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PRODUCTIVITY GROWTH AND TECHNICAL EFFICIENCY IN BANGLADESH MANUFACTURING INDUSTRIES

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1. Introduction :

Productivity growth in the industrial sector has come to be identified as a key factor in the structural transformation of LDCs[1]. Several studies have been carried out on the sources of growth of LDCs using the growth accounting framework pioneered by Denison, Kendrick and Solow. As pointed out by Pack, several important issues cannot be addressed with the help of aggregate data for broadly defined sectors. In recent years several micro-studies on productivity using firm level data in narrowly defined industries have been undertaken . Such studies are potentially useful in understanding the industrial development process in LDCs.

A very recent study for Bangladesh based on firm level data from the Census of Manufacturing Industries (CMI) uses

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1. See H. Pack, "Industrialization and Trade", Chapter 9 in H. Chenery and T.N. Srinivasan (Eds.), Handbook of Development Economics, Vol. I, 1988.

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the growth accounting framework.[2] The present study employs the production framework to study productivity growth and technical efficiency in thirty important four-digit industries in Bangladesh using the CMI data for individual firms for the years 1974-75, 1975-76, 1979-80 to 1985-86.[3] The analysis is conducted in the framework of a three-factor production function with intermediate inputs, labour input and capital input as arguments. The translog (TL) specification is used for 17 industries, for each of which at least 100 observations were available. For the remaining 13 industries with number of observations, between 35 and 99 the Cobb-Douglas specification is used. It may be stated that although the flexible TL form should be used for the investigation of the substitution possibilities between pairs of factors, it seems to offer no special advantage in regard to the study of productivity and technical efficiency. It has been found that the TL and CD forms yield similar results. Our own preliminary exercises have confirmed this. It is somewhat time-consuming to verify the "well-behavedness", that is, the properties of monotonicity and quasi-concavity of the TL specification. We have been able

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2. Productivity and Economic Development in Bangladesh, Working Paper No. 15, HIID/ESEPP Project, March 1990.

3. This paper updates Working Paper No. 19 of HIID/ESEPP Project.

to do this to a very limited extent.

A somewhat novel feature of the study is that it attempts to relax the assumption of time-invariant technical efficiency, following the approach recently suggested by Cornwell, Schmidt and Sickles (1988).

The plan of the paper is as follows : Section 2 outlines the methodology of the study. The three production function models to be estimated are set out in three sub-sections, 2.1 to 2.3. The model of productivity growth and time-invariant technical efficiency is presented in sub-section 2.1. A model intended to bring out year-to-year movements in productivity is set out in sub-section 2.2. This model is useful in examining whether the New Industrial Policy (NIP) of 1982 has contributed to productivity improvement. A generalization of the model of sub-section 2.1, allowing for time-varying technical efficiency, is outlined in sub-section 2.3. Empirical results from the three estimated models are discussed in Sections 3 to 5. Summary and Conclusions are presented in Section 6.

2. Methodology

We shall estimate production functions utilizing CMI panel data for important industries to study the following aspects :

1. Trends in total factor productivity (TFP) of individual industries over the period 1974-75 to 1985-86.
2. Technical efficiency (TE) of individual firms (enterprises or establishments) in each of the industries, assuming that TE is time-invariant.
3. Year-to-year variations in TFP of individual industries over the period 1974-75 to 1985-86, and
4. TE of firms, relaxing the assumption of time-invariance.

2.1 Productivity Growth and Time-Invariant TE

The study of aspects (1) and (2) is based on the production function of the form :

$$Y_{it} = \alpha_i + \gamma_1 . t + \gamma_2 . t^2 + X'_{it}\beta + e_{it} \qquad (1)$$

where i refers to firm i, $i = 1,2,\ldots, n$

t refers to year $t = 1,2,\ldots, T_i$

Y = natural logarithm of deflated value of output

X = Vector of natural logarithms of input variables in physical units or constant prices.

