Journal of Economic Cooperation, **28**, 4 (2007), 81-104

PRIVATIZATION AND REGIONAL AGGLOMERATION EFFECT ON TECHNICAL EFFICIENCY OF BANGLADESH MANUFACTURING INDUSTRY

Azizul Baten*, Masud Rana, Sumonkanti Das
& Mosammet Kamrun Nesa**

This paper examines how far private investment in manufacturing industries of Bangladesh, together with the spatial agglomeration of those industries affect technical efficiency over the period 1981-82 through 1999-2000 using a panel data. Using the Translog stochastic frontier model outlined by (Huang and Liu, 1994:171) we found that private and foreign investment play an important role in explaining technical inefficiency, whereas impact of agglomeration is negligible. The paper also explored whether the degree of private investment has a greater impact on technical efficiency where the domestic industry is characterized by comparatively high productivity. The mean technical efficiency in the period analyzed was estimated to be 56.8%.

Introduction

In the last two decades, many countries launched extensive privatization programs. Despite this growing experience we still lack empirical knowledge of some critical issues. Does privatization affect technical efficiency? How exactly does technology change as a result of

* Contact author, Asso. Prof., Department of Statistics, Shah Jalal University of Science & Technology, Sylhet-3114, Bangladesh.
E-mail: baten_math@yahoo.com
** Department Of Statistics, Shah Jalal University Of Science & Technology, Sylhet-3114Bangladesh

privatization? Do agglomeration economies matter? In this paper we address these questions as we empirically examine the effects of privatization on technical efficiency and technological change, together with the nature and determinants of private investment in the region of Bangladesh, paying particular attention to agglomeration factors, with a panel data set of Bangladesh manufacturing industries.

The contribution of the private sector of Bangladesh is very remarkable for economic development in the domestic and global arena. During the last 33 years the economy of Bangladesh has witnessed fundamental changes in economic, industrial and trade policies. In post-liberation period, the government faced with pressures on financial and management resources, the government soon initiated the process of privatization and gradual expansion of private sector. Private investment ceiling was raised from TK. 2.5 million in 1973 to TK. 30 million in 1974. It was further raised to TK. 100 million in 1975 and totally withdrawn in 1978. The private sector performance is more spectacular in foreign exchange earnings from export. Out of the total foreign exchange earning of US $ 8.66 billion in 2004-2005, private enterprises represented more than 95% of the total earning which has risen from 74.27% in 1990-1991.

The economic theory of privatization is a subset of the vast literature on the economics of ownership and the role for government ownership of productive resources. There are two main branches in this literature: The Social View (Shapiro and Willig, 1990)) and the Agency View (Vickers and Yarrow, 1988); (Shleifer and Vishny, 1994:995)). (Bhaskar and Khan, 1995:267) find that privatization has a large and significant negative effect on white collar workers using employment data from Bangladesh, for 62 jute mills of which 31 were privatized in 1982 and controlling for firm fixed effects.

Industry agglomeration may play a role in reducing technical inefficiency in the domestic sector as a whole, there is also the possibility that industries that are regionally concentrated might also benefit most from private investment induced productivity spillovers, with geographical proximity expected to affect the degree of knowledge transmission through labor markets, buyer-supplier partnerships and general communities of interest. The concept of agglomeration is linked with new approaches in economic geography which have highlighted the competitive potential associated with tight demand and supply inter-linkages among regional clusters of allied industries see for example, (Scott, 1988:171); (Porter, 1990).

Marshall at the end of nineteenth century identified three types of external economies that generate agglomeration: specialized labor, specific inputs and technological spillovers. The agglomeration of industry activity may impact on productivity growth because of its influence on the rate of technical change (Beeson, 1987:36). A key area of debate, however, is the distance over which such agglomeration benefits are significant (Krugman and Venables, 1995:857); (Audretch, 1998:18). However, a number of authors (Head, Ries and Swenson, 1999:197) and (Guimareas, Figueiredo and Woodward, 2000:115) consider this measure to be somewhat crude since the variable should be, at least in part, industry-specific, especially when it is only variable being used to calculate agglomeration economies.

