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SOURCES OF OUTPUT GROWTH IN BANGLADESH FOOD PROCESSING INDUSTRIES: A DECOMPOSITION ANALYSIS

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I. INTRODUCTION

SUSTAINED growth of firms requires consistent improvement in their productivity. Within the industrial sector, the growth of the food processing industry is particularly important for Bangladesh as this is one of the major industries in terms of contribution to total manufacturing production and employment. For example, it ranks second only to textiles in terms of the value of output and employment, accounting for 25 per cent of total industrial output and 16 per cent of total manufacturing employment in 1990/91 (BBS 1995). Empirical studies (Little, Scitovosky, and Scott 1970; Steel 1972; Rahman 1983) carried out in Bangladesh and elsewhere have shown that manufacturing firms had operated with a high degree of unrealized productive capacity due to the excessive controls of the protective regimes in the 1960s and 1970s. It is expected that recent liberalization programs will encourage firms to improve productivity growth. Bangladesh can no longer afford to hold unrealized capacity and recent reforms have put an emphasis on productivity gains rather than, as in past, the injection of new inputs into the production process. Studies examining the extent of capacity realization and the overall productivity performance of firms in the food processing industry are limited in Bangladesh.

The Bangladesh-Canada Agriculture Sector Team (1991) estimated a capacity utilization index using firm-level data from the food processing sector of Bangladesh. This study revealed that capacity utilization ranged from 16 per cent to 56 per cent across firms. Another study in the food processing sector conducted by the International Labour Organization (ILO) (1991) found that 70 per cent of the enterprises realized less than 50 per cent of their productive capacity; another 20 per cent realized 51 to 60 per cent and only 10 per cent realized 61 to 80 per cent of their production capacity. Several studies undertaken by the Harvard Institute for Inter-

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national Development and Employment and Small Scale Enterprise Policy Planning Project of the Bangladesh Planning Commission (HIID-ESEPP 1990a, 1990b, 1990c) have reported that there was no significant relationship between economic policy reforms (in terms of incentive structures) and manufacturing value-added growth and total factor productivity (TFP) growth.

Although these studies have contributed significantly to the supply of information about Bangladesh food manufacturing, their results suffered from the following shortcomings. First, these studies adopted traditional approaches to capacity measurement that ignored firm-specific characteristics which are very important from the productivity point of view. Second, the few studies, which estimated TFP growth, did not distinguish between the two components of TFP growth: improvement in capacity realization and technical progress. Technical progress reflects the impact of new technology through the shifting of the production function. Under normal economic conditions, the index should be nonnegative. Improvements in capacity realization or technical efficiency, on the other hand, reflect firms' ability to improve production with the given inputs and technology by adopting the best practice techniques within the selected technology. Therefore, it is not possible to determine from the earlier studies whether changes in TFP were caused by technological progress or improvements in firm-specific capacity realization. Consequently, it may be argued that in these studies TFP indices were determined with the implicit assumption that all the firms were producing with full productive capacity realization, which is not realistic.

The objective of this study is to examine the sources of output growth in Bangladesh food processing industries during both the pre-reform and the post-reform periods by decomposing output growth into three factors: input growth, changes in capacity realization, and technical progress, using firm-level data.

The paper is organized as follows. Section II summarizes the analytical framework, model specification, and estimation procedures adopted in this paper. Data and empirical results are discussed in Section III. The overall conclusions of this paper are given in Section IV.

II. TOTAL FACTOR PRODUCTIVITY GROWTH AND ITS COMPONENTS

Output growth occurs due to input growth and improvement in total factor productivity (TFP). TFP growth stems from the combined results of technical progress and improvements in productive capacity realization.[1] Technical progress is derived from innovation and the diffusion of new technology. The extent of technical progress is measured by how much the firm's potential frontier shifts from one

[1] This concept was first discussed in Nishimizu and Page (1982).

period to another. A change in capacity realization, on the other hand, shows the movement of the firm's actual output to its maximum possible output or frontier output, given the technology.[2] However, the traditional measures do not distinguish between these two components of TFP growth, rather TFP growth is often used synonymously with technological progress. Failure to take account of changes in capacity realization in measuring TFP growth produces biased TFP estimates that would indicate that all the firms are operating with full productive capacity realization. High rates of technological progress, on the one hand, can coexist with deteriorating capacity realization performance. Relatively low rates of technological progress can also coexist with an improving capacity realization performance, on the other hand. As a result, specific policy actions are required to address the difference in the sources of variation in productivity. In this context, this paper uses the modeling framework discussed by Fan (1991) and Kalirajan, Obwona, and Zhao (1996) for estimating the firm-specific productive capacity and its relationship to TFP growth.