e = Disturbance term

Depending on the size of the sample for a given industry, we estimate either the three-input translog (TL) production function or the three-input Cobb-Douglas (CD) production function. The three inputs are (i) Value of intermediate inputs in constant prices (M), (ii) labour - total number of employees (L) and (iii) capital stock in constant prices (K)[4]. In the case of the CD function, the vector $X' = [\ln M, \ln L, \ln K]$ and in the case of TL function the vector

$$X' = [\ln M, \ln L, \ln K, (\ln M)^2, (\ln L)^2, (\ln K)^2, \ln M.\ln L, \ln M.\ln K, \ln L, \ln K]$$

In our study of aspects (1) and (2), the parameters of primary interest are $\alpha_i (i = 1,2,\ldots,n)$ and γ_1 and γ_2. The productivity (TFP) measure for any firm in the given industry in period t is given by the quadratic function in t :

$$\ln TFP(t) = \gamma_1 . t + \gamma_2 . t^2$$

and the implied rate of growth in productivity, TFPG is

$$TFPG(t) = \frac{d}{dt}[\ln TFP] = \gamma_1 + 2\gamma_2 t$$

and the change in TFPG is

4. The data base and data adjustments are discussed in Productivity and Economic Development in Bangladesh, Working Paper No.15, March 1990, HIID/ESEPP Project.

$$\frac{d}{dt}[TFPG(t)] = 2\gamma_2 .$$

Thus TFPG(t) is a linear function of time, $\gamma_1+2\gamma_2 \cdot t$; γ_1 can be interpreted as the initial TFPG (i.e. when t = 0) and γ_2 can be interpreted as the measure of acceleration ($\gamma_2>0$) or deceleration ($\gamma_2 < 0$) of TFPG. The special case $\gamma_2 = 0$ means that TFPG(t) is a constant, equal to γ_1. The special case $\gamma_1 = \gamma_2 = 0$ means that there is no productivity change.

The parameter α_i is the intercept for the ith firm $i = 1,2,\ldots n$. Differences in α_i across firms in the given industry reflect differences in time-invariant technical efficiency (TE). Let $\alpha_{max} = Max(\alpha_1,\alpha_2,\ldots\alpha_n)$. Then $\exp(\alpha_i-\alpha_{max})$ measures the TE of the ith firm relative to the 'best-practice' firm in the industry. The 'best-practice' firm has TE equal to 100 per cent, according to this view.

We assume that the disturbance term e_{it} fulfils the classical assumptions of zero expectation, constant variance and zero serial correlation. We propose to estimate the production function (1) by ordinary least squares (OLS). This is referred to as the 'within' estimator in the literature.[5]

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5. See P. Schmidt and R.C. Sickles, 'Production Frontiers and Panel Data', Journal of Business and Economic Statistics vol. 2, No. 4, October 1984, pp. 367-374.

OLS estimation of the production function could be justified in terms of the Zellner-Kmenta-Dreze proposition that under the assumption of maximization of expected profits, the explanatory variables and the disturbance term are uncorrelated. The 'within' estimator employed in this study, compared to the generalized least squares (GLS) estimator, has the desirable property that its consistency does not require the assumption of uncorrelatedness of the regressors (inputs) and the firm effects (α_i). Consistency of the estimated firm effects, however, requires that T_i, the number of observations for firm i, tends to infinity.[6] In view of the fact that $T_i \leq 9$, the limitation of our estimates of technical efficiency should be borne in mind.

It is important to draw attention to possible pitfalls in the interpretation of the estimated measures of TE. Since these are derived residually, these are likely to be contaminated by errors of measurement and omitted variables. For this reason, the estimates based on the translog (TL) specification should be preferred to those based on the Cobb-Douglas (CD) specification. Also the TL function is a flexible form. The square and interaction terms in the function provide information on whether substitution possibilities between pairs of inputs diverge from the unitary elasticities of substitution implied by the CD function.

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6. See Schmidt and Sickles, ibid.

Most of the earlier studies on TE have relied on the CD form of the production function. Kopp and Smith (1980) compare the CD, the Constant Elasticity of Substitution (CES) and the TL forms for electricity generation plants; they observe that the TL yields marginally higher efficiency measures.[7] Our own exploratory exercise for several industries has shown that the results from the CD and the TL specifications are in broad agreement in respect of productivity growth, differences in TE as measured by the F-statistic, and the minimum level of TE.