To date, few studies of locational determinants have examined the variables of new economic geography and even fewer studies have examined the locational determinants of private investment in Bangladesh at the regional and industry level. Therefore an effort has been made to examine the determinants of technical efficiency focusing particularly on the role of private manufacturing investment and spatial agglomeration of similar industry activities using three digit industry data from the Census of Manufacturing Industries (CMI) of Bangladesh for the periods 1981-1982 through 1999-2000. The study also explores how far the impacts of private firm spillovers vary according to existing levels of industry productivity and spatial agglomeration. The method adopted involves the estimation of a stochastic production frontier with random components associated with industry technical inefficiency and a standard error. The contribution then attempts to link research on the estimation of technical efficiency, private investment and spatial agglomeration.

The paper continues with the following structure. The second section outlines the stochastic frontier production function approach with the inefficiency effects model and the functional forms of the frontiers. The third section presents the empirical results from estimating the stochastic frontier production model. Finally, the last section contains some conclusions.

Stochastic Frontier Production Function

Let us consider a panel data model for inefficiency effects in stochastic production frontiers based on the model proposed by (Huang and Liu, 1994:171). Efficiency is measured by separating the efficiency component from the overall error term.

Having data for i firms in year t for input and output data ((X_{it}, Y_{it})), the stochastic frontier production function model with panel data is written as:

$$Y_{it} = f(X_{it}; \beta_t).\exp(V_{it} - U_{it}) \quad ....(1)$$

where Y_{it} is the firm output at the t^{th} observation ($t = 1, 2, 3, ...T$) for the i^{th} firm ($i = 1, 2, 3, ...n$);

$f(.)$ represents the production technology;

X_{it} is a vector of input quantities of the i^{th} firm in the t^{th} time period;

β_t is a vector of unknown parameters in the t^{th} time period;

V_{it} are assumed to be independent and identically distributed random errors, which have normal distribution with mean zero and unknown variance σ_v^2.

U_{it} are non-negative unobservable random variables associated with the technical inefficiency in production, such that, for the given technology and level of input, the observed output falls short of its potential output.

According to the specification of (Huang and Liu, 1994:171), the technical inefficiency effect model, referred to as "Non-neutral stochastic frontier model", U_{it}, could be defined as:

$$U_{it} = Z_{it}\delta + Z_{it}^{*}\delta^{*} + W_{it} \quad ....(2)$$

where Z_{it} is a vector of explanatory variables which may influence the efficiency of the firm;

δ is a vector of unknown parameters to be estimated;

Z_{it}^{*} is a vector of values of appropriate interactions between the variables in Z_{it} and X_{it};

δ^{*} is a vector of unknown parameters;

W_{it} is unobservable random variable, which are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance, σ_u^2, such that, U_{it} is non-negative (i.e. $W_{it} \geq -Z_{it}\delta$). The mean $Z_{it}\delta$; $i = 1, 2, 3, ...n$; $t = 1, 2, 3, ...T$ may be different for different firms and time but the variances are assumed to be the same.

An estimated measure of technical efficiency (TE) for the i^{th} firm in the t^{th} time period is defined as the ratio of the observed output, Y_{it}, to the corresponding frontier output, Y_{it}^*, conditional on the levels of inputs used by the firm. Thus the technical efficiency of firm i at time t in the context of the stochastic frontier production function (1) is as:

$$TE = \frac{Y_{it}}{Y_{it}^*}$$

$$= \frac{f(X_{it}, \beta).\exp(V_{it} - U_{it})}{f(X_{it}, \beta).\exp(V_{it})} = \exp(-U_{it}).$$

The unobservable quantity U_{it} may be obtained from its conditional expectation given the observable value of $(V_{it} - U_{it})$ (Jondrow et. al., 1982:233); (Battese and Coelli, 1988:387); (Kalirajan and Flinn, 1983:167).

Functional Forms

There are basically two common functional forms of production function used in studying technical efficiency using stochastic frontier production functions, namely Cobb-Douglas and general Translog functional forms. Since the Cobb-Douglas specification is nested in the Translog model and the form is flexible and imposes fewer restrictions on the data, we start with the Translog specification in our analysis and define it as follows:

$$Y_{it} = \beta_o + \sum_{j=1}^{4} \beta_j X_{jit} + \sum \sum_{j \leq k=1}^{4} \beta_{kj} X_{jit} X_{kit} + V_{it} - U_{it} \quad ....(3)$$

where Y is the log of gross output and four input variables (X_j) are the logs of capital, manual labor, non-manual labor and year of observation. In this model year of observation and its interaction with input variables are included in a way to specify both neutral and non-neutral technical change respectively.