Drawing on Klein (1960), Färe, Grosskopf, and Kokkelenberg (1989) developed a method of measuring plant capacity realization based on Farrell's (1957) measure of output-based technical efficiency by using a nonparametric linear programming frontier production function approach. However, measurement errors in output cannot be taken into account in the programming approach. This limitation can be serious when using secondary data from developing countries where the method of data collection may not be very accurate. There is no reason to believe that all firms' production behavior in an industry will be equal. Actually, different levels of output may be obtained by different firms, albeit using the same technology and the same set of inputs. As Stigler (1976) has argued, such differences occur due to differences in the knowledge of how effectively to apply each productive factor. Then it becomes important to incorporate such variations in the method of application of inputs into the production process to gauge the performance of firms operating under different production environments.

This is possible with the application of the modeling framework of the varying coefficient frontier production function discussed by Lass and Gempesaw (1992) and Kalirajan and Obwona (1994). Lucas (1981) provides further justification for using the varying parameter frontier production function approach. He argued, "The standard stable parameter view of econometric theory and quantitative policy evaluation appears not to match several important characteristics of econometric practice. For example, fixed coefficient econometric models may not be consistent with the dynamic theory of optimizing behavior (of firms); that is, changes in economic

[2] Clearly, capacity realization is a broader concept than the ordinary measure of capacity utilization which is defined as the most efficient output minimizing the present values of the cost stream for a given stock of capital and technology (see Morrison 1985, 1988; Kang and Kwon 1993).

or policy variables will result in a new environment that may, in turn, lead to new optimal decisions and new economic structures" (pp. 109–10). Also, the random coefficient framework facilitates the examination of the impact of reform on the production performance of firms in the absence of reliable data on all reform measures because, as Maddala (1977) pointed out, these policy variables would be entering the model as determinants of the magnitude of the parameter of the model.

Assuming Cobb-Douglas technology, the random coefficient frontier production function can be written as:

$$\ln y_i = \beta_{1i} + \sum_{j=1}^{k}\beta_{ij}\ln x_{ij} + \varepsilon_i, \quad i = 1, 2, 3, \ldots, n, \tag{1}$$

where y refers to output; the xs are non-stochastic inputs, and ε is the statistical error term with "normal" properties. The above model requires that $nK + n$ coefficients are estimated with the help of only n observations. Since intercepts and slope coefficients vary across firms, we can write:

$$\begin{aligned} \beta_{ij} &= \bar{\beta}_j + u_{ij}, \\ \beta_{1i} &= \bar{\beta}_1 + \delta_i, \end{aligned} \tag{2}$$

where $\bar{\beta}_j$ is the mean response coefficient of output with respect to the jth input, $\bar{\beta}_1$ is the mean intercept term, and u_{ij} and δ_i represent the deviations of the individual response coefficients from the mean response coefficients. It is assumed that u_{ij} and δ_i satisfy all the "classical" assumptions. In addition to the "classical" assumptions, the following assumptions are made:

$$\begin{aligned} &E(\beta_{ij}) = \bar{\beta}_j, \\ &\mathrm{Var}(\beta_{ij}) = \sigma_j^2 > 0, \end{aligned}$$

and

$$\mathrm{Cov}(\beta_{ij}, \beta_{im}) = 0, \quad j \neq m.$$

These imply that the random coefficients β_{ij}s are independently and identically distributed with fixed mean $\bar{\beta}_j$ and variance σ_j^2, given j.

Combining equations (1) and (2) one can write:

$$\ln y_i = \bar{\beta}_1 + \sum_{j=1}^{k}\bar{\beta}_j\ln x_{ij} + v_i, \tag{3}$$

where $v_i = \delta_i + \varepsilon_i + u_{ij}\ln x_{ij}$.

Thus, equation (3) is a linear regression with constant coefficients of mean responses and heteroscedastic disturbances. It may be noted that the Hildreth-Houck (1968) random coefficient model belongs to this class of heteroscedastic error models. Therefore, the random coefficient regression model is reduced to a model with fixed coefficients, but with heteroscedastic variances. This heteroscedasticity will remain for all j values so long as the square of the explanatory variables is present. Therefore, the ordinary least squares (OLS) method yields unbiased but inefficient estimates of mean response coefficients.

In this study, we used the Aitken's generalized least squares (GLS) to estimate $\bar{\beta}$s by following the arrangements of Swamy (1970).[3] Now, following Griffiths (1972), the actual firm-specific and input-specific response coefficient predictor for the ith observation for the jth input β_{ij}, which is the best linear unbiased predictor (BLUP), can be obtained.

The assumptions underlying the above model (1) are as follows:

(i) Capacity is measured here from observed input and output, based on the best practice performance of all the firms in the sample. Following Klein, only when a firm uses a particular input with full efficiency, does it receive the highest possible response from that input. A firm may or may not use all the inputs with full efficiency.

(ii) The maximum possible output stems from two sources. One, the efficient use of each input contributes individually to the potential output, and can be measured by the magnitude of the varying random slope coefficients (β coefficients other than β_1). Two, any other firm-specific intrinsic characteristics including scale economies, which are not explicitly included in the model, may produce a combined "lump sum" contribution over and above the individual contributions from the core input to output. The varying intercept term (β_1) captures this aspect in the model.