2.2 Year-to-Year Variations in TFP

Inter-year differences in productivity in any industry is analysed by estimating the following relationship :

$$Y_{it} = \delta_t + X_{it}'\beta + e_{it}, \qquad (2)$$

where all symbols other than $_t$, have the same meaning as in (1). δ_t is the intercept for year t, t = 1974-75, 1975-76, 1979-80,..., 1985-86. Differences in $_t$ reflect year-to-year differences in productivity (TFP). Relationship (2) has been estimated by OLS for 17 industries. Using the estimates of $_t$ for different years, an index

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7. R.J. Kopp and V.K. Smith (1980) 'Frontier Production Estimates for Steam Electric Generation: A Comparative Economic Analysis', Southern Economic Journal, 47, 1049-59.

of year-wise productivity (TFP) performance has been constructed with 1982-83 = 100 :

$$TFP(t) = \exp \{ \delta_t - \delta_{1982-83} \} \times 100.$$

2.3 Time-Varying Technical Efficiency

Here we relax the restrictive assumptions with regard to productivity change and technical efficiency implicit in (1).

We estimate a model of the form suggested recently by Cornwell, Schmidt and Sickles[8] :

$$Y_{it} = \alpha_{it} + X_{it}'\beta + V_{it} \qquad (3)$$

where $\alpha_{it} = \theta_{i1} + \theta_{i2}t + \theta_{i3}t^2$

and other symbols have the same meaning as in (1)

Let $\hat{\beta}$ be the 'within' estimator of β. The vector $\theta_i = [\theta_i, \theta_{i2}, \theta_{i3}]'$ is estimated by regressing the residuals $(Y_{it} - X_{it}'\hat{\beta})$ for firm i on t and t^2 . The null hypothesis of time-invariant technical efficiency for firm i is equivalent to $H_0 : \theta_{i2} = \theta_{i3} = 0$. This hypothesis is tested by testing the significance of the

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8. C. Cornwell, P. Schmidt and R.C. Sickles, 'Production Frontiers with Gross-Sectional and Time Series Variation in Efficiency Levels', unpublished, Sept. 1988.

R^2 for the regression of $(Y_{it} - X'_{it}\hat{\beta})$ on t and t^2. This test is possible only for firms with at least 4 observations.

3. Productivity Growth and Time-Invariant Technical Efficiency : Results

We have first obtained the ['within'] estimates of the Model I : the TL function for 17 industries for which more than 100 observations are available, and the CD function model for 13 other industries for each of which the total number of observations is less than 100, but more than 35. The results for these two categories of industries are presented in Appendix Tables A.1 and A.2, respectively.

Rather than comment on the details of the regressions, we shall bring out the salient features by examining the summary results bearing upon productivity growth and inter-firm differences in technical efficiency. The summary results are presented in Tables 1 and 2.

3.1 Productivity Growth : The figures in columns (4) and (5) of Tables 1 and 2 provide information about productivity growth over the period 1974-75 to 1985-86. The coefficient of t (col.4) is an estimate of the rate of productivity growth (TFPG) when t = 0, i.e. for the year 1973-74. The coefficient of the t^2 variable is a measure of the change (acceleration/deceleration) in TFPG over time.

In terms of TFPG, the 30 industries taken up for study fall into five distinct categories. The categories, their defining characteristics, and the industries in each category are shown below.

Category	Defining Characteristics	Number	Industries	
I	No significant productivity change (coefficients of t and t^2 are both insignificant)	15	3119 3206 3413 3501 3504 3521 3525 3569	3804 3805 3809 3819 3824
II	Acceleration from an initially negative TFPG (coefficient t significantly negative and coefficient of t^2 significantly positive)	3	3118 3141 3816	
III	Acceleration from the initial zero TFPG (coefficient of t insignificant and coefficient t^2 significantly positive)	2	3201 3819	
IV	Stagnation at an initially positive TFPG	6	3112 3122 3126	3204 3231 3422

V	Deceleration from an initially positive TFPG	4	3114 3203 3213 3713

Thus one-half of the 30 industries are characterized by stagnation in the matter of productivity. Two major industries, namely, Rice Milling (3119), Handloom textiles (3206) and several Chemical (two-digit code 35) as well as metal based (two-digit code 38) are found in this category.