In this specification if β_{kj}, the second-order terms, are all equal to zero then the model reduces to standard Cobb-Douglas form. The inclusion of year of observation as a variable allows for the shifts of the frontier over time, which is interpreted as technical change. Technical change is neutral if all $\beta_{4j}, j = 1,2,3$ are equal to zero. Using generalized likelihood ratio test we can test the significance of the neutral and non-neutral technical change in the model.

In the second part of the model, the inefficiency effects follow from equation (2), provided these effects are stochastic and not merely a deterministic function of the relevant explanatory variables. Thus, the mean efficiencies for each firm, m_{it}, are explained as follows:

$$m_{it} = \delta_o + \sum_{k=1}^{3} \delta_k Z_{kit} + \sum_{k=1}^{3} \sum_{j=1}^{4} \delta_{kj} Z_{kit} X_{jit} + W_{it} \quad ....(4)$$

where Z_1 is the dummy for foreign investment, Z_2 is PRIVATE and Z_3 is AGGLOM, are three explanatory variables. Here PRIVATE is the variable that shows the degree of private penetration of the given industry sector, AGGLOM is the regional industry agglomeration variable. The variable Z_1 takes the value 1 if the industry receives foreign investment otherwise it takes zero. The dummy variable is included in the model to capture the significance of foreign investment in the average efficiency levels of the industries.

Our study area covers 3-digited census industries, under registered manufacturing sectors of Bangladesh over the reference period 1981-1982 through 1999-2000. The numbers of sample industries, whose data are considered in this study, were 26 for each year. Thus, these data involved a total of 416 observations over the 16-year period. Private penetration at the industry level (PRIVATE) is measured as the share of industry gross output that is accounted for by private owned industry. The Census of Manufacturing Industries (CMI) reports the industry gross output for each of the six administrative divisions of Bangladesh. The divisional shares of given industry gross output was calculated and then a location quotient was derived. The location quotient reveals how specialized a division is in terms of a given industry. The location quotient was calculated by dividing the divisional share of gross output of the selected industry of Bangladesh, by the same division's share of total gross output. A location quotient of greater than one indicates that the division in question has a share of selected industry gross output greater than its size in terms of share of total gross output of Bangladesh manufacturing industry would suggest. For each of the 26 defined, this gave a series of 6 location quotients. The standard deviation of these location quotients were calculated and then a coefficient of variation. The value of the coefficient of variation is the measure of agglomeration (AGGLOM) used here. Where shares of industry gross output are evenly spread across divisions then the divisional location would tend towards one and the resulting standard deviation and coefficient of variation would tend to zero. More spatially concentrated industries would tend to have higher coefficients of variations. Agglomeration of industry was measured by (Driffeld and Munday, 2001:391). It is important to recognize that this agglomeration variable describes divisional concentrations of industry activity and is hence only a guide to the existence of clusters of allied industry activity.

Empirical Results

Following (Huang and Liu, 1994:171), the frontier production function defined by (3) and the inefficiency model defined by (4) are estimated simultaneously by using maximum likelihood method for each industry separately. The estimation procedure is performed using FRONTIER 4.1 computer program (Coelli, 1996), which uses Davidson-Fletcher-Powell Quasi-Newton method to obtain the maximum likelihood estimates. This simultaneous estimation is considered to be superior to the two-stage estimation because of two reasons. First, the two-stage estimation is inconsistent in its assumption regarding the independence of the inefficiency effects in the two estimation stages (Coelli, 1996a). Second, the efficiency scores are bounded variables, because of the non-normality and bounded range of the error term (Lovell, 1993). The variance parameters are estimated in terms of $\gamma = \frac{\sigma_u^2}{\sigma^2}$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

As outlined above, the initial stage in the estimation of the frontier is to determine the appropriate specification for the frontier model. This involves several tests based on technical efficiency restrictions implied by the different error structures (Battese and Coelli, 1992:153); (Kumbhakar, 1993:11). A number of statistical tests were carried out to identify the appropriate functional forms and the presence of inefficiency and its trend. For this let us use the generalized likelihood-ratio (LR) statistic as defined below:

$$\lambda = -2[L(H_o) - L(H_1)]$$

where $L(H_o)$ is the log likelihood value of the restricted frontier model as specified by the null hypothesis H_o and $L(H_1)$ is the log likelihood value of the unrestricted frontier model under alternative hypothesis H_1. This test statistic has a chi-square or a mixed chi-square distribution with degrees of freedom equal to the difference between the parameters in the null and alternative hypothesis. Table 2 in the appendix presents the results of these tests.

