutary underpinnings in explaining positions of various enterprises relative to the production function. Different uses of primary factors do not necessarily present the entire picture of efficiency as it also inextricably affected by non-measurable variables linked to management.

V. CONCLUDING REMARKS

The present paper highlights the role of economic efficiency (allocative and technical) in production in three types of rural industries in Bangladesh. Among the set of findings that seem to have emerged from the foregoing analyses we can in particular note the following.

First, the production function analyses show that industries using at least some capital, i.e., more than 1,001 taka per worker in 1980 prices, have potentials of allocative efficiency. Estimates of marginal productivities of labor and capital and CES function highlight that further increase in allocative efficiency is achievable through appropriate pricing of capital and its proper disbursement among the proprietors. There is no production advantage for the large-scale industries over their smaller counterpart as revealed by the absence of increasing returns to scale in the latter.

Second, the estimates of total productivity ratio reinsure that most inefficient group of enterprises are those which use either no capital (1,000 taka and less per worker) or very highly capital-intensive, e.g., jute baling, hosiery, and job printing. Incidentally, the disaggregation at product level has enabled us to identify the specific industries and their relative efficiency with regard to output they produce per unit of all factor inputs combined.

Third, the economic profit estimates demonstrate that there is no incisive conflict between allocation and augmentation of resources in terms of generating profits. Again, this is visible for the enterprises using at least some capital.

Finally, with regard to variations in technical efficiency, we found that formal education with regard to the technical aspects of production, training, and financial record keeping are the most important factors. Using a frontier probabilistic Cobb-Douglas production function it appears that management is labor augmenting in cottage industries using capital over 1,000 taka per worker but it is moderately capital augmenting in small industries.

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APPENDIX TABLE I

PRODUCTIVITY AND CAPITAL INTENSITY

Product Types and Sectors	Capital/Labor Ratio (Taka)		Value Added/ Labor Ratio (Taka)		Value Added/ Capital Ratio	Total Productivity
	Capital per Worker	Capital/ Labor Hour	Value Added per Worker per Year	Value Added per Labor Hour	Value Added per Taka of Capital	Value Added as a Proportion of Weighted Value of Labor and Capital
Food & agricultural products						
Jute baling	49,909	38.95	14,933	11.65	0.30	0.43
Dairy products	2,876	0.93	8,068	2.62	2.81	1.45
Oil making	993	0.66	2,554	1.70	2.57	1.05
Bakery product	8,440	3.36	8,771	3.49	1.04	1.02
Grain milling	12,698	4.96	14,937	5.83	1.18	1.30
Dhenki products	133	0.13	1,126	1.14	8.48	0.90
Sugarcane gur	609	1.06	1,638	2.86	2.69	1.51
Juice gur	110	0.21	600	1.13	5.46	0.88
Bidi making	518	0.58	1,636	1.83	3.16	1.14
Tobacco processing	8,321	4.76	8,322	4.76	1.00	1.09
Wood cane & bamboo products						
Saw milling	14,474	7.00	14,003	6.77	0.97	1.16
Handsaw timber	3,243	1.55	3,395	3.22	2.07	1.45
Carpentry	755	0.23	7,000	2.09	9.2	1.57
Boat making	760	0.70	2,435	2.24	3.20	1.36
Shital pati	23	0.03	981	1.10	43.55	0.97
Hogla mat	33	0.05	624	1.02	19.15	0.88
Bamboo chatai	16	0.03	771	1.25	49.55	1.11
Basketary	13	0.01	739	0.74	60.75	0.66
Bamboo handicrafts	70	0.11	583	0.90	8.32	0.75
Cane & bamboo furniture	33	0.02	1,682	0.85	51.58	0.76
Cane & bamboo fishing equipments	29	0.01	543	0.53	38.93	0.47
Textiles & coir						
Bedding material	2,553	1.84	4,242	3.06	1.66	1.27
Silk weaving	3,056	2.76	3,127	2.83	1.02	0.94
Handloom lungi, sari	1,622	0.55	4,727	1.59	2.91	1.03
Handloom gamcha/ napkin	1,251	0.54	3,529	1.51	2.82	0.98
Reeling yarn	47	0.05	738	0.81	15.62	0.70
Fishing nets	33	0.04	567	0.77	17.17	1.67
Jute rope & cordage	58	0.05	854	0.69	14.79	0.60
Jute handicrafts	177	0.36	795	1.61	4.49	1.14
Coir rope & cordage	4	0.06	498	0.71	11.31	0.61
Coir door mats	118	0.10	2,064	1.83	17.56	1.52
Cloth printing	1,366	1.24	3,421	3.12	2.50	1.55
Tailoring	3,963	1.80	6,552	2.97	1.65	1.25

APPENDIX TABLE I (Continued)

Product Types and Sectors	Capital/Labor Ratio (Taka)		Value Added/ Labor Ratio (Taka)		Value Added/ Capital Ratio	Total Productivity
	Capital per Worker	Capital/ Labor Hour	Value Added per Worker per Year	Value Added per Labor Hour	Value Added per Taka of Capital	Value Added as a Proportion of Weighted Value of Labor and Capital
Woolen knitted goods	547	0.86	1,493	2.55	2.73	1.34
Hosiery	33,235	18.61	10,684	5.98	0.32	0.44
Metal works						
Blacksmithy	762	0.36	4,614	2.20	5.98	1.54
Jewelry	1,751	0.55	8,120	2.54	4.64	1.64
Sheet metal products	2,464	1.21	3,948	1.94	1.60	0.98
Metal handtools	6,468	2.99	8,734	4.04	1.35	1.28
Metal furniture and fixtures	3,241	2.01	8,075	3.27	1.53	1.30
Leather & rubber products						
Leather processing	22,975	17.08	10,397	7.73	0.45	0.61
Footwear making	1,070	0.33	8,524	2.60	7.97	1.86
Suitcase and bags	1,828	0.91	6,190	3.07	3.39	1.72
Plastic products	11,848	6.19	10,407	5.44	0.88	1.02
Chemicals						
Indigenous drugs	3,472	3.81	4,373	4.80	1.26	1.29
Soap & tooth powder	12,903	4.99	11,368	4.39	0.88	0.97
Lac	4,648	5.39	7,700	8.92	1.66	1.87
Agar and atar	905	1.35	1,298	1.93	1.43	0.94
Lime	20	0.01	1,327	0.57	66.76	0.51
Printing & paper products						
Job printing	31,254	9.47	8,299	2.51	0.27	0.34
Book binding	3,305	1.34	6,593	2.67	1.99	1.29
Paper & paper products	181	0.08	1,738	0.73	9.56	0.62
Glass & ceramics						
Pottery	789	0.52	1,221	0.80	1.55	0.53
Bricks & tiles	387	0.37	1,973	1.87	5.10	1.31
Repairing & miscellaneous						
Motor vehicle repair	4,759	2.07	6,739	2.94	1.42	1.15
Welding	4,343	1.66	9,130	3.49	2.10	1.53
Rickshaw, bicycle repairing	3,829	1.22	9,015	2.88	2.35	1.44
Electrical goods repairing	2,400	1.49	4,275	2.49	2.73	1.22
Watch repairing	2,411	0.91	5,489	2.49	2.73	1.39
Footwear repairing	355	0.29	1,248	1.03	3.51	0.76
Miscellaneous repairing	1,968	0.81	4,953	2.04	2.51	1.19