Cotton Textiles (3201), Grain Milling (3118), Fabricated metal products, n.e.c. (3819), Bolts, nuts and rivets (3816) and Cigarettes (3141) are characterized by acceleration in TFPG from initially negative or zero TFPG.

Three industries in the food manufacturing group namely, 3112, 3122 and 3126, Silk and synthetic textiles (3204), Tanning and Finishing (3231), and Printing and Publishing of books (3422) show no significant change in TFPG over time.

Fish and sea foods (3114), jute textiles (3203) Knitting mills (3213) and Iron and Steel re-rolling (3713) have shown significant deceleration in TFPG over the sample period.

Thus stagnation is the predominant feature of the change over the twelve-year period 1974-75 to 1985-86.

3.2 Time-Invariant Technical Efficiency .

Results on the technical efficiency of individual firms (or establishments) in the 30 industries are presented in columns (6) to (8) of Tables 1 and 2. The figures in col. 6 show that inter-firm differences in technical efficiency are statistically significant, at 5 per cent level, in 24 industries. Jute Textiles (3203), Wooden Furniture (3321), Match manufacturing (3525), Furniture and Fixtures-metal (3804) Bolts, Nuts and Rivets (3816) Fabricated metal products, n.e.c. (3819) and Textile Machinery (3824) are the only industries where all the firms in the given industry are quite similar in respect of technical efficiency.

Minimum technical efficiency, that is, technical efficiency of the least efficient firm in the industry is shown in col. 7 of Tables 1 and 2. For about one half of the industries, the minimum technical efficiency does not exceed 35 per cent. It is above 60 per cent in only 3 industries. Technical efficiency differences in most industries are quite large.

Average (median) technical efficiency of firms in each industry is shown in col. 8 of Tables 1 and 2. In 14 of the industries, it does not exceed 50 per cent. However in 13 it is above 66 per cent. Only in two industries (3321 and 3805) it is above 92 per cent.

The results on technical efficiency presented above suggest that there is considerable scope for the improvement of technical efficiency of firms in most of the industries.

We saw that five industries (3118, 3141, 3816 of category II and 3201 and 3819 of category III) experienced acceleration in TFPG over the period 1974-75 to 1985-86. The median technical efficiency for these industries are 26, 63, 79, 42 and 55 per cent respectively. Similarly, the range of variation in median technical efficiency for 15 industries of Category I which experienced no productivity change is very high, 32 per cent to 98 per cent. Thus, the association between productivity performance (at the industry level) and average technical efficiency appears to be weak.

4. Year-to-Year Variations in Productivity

The productivity results presented in Tables 1 and 2 were intended to analyse the medium-term trends in productivity over the period 1974-5 to 1985-86. In this section we present results which focus on the year-to-year variations in productivity. We shall compare the productivity level in each year, except 1976-77, 78-79, and 79-80 for which CMI data are not available, with that in 1982-83 in which year the New Industrial Policy (NIP) was introduced. The comparison of the years 1983-84, 1984-85 and 1985-86 with 1982-83 will enable us to assess the impact of NIP on

productivity. We-carry out the analysis with the help of year dummies in the production function regression - relationship (2). It must, however, be admitted that this methodology is not satisfactory for policy evaluation for at least two reasons.

(1) The policy instruments are not incorporated in our analysis.

(2) The coefficients of the year dummies will reflect not only the effect of policy instruments on productivity but also the effect of all year-specific factors.