The first test shows that, given the specification of the technical inefficiency effects model, the null hypothesis that the Cobb-Douglas functional form is preferred to the Translog is rejected by the data. This indicates that input elasticities and substitution relationships are not constant for industries of different sizes and with different input values in the manufacturing industries of Bangladesh. The LR test establishes that some unknown combination of the squared and cross-product terms in the Translog improve the fit of the models, even in cases where few or even none of these variables are individually significant according to the t statistic. The second null hypothesis of no technological change at the frontier is also rejected, implying shift of the production frontier over time whereas the null hypothesis of neutral technical change is accepted by the data. These two hypotheses indicate that neutral technical change exists in the Bangladesh manufacturing industry. The null hypothesis explored in test 4 is that each firm is operating on the technically efficient frontier and that the systematic and random technical inefficiency effects are zero. The null hypothesis that $\gamma = \delta_0 = \delta_1 = ... = \delta_{43} = 0$ is rejected, suggesting that inefficiency was present in production and that the average production function is not an appropriate representation of the data. The estimate of γ indicates that the proportion of the one-sided error in the total variance of the composed error term is as high as 91% for non-neutral stochastic frontier model (Table 3). This in turn means that the variation in the observed level of output is not just due to random shocks but also can be explained by the differences in the levels of technical efficiency of the industry and thus inefficiencies in production are the dominant source of random error. Finally, given the specifications of the non-neutral stochastic frontier model, the hypothesis that the neutral model is an adequate representation, $H_o : \delta_{ij} = 0;\ i = 1,2,3,4;\ j = 1,2,3$, is rejected by the data. Thus, the hypotheses testing results show that our specifications of equation (3) and (4) are more suitable to the data compared to other alternative specifications.

The parameter estimates of the preferred frontier production function and inefficiency model are given in table 3 in appendix. Given the results of the tests of hypothesis, the preferred frontier model is that without interactions between year of observations and the input variables. Among the first order coefficients, capital, manual and non-manual labor turned out to be statistically significant at 5 percent level of significance based on the asymptotic t-values. The positive sign of the estimated coefficient of year of observation indicates that there was technical progress in mean frontier model. Capital and non-manual labor input variable showed negative sign. The second order coefficient of manual and non-manual labor came out to be negative and statistically significant whereas that of capital and year of observation are positive and insignificant.

The estimates of inefficiency model give how the technical inefficiency is related to variables of our interests. The dummy variable representing the contribution of foreign investment in an industry along with private investment variable has a negative sign though it is not statistically significant. This indicates that foreign and private investment in manufacturing industry of Bangladesh has a favorable effect on technical efficiency. The interactions between manual labor and AGGLOM, non-manual labor and private have significant negative effect on technical inefficiency suggesting that their joint impact are contributing positively on efficiency.

The parameter estimates of divisional agglomeration turned out to be positive and significant indicating that geographical concentration has an unfavorable effect on its domestic industry level efficiency. This is a surprising result. Because Dhaka, capital city of Bangladesh, comprises on average 50.5% of gross output of manufacturing industry of Bangladesh from the lowest of 38.6% in 1981-1982 to the highest of 68.5% in 1999-2000. That of Chittagong, commercial capital city of Bangladesh, is on average 30.8%. The rest four divisions namely Barisal, Khulna, Rajshahi and Sylhet comprise the rest of 28.7% share on total all together.

In order to further examine the relationship between technical efficiency, private investment and agglomeration, equation (3) and (4) are re-estimated using a series of sub-samples of the data. The sample was split according to observed levels of industry labor productivity and agglomeration. This is done in the following ways: labor productivity is calculated by dividing gross output by total labor input i.e. sum of manual and non-manual labor for each industry, average labor productivity is calculated and the sample is split according to grand average of labor productivity. This gives 16 industries as low productive and the rest is treated as high productive. The two sub-samples are then re-estimated. This procedure enables us two consistent sub-samples for estimation.