(iii) The largest magnitude of each response coefficient and the intercept term from the production coefficients of equation (1) constitute the production coefficients of the frontier function showing the maximum possible output.

To elaborate, let $\beta_1^*, \beta_2^*, \ldots, \beta_k^*$ be the estimates of the parameters of the frontier production function yielding the potential output. The frontier coefficients β_j^*s are chosen in such a way to reflect the condition that represents the production responses of adopting the "best practice" techniques. These are obtained from among the individual response coefficients which vary across observations as,

$$\beta_j^* = \max_i(\hat{\beta}_{ij}), \quad i = 1, 2, \ldots, n, \; j = 1, 2, \ldots, k. \tag{4}$$

When the response coefficients are selected by using equation (4), then the potential output for the ith firm can be derived as:

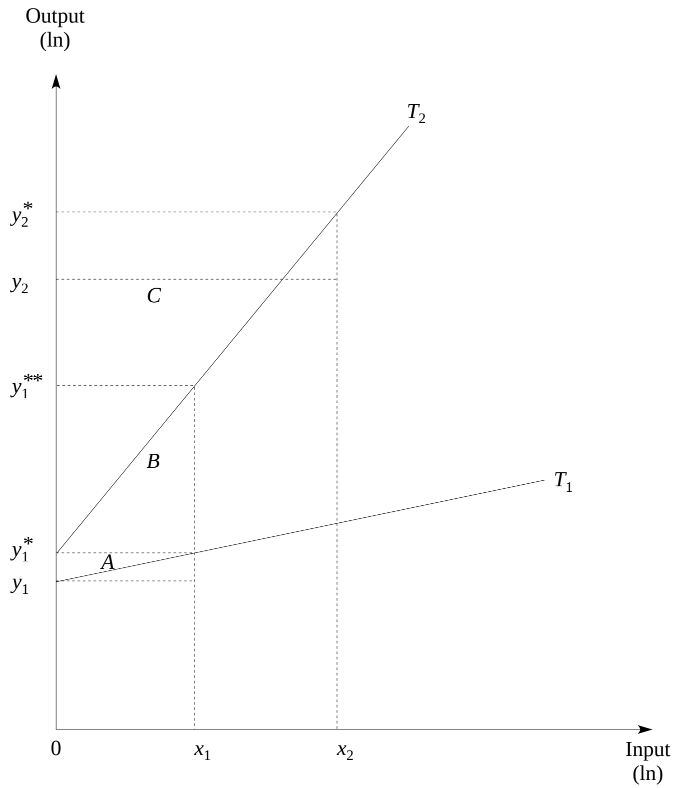
$$\ln y_i^* = \beta_1^* + \sum \beta_j^* \ln x_{ij}, \tag{5}$$

where x_{ij}s refer to actual levels of inputs used by the ith firm.

Now, with the estimation of the potential output, the ratio of firm's realized out-

[3] This method involves iterative procedures and iterations continue until parameter βs are stabilized. Interested readers should refer to Swamy (1970, 1971), Swamy and Mehta (1975), and Griffiths (1972).

Fig. 1. Sources of Output Growth



put to its potential output measured in original units is calculated as the firm's productive capacity realization (*PCR*).

$$PCR_i = \text{(realized output / potential output)}.$$

In logarithmic terms,

$$\ln(PCR)_i = \ln y_i - \ln y_i^*. \tag{6}$$

Drawing on Kalirajan, Obwona, and Zhao (1996), Figure 1 illustrates the decomposition of total output growth into input growth, improvement in capacity realization and technical progress. The horizontal axis measures a typical firm's inputs in logarithm and the vertical axis measures its output in logarithm. Let us assume that the firm is faced with two production frontiers, the "efficient production technologies" for two periods, T_1 and T_2 respectively. During period 1, if the firm is producing with full productive capacity by adopting the best practice techniques, its realized output will be y_1^* at x_1 input level. However, because of various organizational constraints, such as lack of proper incentive structure for workers, the firm may not be adopting the best practice techniques and therefore, may be producing at somewhere less than its full capacity, which implies that the realized output $\ln y_1$ is smaller than the maximum possible output y_1^*. PCR_1 measures this gap by the vertical distance between y_1 and y_1^*.

Now, let us suppose that there is technical progress due to the improved quality of human and physical capital induced by policy changes. As a result, a firm's potential frontier shifts to T_2 during period 2. If the given firm keeps up with the technical progress, more output is produced from the same level of input. Therefore, the firm's output will be y_1^{**} from x_1 input shown in Figure 1. Technical progress is measured by the distance between two frontiers ($T_2 - T_1$) evaluated at x_1. Now the firm is generally induced to increase its levels of input during period 2. Its maximum possible output is y_2^* for new levels of input x_2, and its realized output is $\ln y_2$. The vertical distance between y_2 and y_2^* is represented by PCR_2. Therefore, the contribution of the change in capacity realization to output growth between the two periods is measured by the difference between PCR_1 and PCR_2. When this difference is positive, the firm's productive capacity realization is improved and vice versa. Now, output growth due to input growth between the two periods can be measured by the distance between y_2^* and y_1^{**} along the frontier 2. Referring to Figure 1, the total output growth can now be decomposed into three components: input growth, changes in capacity realization, and technical progress.