The estimated regressions are to be found in Table A.3. Appendix. The indices of year-wise productivity performance for seventeen industries based on production function regressions with year dummies are presented in Table 3. The index has the value 100 for the year 1982-83. The F statistic for year dummies is significant at 5 per cent level only for 9 industries out of 17.[9] In the pre-1982-83 period, no clear upward trend in productivity is discernible for most of the 17 industries. In 1983-84, in only two industries

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9. It may be noted that the results of Table 3 are not quite comparable with those in Tables 1 and 2, because the regressions underlying the results of Table 3 do not contain firm dummies. The available software does not permit the simultaneous presence of firm and year dummies.

(3201, 3204, 3206, 3231 and 3501) experienced significantly higher levels of productivity, while none recorded significantly lower level compared to 1982-83. With the exception of four industries (3119, 3213, 3525 and 3713) all industries fared better in 1985-86 compared to 1982-83. Similarly, in years 1983-84 and 1984-85 eleven industries fared better than in 1982-83. Thus there is some evidence to show that the productivity performance of the industries in the post-1982-83 period improved somewhat. But the evidence is far from conclusive.

5. Time-Varying Technical Efficiency : Results

The summary results of estimating the time-varying technical efficiency model (3) for 18 industries are presented in Table 4 . It may be seen from the table that for a good majority of firms in each industry there was no significant change in productivity or technical efficiency over time (see col. 5 in relation to col. 2). As many as 256 firms (70 per cent) out of a total of 361 sample firms in the 18 industries stagnated. For them technical efficiency is time-invariant. For 74 firms there was significant change in technical efficiency over time: acceleration for 46 firms (col. 3) and deceleration for 28 (col. 4) Cotton Textiles (3201), Tanning and Finishing (3231) Printing and Publishing of Books (3422), Fabricated Metal Products (3819), Miscellaneous Plastic Products (3569) Handloom textiles

(3206) and Plumbing Equipment (3817) had among their firms several which experienced increase in technical efficiency. On the other hand, several firms in Jute Textiles (3203), Tanning and Finishing (3231) and Iron and Steel Re-rolling (3713) suffered deceleration in productivity.

Average technical efficiency as estimated from Model I and presented in columns (6) to (8) for different groups of firms does not reveal any relationship between acceleration/deceleration of productivity and the measure of time-invariant technical efficiency.

We present in columns 9 and 10 of Table 4, information about the performance over time of the least efficient and the most efficient firms. Out of 18 cases, only in two (3122 and 3201) the least efficient firm improved its productivity performance, in 13 cases it stagnated and suffered a setback. in two (3114 and 3713) other cases. The most efficient firm further accelerated in one case (3805), decelerated in 2 cases (3521 and 3525) and stagnated in the other cases.

Thus time-invariance or stagnation in productivity performance was the characteristic of over 70 per cent of the sample firms. Acceleration was more in evidence than deceleration. Different industries had different numerical shares in the accelerating, decelerating and stagnant groups of firms.

6. Summary and Conclusions

In this paper we have presented results of an exercise on micro-productivity for 30 important four-digit industries in Bangladesh covering the period 1974-75 to 1985-86. The study has utilized establishment data from the Census of Manufacturing Industries. The paper has dealt with two aspects

(i) Growth in total factor productivity (TFP) at the industry level and

(ii) Technical efficiency (or productivity) of individual establishments in each industry.

Panel data have been used to estimate three types of production models, one of which seeks to relax the assumption of time-invariant technical efficiency.

The empirical results are quite striking :

(a) Fifteen of the thirty industries experienced no significant productivity change over the period. Very few (5) industries showed significant acceleration in TFP change. Several suffered from deceleration in productivity change. The overall picture that emerges is one of stagnation in productivity.

(b) Differences in technical efficiency across firms were found to be significant in a majority of industries. The minimum level of technical efficiency and/or median technical efficiency was rather low in many industries. These results suggest that there is considerable scope for improvement of the productivity of individual firms in most industries.

(c) Year-to-year variations in productivity were found to be significant in several industries. The post NIP years registered marginally better performance in a few industries. The year 1985-86 showed somewhat better results in several industries . However, the over-all impression the results produce is that there was no pronounced improvement in productivity over the years, consistent with other evidence presented in this paper and elsewhere.