The results of the re-estimation of the two sub-samples are given in Table 4 and 5. The results demonstrate that it is important to split the sample in order to explain the variations in total factor productivity. For example, spillovers from private investment are only negative and significant (Table 4) in industries of above average productivity whereas that is positive and insignificant (Table 5) in industries of below average productivity. This suggests that a critical level of productivity is a necessary condition for spillovers from private investment to occur. The results also suggest that the coefficient of inefficiency effect parameter is quite different for the two sub-samples. It is almost unity in low productive industries. Again, the coefficient regional agglomeration parameter turned out to be positive and significant for both samples. This means, for example, that the effect of private investment in a given industry sector could vary according to whether the industry is characterized by comparatively high or low productivity. Therefore the equation must be estimated separately for these sub groups.

Technical efficiencies for the 26 manufacturing industry of Bangladesh over the reference period 1981-1982 to 1999-2000 are estimated for each year. The mean technical efficiency is estimated to be 56.8%. That is, over the period analyzed, average industry produced only about 57% of maximum attainable output. Mean efficiency by year increased from the lowest level (0.370) in 1982-1983 to the highest level (0.825) in 1999-2000. This means that, according to the stochastic production frontier, the contribution of the efficiency change to total factor productivity after 1981-1982 was an increment in productivity growth.

Conclusion

This study provides inefficiency estimation and variations in inefficiency between industries through decisions concerning ownership factors along with spatial agglomeration over the period 1981-1982 through 1999-2000 in a panel of manufacturing industries of Bangladesh.

A Translog stochastic frontier production function with inefficiency effects model, outlined by Huang and Liu (1994), is applied. The results indicate that inefficiency was present in production and that the traditional average response functions and Cobb-Douglas functional form with neutral stochastic frontier model are not an appropriate representation of the data. Our analysis shows that the choice of efficiency estimation method can make a significant difference in relation to average efficiencies.

The results reveal something of the dynamic benefits of private investment in Bangladesh. The extent of private investment in a domestic industry is a determinant of technical efficiency. Such improvements in technical efficiency are expected to feed through into the international competitiveness for manufacturing industry of Bangladesh. These findings are important in the context of concerns over the contribution of private investment to national and regional development process. The result suggests that spillovers are more pronounced in industries that are relatively productive. At the same time, we found that foreign investment plays an important role in explaining technical efficiency levels in manufacturing industry of Bangladesh.

The mean technical efficiency is estimated to only 56.8% according to the non-neutral stochastic production frontier. Considerable technical inefficiencies exist in manufacturing industry of Bangladesh and the results showed that mean technical efficiencies had highly increased in two manufacturing industries, namely Drugs and pharmaceutical products and Beverage industry whereas Manufacture of Textiles and Fabricated metal products had experienced a decline in the mean technical efficiencies over the period. The industries operate 43.2% below the potential frontier production level with the given inputs and production technology. Thus the industries are not in a position to tap the benefits of the development of production technology. Since the overall technical efficiency level is just more than half, there is no justification at present to further develop the technology.

Table 1: Data and Variable

All monetary variables were put into real terms (1981-1982 prices). Industry data for 26 three digit industry (BSIC) derived from the Census of Manufacturing Industries (CMI)of Bangladesh. Data available for 1981-1982 through 1999-2000.

Dependent Variable:

Y: Gross output: Gross output is the value of products and by-products, plus receipts for work done and for services to others, plus net change in work-in-progress. Products and by-products are valued at the ex-factory prices, including excise duty, sales tax and other indirect taxes.

Independent Variables:

X_1: Total fixed assets: Total fixed assets mean all assets, whether obtained from other enterprises or produced by the establishment out of its resources for its own use, which are expected to have a productive life of more than one year. It consists of land, buildings, other construction, machinery tools and equipment, transport etc.

X_2: Manual labor: Manual labor includes all classes of permanent and salaried employees of the establishment such as managers, clerks, typists and other administrative workers.