In accordance with the figure, the decomposition can be given as follows:

$$
\begin{aligned}
&\ln y_2 - \ln y_1 = A + B + C,\\
&\text{Output growth rate} = (\ln y_2 - \ln y_1^{**}) + (\ln y_1^{**} - \ln y_1^*) + (\ln y_1^* - \ln y_1)\\
&\qquad = [(\ln y_1^* - \ln y_1) - (\ln y_2^* - \ln y_2)] + (\ln y_1^{**} - \ln y_1^*)\\
&\qquad\quad + (\ln y_2^* - \ln y_1^{**})\\
&\qquad = [(\ln PCR_2 - \ln PCR_1) + TP] + \Delta y_x,\\
&\text{Output growth rate} = (\text{growth rate of capacity realization}\\
&\qquad + \text{growth rate of technology})\\
&\qquad + \text{growth rate of inputs.} \qquad (7)
\end{aligned}
$$

Equation (7) is used in this study to estimate the above three sources of output growth, where $\ln y_1^{**}$ is estimated using input level during period 1 and frontier coefficients of period 2; $\ln y_1^*$ and $\ln y_2^*$ are frontier outputs estimated by GLS as indicated above, and $\ln y_1$ and $\ln y_2$ are actual realized outputs.

III. DATA AND EMPIRICAL RESULTS

The data for the present study have been taken from the Census of Manufacturing Industries (CMI) conducted yearly by the Bangladesh Bureau of Statistics (BBS).

The CMI covers all the manufacturing establishments in Bangladesh with ten or more employees. For this study, firm-level cross-section data on Bangladesh food processing industries surveyed in three individual years, i.e., 1981 (pre-reform period), 1987 (transitional period), and 1991 (post-reform period), were used. Unlike most of the previous studies on capacity realization in Bangladesh, and elsewhere, this study uses four-digit industry-level data, classified according to the Bangladesh Standard Industrial Classification (BSIC), which corresponds to the International Standard Industrial Classification (ISIC).

The CMI provides production and sales information on a varied number of firms within an industry for different years, which means that the firms appearing in one survey may or may not be included in the next survey. Given the objective of this study, only firms covered in the three chosen survey years were taken for analysis. There were ninety-seven such firms in the selected three years (1981, 1987, and 1991). Among these ninety-seven common firms, firms with inconsistent data and errors were omitted. For example, firms which had equal or greater value added than their sales proceeds, and firms with negative or zero value added were all removed from the data set because their inclusion could have biased the results.[4] Four firms (one firm in 1981, one firm in 1987, and two firms in 1991) were found to have such a data problem. Therefore, deleting these four firms, ninety-three firms which accounted for 40 per cent of the total firms in the food manufacturing industries reported in the census, were selected for each year of analysis. Based on the availability and reliability of data, value added, and two inputs, labor and capital, were considered for estimating the production frontier.[5]

In the literature on productivity measurement, both value added and gross output are concomitantly used to measure output. Many researchers argue that the use of value added is valid only if capital and labor can be easily separated from materials. Sudit and Finger (1981) contend that the separability assumption is economically restrictive since most of the production processes, probably do not exhibit independence of (core) factor inputs and other material use. Gollop and Jorgenson (1979) and Nishimizu and Robinson (1986) express a similar concern. Griliches and Ringstad (1971) advance arguments in favor of using value added because it facilitates the comparison of results for firms which may be heterogeneous in material consumption. Inclusion of materials as an input may lead to the problem that all the

4 False reporting of gross value of output, material use, and other financial variables occurs mainly because of producers' desire to avoid tax and their unwillingness to share information with governmental agencies because of fears that the data could be used for punitive purposes or be disclosed to their competitors.

5 The time and cross-sectionally varying coefficient models are most generally adopted for analyzing panel data. They are also the most difficult to handle notationally, computationally and analytically. Only the cross-section framework of estimation is used in this paper. However, a statistical test for differences in parameter estimates across time was conducted.

variation in productivity growth is captured by material consumption, thus obscuring the role of physical and human capital. In the literature, the use of value added is considered to be preferable in comparing the performance of firms with various degrees of vertical integration and different product mixes. It also has an advantage over the gross value of output, as it takes into account differences and changes in the quality of inputs. Solow (1957) also recommended that the best output measure for productivity measurement be the net output or value added. Furthermore, the CMI estimates of intermediate inputs are not available consistently over the period of analysis.