(d) We examined the productivity growth experience of 361 sample firms belonging to 18 industries. 70 per cent of these firms experienced no significant change in productivity or technical efficiency over the period 1974-1986. Only 46 firms registered improvement in technical efficiency, while 28 suffered a decline.

In brief, with a few exceptions, firms in Bangladesh industries displayed no signs of productivity growth.

We have carried out some limited exercises to explain the inter-firm differences and temporal variations in technical efficiency in terms of scale of the enterprise, skill composition of the labour force, capital intensity and material intensity. The explanatory power of the regressions is very low, and the explanatory variables have insignificant coefficients for most of the industries .

The limitations of our results have been highlighted at the appropriate places. These should be kept in mind.

Several other aspects of the production function could be analyzed from the available data. Some work has already been completed. It will form the subject of another paper.

Summary Results on TPRG and Technical Efficiency (TE) based on Estimates of the Production Function Frontier

Industry Code (1)	Number of firms (2)	Number of obs (3)	Coefficient of t (4)	Coefficient of t^2 (5)	F statistic for TE differences (6)	Technical Efficiency(%) Minimum (7)	Technical Efficiency(%) Median (8)
3118	41	237	-.207* (.034)	.013* (.002)	3.359*	18.9	26.3
3119	38	226	.022 (.077)	.0005 (.005)	2.077*	22.6	32.4
3122	35	244	.043* (.020)	-.0014 (.0011)	3.246*	45.8	55.2
3125	55	402	.090* (.021)	-.0008 (.001)	5.464*	17.2	49.9
3201	40	302	+.020 (.017)	.002* (.001)	3.616*	9.4	41.8
3203	44	364	.139* (.029)	-.005* (.002)	1.039	42.8	71.8
3204	40	293	.044* (.016)	.0007 (.001)	1.899*	47.2	49.4
3205	29	157	-.023 (.053)	.003 (.004)	3.685*	6.1	27.4
3213	54	404	.043* (.013)	-.002* (.001)	2.495*	55.4	66.3
3231	51	357	.050* (.024)	-.0002 (.001)	1.419*	43.0	70.2
3422	30	165	.058* (.021)	-.001 (.001)	6.199*	37.8	69.9
3501	74	485	.015 (.031)	.002 (.002)	3.543*	16.2	42.7
3521	13	103	.019 (.045)	.002 (.003)	2.829*	30.1	55.7
3525	12	103	.022 (.046)	.001 (.003)	1.485	25.6	50.0
3713	20	167	.135* (.036)	-.008* (.002)	2.673*	21.4	67.0
3809	25	180	.012 (.033)	.0025 (.002)	3.400*	25.6	38.9
3819	16	121	-.024 (.029)	.0045* (.0017)	10.491*	38.6	55.3

Note: See Appendix 1 for the description of industry code (co. 1).

* Significant at 5% level

Table 2

Summary Results on TFPG and Technical Efficiency (TE)
based on Estimates of the CD Production Function Frontier

Industry	Number of Firms	Number of Observations	Coefficient of t	Coefficient of t^2	F-statistic for firm effects	Technical Efficiency Minimum	Technical Efficiency Median
1.	2	3	4	5	6	7	8
3112	9	51	.091* (.014)	–	11.248*	1.6	10.4
3114	5	37	0.303* (.143)	–.018* (.009)	2.850*	46.0	67.5
3321	11	73	.008 (.032)	.001 (.002)	1.225	76.2	92.9
3141	6	48	–.107* (.047)	.007* (.003)	3.032*	57.8	63.2
34[illegible]	10	72	–.007 (.051)	.003 (.003)	4.391*	29.1	44.1
350	3	55	–0.28 (.081)	.002 (.005)	7.351*	20.2	42.1
3504	6	47	.0246 (.064)	–.0009 (.004)	3.902*	27.0	42.2
3569	11	81	–.004 (.007)	–	3.166*	52.9	69.3
3804	7	49	–.007 (.060)	.0032 (.0037)	0.961	27.1	46.0
3805	6	38	.065 (.041)	–.0012 (.0023)	4.168*	56.3	97.7
3816	9	68	–.057* (.026)	.0041* (.0016)	1.800	70.5	79.1
3817	9	69	.017 (.034)	.0007 (.002)	4.125*	61.3	89.0
3824	7	48	–.035 (.57)	.0063 (.0037)	2.146	56.1	74.0

* Significant at 5 per cent level

Table 3

Index of Year-wise Productivity (TFP) Performance based on Production Function Estimates with Year Dummies 1982-83 = 100.

Industry	Year								F Stat for Year dummies
(1)	1974-75 (2)	1975-76 (3)	1979-80 (4)	1980-81 (5)	1981-82 (6)	1983-84 (7)	1984-85 (8)	1985-86 (9)	(10)
3118	97	154*	95	92	96	99	103	108	1.52
3119	-	76	78*	85	91	93	96	83	1.05
3122	82*	89	100	91	93	99	101	101	2.43*
3126	107	99	114	96	94	127*	99	111	3.20*
3201	80*	95	92	95	93	113*	105	124*	8.37*
3203	54*	86*	97	89	84*	101	104	115	9.37*
3204	69*	74*	89*	94	99	106	107	131*	17.7*
3205	92	92	106	97	94	82	106	149*	0.66
3213	78*	76*	93	78*	94	97	92*	98	2.10
3231	80*	83*	95	111	100	104	103	131*	7.24*
3422	92	58	91	97	97	103	106	115	13.75*
3501	80*	84*	108	107	100	104	109	167*	8.76*
3521	90	98	97	107	91	104	95	133	1.40
3525	92	92	82	79	98	118	106	95	1.01
3713	81	88	93	98	121	98	96	93	1.64
3809	87	78*	83*	86*	89	96	94	104	1.83
3819	86	86	93	91	96	109	112	124	2.91*

* : The corresponding coefficient is significant at 5 per cent level.

Notes:
1. See Appendix 1 for the description of the industry Code (Col.1).
2. The index of productivity performance presented in the table is based on the coefficients of the dummy variables for years in the panel data regressions. Firm dummies are not present in these regressions.

Table 1

Summary results on temporal variation in Technical Efficiency based on Frontier (TL/CD) Production Function

Industry Code	Sample No. of firms				Average Technical Efficiency (Percent)			Performance of the	
	I	GA	GD	GS	I	GA	GD	Least efficient firm	Most efficient firm
1	2	3	4	5	6	7	8	9	10
3122	32	2	2	28	55	50	53	Improved	stagnated
3201	40	11	1	28	42	32	18	Improved	stagnated
3203	44	1	8	33	72	66	32	stagnated	stagnated
3206	29	3	1	13	27	15	24	stagnated	–
3231	51	5	5	33	70	64	72	–	–
3422	30	4	1	20	70	66	73	stagnated	stagnated
3521	13	1	1	11	56	33	100	stagnated	decelerated
3525	12	1	1	10	50	39	63	stagnated	decelerated
3713	20	2	3	15	67	64	35	decelerated	stagnated
3819	26	4	1	21	55	57	76	stagnated	stagnated
3114	5	0	2	3	68	–	57	decelerated	stagnated
3503	8	0	0	8	49	–	–	stagnated	stagnated
3569	11	3	2	6	69	83	65	stagnated	stagnated
3904	7	1	0	6	46	44	–	stagnated	stagnated
3305	6	2	1	2	98	99	77	stagnated	accelerated
3816	9	2	0	7	79	79	–	stagnated	stagnated
3817	9	3	0	6	89	83	–	stagnated	stagnated
3824	7	1	0	6	74	72	–	stagnated	stagnated

Notes: (1) I = Industry, GA = group which experienced acceleration in TFP GD = group which experienced deceleration in TFD, GS = group which experienced stagnation in TFP, as revealed by the F test

(2) For some firms in several industries the number of (yearly) observations is less than 4. For such firms the null hypothesis of stagnation in productivity could not be tested.

(3) Average Technical efficiency figures given in columns (6)-(8) are based on regressions with time invariant efficiency.