Capital is one of the essential inputs in measuring productivity. Accurate measurement of the capital input is needed to explain productivity variations across firms as well as the changes in the structure of industry. Measurement of capital input is difficult, and in some ways contentious, because stock accumulates over a period of time and is valued at different stages of the life-cycle. Three items are required for measuring capital input: (i) bench-mark capital stocks, (ii) correct measurement of life of capital, and (iii) measurement of depreciation. Given these problems, various methodologies were developed in the literature to estimate capital stock, but all these measures provide estimates which are second-best-type solutions and estimates have to be considered with certain reservations. In this study, the well-known perpetual inventory approach was used. The perpetual inventory method is widely used in census data including depreciation series, at book value, to estimate capital stock.[6]

Gross fixed assets were used in this study as capital inputs, namely, the aggregate book values of land, buildings, machinery, tools, transport, and office equipment, etc. The CMI provides a gross book value of fixed assets net of depreciation allowances, and “balancing, modernization, rehabilitation, and expansion” (BMRE) expenditure figures. BMRE figures include new machinery and equipment, building construction and development, and land improvement, etc. Taking BMRE expenditure figures as new investment and adding these figures to the year-end value of fixed assets yields the gross value of capital. This accountant’s practice of measuring fixed assets net of depreciation is flawed, irrespective of which depreciation formula is applied. Accountants’ depreciation rates do not necessarily accurately reflect the loss of efficiency of assets to which they pertain. However, the use of gross figures can be justified in the context of developing countries, such as Bangladesh, on the grounds that capital stock is more often used at approximately constant levels of efficiency for a period far beyond the accounting life measured by normal depreciation until it is eventually discarded or sold for scrap. Thus, even though the value of the old machinery declines, it need not lead to a decline in the

[6] Since depreciation at book value grossly overestimates the true capital consumption, it produces biased estimates of capital stock.

current services of the capital outfit. Capital figures have deflated by the wholesale price indices for non-electricity machinery and equipment to yield capital stock at the 1987 prices.

Several functions, such as Cobb-Douglas, CES, and translog, can be assumed for the production process to evaluate industrial performance in Bangladesh. However, the reliability of the estimates of capacity realization indices hinges crucially on the specification of the model. The Cobb-Douglas functional form has been extensively used in stochastic frontier production function analysis. Census data are unlikely to support more elaborate functional forms (Griliches and Ringstad 1971) and the Cobb-Douglas functional form affords maximum flexibility in dealing with data imperfections (Tybout 1990). Again, Narasimham, Swamy, and Reed (1988) demonstrated, in line with the argument of Zellner (1969), that the Cobb-Douglas production function is less restrictive when all the coefficients are allowed to vary. Moreover, the Cobb-Douglas functional form has been acknowledged by researchers to fit the Bangladesh manufacturing data reasonably well.[7]

At the onset, the functional specification was tested. In the light of the above discussion, nested hypothesis testing was conducted in which a translog function was estimated and was tested for the Cobb-Douglas functional form. The null hypothesis of Cobb-Douglas functional form for the production function for the present data set was not rejected at 0.05 level of significance by an F-test with $F(3, 87) = 1.7290$. Next, the assumption of random coefficients was tested using the Brausch-Pagan's LM test. The test statistic produced a chi-square value of 6.39 with 2 degrees of freedom which is significant at the 5 per cent level. Therefore, the following Cobb-Douglas production function with two inputs in the random coefficients framework was used to estimate the firm-specific productive capacity realization:[8]

$$\ln y_i = \beta_{1i} + \sum_{j=2}^{3} \beta_{ij} \ln x_{ij} + \varepsilon_i, \quad i = 1, 2, 3, \ldots, 93, \tag{8}$$

where y refers to value added and the xs are capital and labor, respectively.

The iterated GLS estimates of the actual response coefficients, mean response coefficients of inputs, and frontier production coefficients are given in Table I. All the mean response coefficients are significant at the 5 per cent level. The signs and magnitudes of these variables are in conformity with theoretical expectations. The range of actual response coefficients show that the methods of application of inputs varies across the sample firms. In other words, the contributions of input to output differ from firm to firm. When the differences between the coefficient estimates across the years are tested by applying the statistical testing of means of sampling

7 See for example Krishna and Sahota (1991).

8 In order to account for the heterogeneity across sub-sectors of the food processing industry, nine dummy variables were included as intercept shifters. But, none was statistically significant.

TABLE I

RANGE OF ACTUAL RESPONSE AND MEAN RESPONSE COEFFICIENTS OF INPUTS AND COEFFICIENTS OF THE FRONTIER PRODUCTION

Input	Range of Actual Response Coefficients	Mean Response Coefficients	Coefficients of the Frontier Production
1981:			
Constant	0.7227–0.8447	0.8377 (0.0828)	0.8447
Capital	0.5974–0.6359	0.5746 (0.0189)	0.6359
Labor	0.4418–0.4774	0.4224 (0.0243)	0.4774
1987:			
Constant	0.8273–0.8851	0.8804 (0.0876)	0.8851
Capital	0.6284–0.6635	0.6311 (0.0190)	0.6635
Labor	0.3369–0.4003	0.3555 (0.0241)	0.4003
1991:			
Constant	0.5069–0.5815	0.5768 (0.0507)	0.5815
Capital	0.7364–0.7580	0.7464 (0.0111)	0.7580
Labor	0.1542–0.2526	0.1589 (0.0145)	0.2526

Note: Calculated from BBS, "Census of Manufacturing Industries," for three individual years (1981, 1987, and 1991) to compare the pre-reform, transition, and post-reform periods. Figures in parentheses indicate standard errors.

distributions, the null hypothesis of no differences was rejected for all the three estimates.[9]

The estimates of frontier coefficients presented in the last column of Table I indicate the maximum possible contribution of input to output, when firms are operating on their frontiers, by adopting the best practice techniques. Moreover, these estimates are obtained by relaxing the conventional assumption of neutral shift of the frontier production function.

[9] The statistic used to test the differences between the estimated coefficients across years is as follows: Z = (estimate of year1 − estimate of year2)/{square root of [(variance of estimate of year1 / number of observations) + (variance of estimate of year2 / number of observations)]}. Z follows a normal distribution, and is calculated ignoring the sign. In this study the number of observations is ninety-three. The testing is done between 1981 and 1987, and 1987 and 1991, and the results are presented below in that order. The Z statistics for the constant, capital, and labor, respectively are: constant (5.212 and 28.92), capital (5.2 and 5.053), and labor (24.317 and 5.815). The null hypothesis of no difference is rejected at the 1 per cent level of significance.

By following equation (5), firms' maximum possible outputs were obtained to estimate the firm-specific capacity realization indices. Industry-wide results are shown in Table II.

Table II reveals considerable variations in capacity realization across firms in food manufacturing industries. In terms of average rate of capacity realization, firms producing hydrogenated vegetable oil were the most efficient with a 91 per cent mean and a 100 per cent for the most efficient firm in 1981, followed by firms manufacturing edible oil, realizing a mean of about 78 per cent, firms engaged in tea and coffee blending at 67 per cent, and grain milling at about 62 per cent productive capacity in the same year. Industries dealing with fish and seafood processing, rice milling, manufacturing of bakery products, sugar as well as tea and coffee processing were relatively inefficient with mean *PCR* levels below the industry's average of about 51 per cent. Industries within the food processing industry group achieved almost similar rates of average capacity realization during the transition period (1987). The mean rate increased dramatically in the fish and seafood sector, perhaps due to its export-oriented nature and to the sharp increase in foreign demand for processed fish products during this period.

During the post-reform period, the edible oil industry became the most efficient with the highest mean capacity realization of about 82 per cent. It may be argued that firms in this industry were producing close to their production frontiers as the minimum *PCR* was 61 per cent. The industries engaged in the manufacturing of hydrogenated vegetable oil, fish and seafood, and dairy products also performed well. Other industries achieved moderate rates of capacity realization, but those engaged in the manufacturing of bakery products, sugar products, and in tea and coffee processing performed poorly by realizing a *PCR* below the industry's mean of 58 per cent.

Changes in mean capacity realization rates in the food processing industry over the three periods suggest that enterprises in different sectors within the industry recorded only moderate increases in efficiency during the post-reform period. The average rate of capacity realization for this industry increased by only 7 per cent, from 51 per cent in 1981 to 58 per cent in 1991. There is still a substantial unrealized productive capacity in most of the enterprises in the food processing industry. The lowest rate of capacity realization increased by only 2 percentage points, indicating that many enterprises in different sectors within the industry still produce far below their frontier by realizing a productive capacity around the marginal rate. On the average, capacity realization increased most sharply in the fish and seafood sector by 31 per cent from a low mean of 47 per cent in 1981 to 78 per cent in 1991. The reason for this sharp rise may be attributed to the outward orientation of this sector and the need for competition. All the firms in this sector adopted a 100 per cent export orientation approach. The remaining industries showed little or no improvement and still performed poorly during the post-reform period 1987–91. Of

TABLE II

INDUSTRY-WIDE PRODUCTIVE CAPACITY REALIZATION INDICES FOR 1981, 1987, AND 1991

Name of Industries	1981			1987			1991		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Dairy products (3112)	48.071	86.223	61.240	51.730	88.524	61.504	62.970	83.423	72.655
Fish and seafood (3114)	40.692	52.835	46.912	51.191	63.522	57.678	58.412	69.490	77.745
Hydrogenated veg. oil (3115)	84.069	100.00	91.075	85.078	100.00	90.929	78.729	86.055	81.411
Edible oil (3116)	57.138	88.346	78.145	52.177	90.422	76.903	61.915	100.00	82.122
Grain milling (3118)	46.257	78.969	62.186	52.415	78.833	65.705	62.574	80.579	72.293
Rice milling (3119)	44.049	75.527	59.563	35.084	85.419	56.446	46.201	81.441	62.032
Bakery products (3122)	37.582	64.105	49.747	39.895	80.797	54.569	42.079	86.260	56.429
Sugar factories (3123)	30.311	47.486	38.527	30.109	48.721	37.690	32.944	62.298	45.473
Tea and coffee processing (3126)	30.555	85.970	45.542	38.278	79.586	48.034	39.975	88.629	53.973
Tea and coffee blending (3127)	50.751	84.062	67.406	55.436	77.210	66.323	66.654	79.905	73.279
Total	30.311	100.00	51.318	30.109	100.00	53.284	32.944	100.00	58.787

Note: Numbers in parentheses are industrial codes according to the Bangladesh Standard Industrial Classification (BSIC). See also note to Table I.

TABLE III

ANNUAL AVERAGE OUTPUT GROWTH RATES OF FOOD PROCESSING INDUSTRIES BY SOURCES, 1981–91

(%)

Industries	1981–87			1987–91		
	Output Growth	TFP Growth	Input Growth	Output Growth	TFP Growth	Input Growth
Dairy products (3112)	3.300	1.374	1.926	4.701	1.697	3.004
Fish and seafood (3114)	5.480	3.027	2.453	4.695	2.573	2.122
Hydrogenated veg. oil (3115)	2.822	1.073	1.750	3.858	1.084	2.774
Edible oil (3116)	2.767	0.688	2.079	0.698	–0.358	1.056
Grain milling (3118)	2.485	0.841	1.643	0.783	–0.951	1.734
Rice milling (3119)	3.873	1.382	2.491	2.096	0.397	1.698
Bakery products (3122)	2.802	1.127	1.675	2.990	0.658	2.332
Sugar factories (3123)	2.719	0.127	2.592	2.776	–0.911	3.687
Tea and coffee processing (3126)	3.227	1.096	2.131	3.897	1.407	2.489
Tea and coffee blending (3127)	4.194	1.618	2.576	4.768	1.851	2.917

Source: Calculated from BBS, "Census of Manufacturing Industries" (1981, 1987, 1991).
Note: Numbers in parentheses are industrial codes from the BSIC.

these, the performance of the sugar industry was the worst. This may be because: (i) all the sugar factories belong to the public sector; and it is generally considered that managers of public enterprises are reluctant to utilize full capacity for various organizational reasons, (ii) long gestation period and the seasonality of sugar factories which prevents them from achieving full capacity realization.

Now applying equation (7), the detailed estimates of sources of output growth for ten sectors of the food processing industry group for the periods 1981–87 and 1987–91 are presented in Table III.

There were considerable variations in performance among the sectors within this industry group. Dairy product and fish and seafood sectors as well as tea and coffee processing and blending sectors performed well in terms of output and TFP growth during both periods. The fish and seafood sector experienced the highest rate of growth, of about 5.5 per cent and 4.7 per cent per annum during the 1981–87 and 1987–91 periods, respectively. This sector is typically composed of small units, with little capital and abundant natural resources supporting the growth of the sector. As mentioned earlier, the production of this sector is geared mainly towards export markets and the opening up of the economy during the 1980s further stimulated the growth of this sector. As a result, this sector achieved the highest total TFP growth, of 3 per cent per annum during the 1981–87 period and about 2.5 per cent per annum during the 1987–91 period. Finally, this is the only sector where TFP was growing faster than input growth during both periods.

Sugar factories are large-scale industries. All the enterprises in this sector are publicly owned and run by the Bangladesh Sugar and Food Industries Corporation

(BSFIC). Since these enterprises enjoyed a seller's market (i.e., no competitors in the market), managers or producers were reluctant to improve productivity. Consequently, sugar factories displayed the worst performance with TFP growth of only 0.12 per cent per annum during the 1981–87 period and a negative rate of 0.91 per cent per annum during the 1987–91 period. Other industries that experienced declining TFP growth included those dealing with edible oil, grain milling, rice milling, and bakery products.

The above decomposition of output growth into its two major components provides valuable perspectives concerning productivity. Although most industries experienced accelerated output growth from the early to late 1980s, growth rates were not as high as anticipated. Moreover, growth of inputs contributed significantly to output growth in almost all the industries, and in many industries input use increased at approximately the same rates as output growth. This occurred because firms were encouraged to inject more resources as a consequence of the incentive structure provided by the government in the 1980s, particularly in the trade sectors. TFP growth contributed substantially to output growth in some industries such as fish and seafood both during the 1981–87 and 1987–91 periods. In some other industries, although TFP growth improved from the early to late 1980s, nonetheless, growth of inputs still remained the major contributor to output growth.

However, it is not possible to determine whether the changes in TFP were caused by technological progress or improvements in firm-specific capacity realization. None of the earlier studies in Bangladesh had decomposed TFP growth into its two major components.[10] Following equation (7), components of TFP growth were calculated using firm-level data for the selected industry groups. Industry-wide empirical estimates of average rate of changes in capacity realization and technological progress are presented in Table IV. Changes in capacity realization rates for various sectors of this industry group were not substantial, indicating that these industries failed to improve their performance with the existing production technology and some even declined marginally during this period. The maximum rate of contribution of improvement in capacity realization to TFP growth was only 33 per cent in the fish and seafood sector. This industry also experienced the highest rate of technological progress, at nearly 3 per cent per annum. The recent origin of this industry, and steeply rising external demand, probably led to this growth. The above results are in agreement with those of HIID-ESEPP (1988) and Sahota et al. (1991), although they used a traditional growth accounting method and TFP was measured as the residual.

[10] Using firm-level data from the U.S. electric utility industry, Callan (1986) estimated TFP growth as the sum of technical progress and the changes in capacity realization. These two components of TFP growth were obtained by modeling capacity realization as an argument in the cost function, and taking total derivatives of the cost function with respect to time. Moreover, the specification of the cost function implicitly assumes that the cost function shifts neutrally and that the rate of technical change is constant over time. These assumptions are restrictive.

TABLE IV

DECOMPOSITION OF ANNUAL AVERAGE TFP GROWTH RATES OF FOOD PROCESSING INDUSTRIES, 1981–91

(%)

Industries	1981–87			1987–91		
	TFP Growth	Change in *PCR*	Tech. Progress	TFP Growth	Change in *PCR*	Tech. Progress
Dairy products (3112)	1.374	0.004	1.370	1.697	0.088	1.591
Fish and seafood (3114)	3.027	1.020	2.007	2.573	1.044	1.529
Hydrogenated veg. oil (3115)	1.073	–0.003	1.075	1.084	–0.094	1.178
Edible oil (3116)	0.688	–0.010	0.698	–0.358	0.050	–0.407
Grain milling (3118)	0.841	0.036	0.805	–0.951	0.065	–1.016
Rice milling (3119)	1.382	–0.029	1.410	0.397	0.053	0.344
Bakery products (3122)	1.127	0.051	1.075	0.658	0.036	0.622
Sugar factories (3123)	0.127	–0.009	0.137	–0.911	0.079	–0.990
Tea and coffee processing (3126)	1.096	0.022	1.074	1.407	0.062	1.346
Tea and coffee blending (3127)	1.618	–0.010	1.628	1.851	0.069	1.783

Source: Same as for Table III.
Note: Negative signs for changes in capacity realization indicate that capacity realization declined from the previous period to the latter period and negative signs for TFP growth implies negligible growth in factor productivity.

Average rates of capacity realization among edible oil, grain milling, and sugar factories improved from the previous period but did not grow fast enough to outweigh the negative rates of technological progress. Although some industries experienced declining rates of technological progress from the early to late 1980s, technological progress still accounted for the majority of TFP growth. In Bangladesh, technological progress is achieved by importing new technologies due to the opening of the domestic economy to the world market.[11] However, in spite of the adoption of new technology for several years, manufacturing performance remains sluggish. As reported in the Asian Development Bank study (ADB 1987), firms simply import foreign equipment but do not adopt the best practice techniques for the application of inputs. Since no individual efforts were undertaken to improve the utilization of existing resources, no really effective changes took place in the production methods. Since industrial enterprises do not have their own in-house R&D activities and also lack effective linkages with government-sponsored R&D organizations, modification or adaptation of imported technology to local conditions has been very rare in recent years. The results of this paper confirm the conclusions of ILO (1991) and the World Bank (1992) that new technology, but old methods of application of inputs, failed to provide any significant "technological breakthrough" in the manufacturing industries in Bangladesh.

[11] Recent economic reforms in Bangladesh have also included the removal of quantitative restrictions, rationalization of the tariff structure, unification of multiple exchange rates, various incentives for imports by export-oriented firms, etc. to encourage production and productivity.

IV. CONCLUSIONS

Using firm-level data from Bangladesh food processing industries in a varying coefficient production frontier framework which takes into account the differences in individual input responses to output, first, this study decomposed output growth both during the pre-reform and post-reform periods into input growth, and TFP growth. The results show that input growth contributed significantly to output growth in almost all the industries, although TFP growth improved from the early to late 1980s, and in many industries input use increased at approximately the same rates as output growth. Next, this paper also examined whether changes in TFP from the pre-reform period to the post-reform period were caused by technological progress or improvements in firm-specific productive capacity realization. Although some industries experienced declining rates of technological progress from the early to late 1980s, technological progress still accounted for the majority of TFP growth. The results also show that there is a wide variation in capacity realization among firms, though a few experienced significant improvement in capacity realization during the post-reform period. The results imply that there has been a substantial unrealized productive capacity in the Bangladesh food manufacturing sector which could be eliminated.

The implications are as follows: (1) the general hypothesis that firms will exploit the technology fully, once it is given to them, is not valid in the food processing industries in Bangladesh; (2) the whole issue of the appropriate balance in emphasis between efficient choice of technology and efficient use of chosen technology is being neglected with the erroneous assumption that firms can apply technology efficiently, but cannot select it efficiently; and (3) there is still a potential to increase the output in the Bangladesh food industries without further increasing inputs, by improving the method of application of inputs.

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