X_3: Non-manual labor: Non-manual labor means those who are engaged directly in the production process and includes those engaged in manufacturing, assembling, packing, repairing etc. Working supervisors and persons engaged for repair and maintenance are also included.
X_4: Year: Year is the year of observation where X_4 = 1, 2, 3, ……,13, 15, 17, 19 for the years 1981-1982, 1982-1983, 1983-1984, …….. ,1993-1994, 1995-1996, 1997-1998 and 1999-2000 respectively.

Explanatory Variables:

Z_1: Z_1 is the dummy variable for foreign investment in manufacturing industry. It takes the value 1 if the industry receives foreign investment, otherwise zero.

PRIVATE (Z_2): Percentage share of industry gross output that is accounted for by private owned manufacturing industry.

AGGLOM (Z_3): Industry agglomeration measured as the coefficient of variation for industry level location quotients across the 6 administrative divisions of Bangladesh.

Table 2: Generalized Likelihood-Ratio Tests of Hypotheses for Parameters of the Stochastic Frontier Production Function for Manufacturing Industries in Bangladesh

Null Hypothesis	Likelihood Function	Test Statistic λ	Critical Value	Decision
Non-neutral Stochastic Frontier	-330.217			
Cobb-Douglas Production Function $H_o : \beta_{ij} = 0, i \le j = 1, 2, 3, 4$	-345.674	30.914	16.92	Reject H_o
No Technical Change $H_o : \beta_4 = \beta_{i4} = 0, i = 1, 2, 3, 4$	-339.400	18.366	11.07	Reject H_o
Neutral Technical Change $H_o : \beta_{i4} = 0, i = 1, 2, 3$	-330.866	1.298	7.815	Reject H_o
No Technical Inefficiency $H_o : \gamma = \delta_o = \delta_1 = ... = \delta_{43} = 0$	-366.685	72.937	*26.59	Reject H_o
Neutral Stochastic Frontier $H_o : \delta_{ij} = 0, i = 1,2,3,4; j = 1,2,3$	-344.034	27.634	21.03	Reject H_o

Source: Author's computation
Notes:

All critical values are at 5% level of significance.

*The critical value is obtained from table of (Kodde and Palm, 1986:1243). The null hypothesis which includes the restriction that γ is zero does not have a chi-square distribution, because the restriction defines a point on the boundary of the parameter space.

Table 3: Maximum-Likelihood Estimates for Parameters of the Non-Neutral Stochastic Frontier Involving Firm-Specific Variables and Year

Variable	Parameter	Non-neutral Stochastic Frontier	
		Coefficient	t-ratio
Constant	β_o	0.6962	0.1811
Capital	β_1	-1.5746*	-3.5162
Manual Labor	β_2	11.7548*	3.7492
Non-manual Labor	β_3	-8.1437*	-2.8833
Year	β_4	0.0081	0.3297
$(\text{Capital})^2$	β_{11}	0.0066	0.3130
$(\text{Manual Labor})^2$	β_{22}	-3.7952*	-3.0110
$(\text{Non-manual Labor})^2$	β_{33}	-2.9212*	-2.7389
$(\text{Year})^2$	β_{44}	0.0013	1.0992
Capital * Manual Labor	β_{12}	0.3331	1.3952
Capital * Non-manual Labor	β_{13}	-0.2602	-1.1896
Manual Labor * Non-manual Labor	β_{23}	6.5974*	2.8567
Constant	δ_o	1.4451*	5.8394
Dummy	δ_1	-1.0887	-0.9589
PRIVATE	δ_2	-0.0063	-0.5846
AGGLOM	δ_3	0.0205*	2.5978
Capital * Dummy	δ_{11}	0.1213	1.4382
Capital * PRIVATE	δ_{12}	-0.0028	-2.2832
Capital * AGGLOM	δ_{13}	-0.0008	-1.2411
Manual Labor * Dummy	δ_{21}	-0.4350	-0.6543
Manual Labor * PRIVATE	δ_{22}	0.0205*	3.6821
Manual Labor * AGGLOM	δ_{23}	-0.0190*	-4.1952
Non-manual Labor * Dummy	δ_{31}	0.3433	0.5525
Non-manual Labor * PRIVATE	δ_{32}	-0.0171*	-3.4597
Non-manual Labor * AGGLOM	δ_{33}	0.0192*	4.7308

(Continued)

Table 3 (Continued)

Variable	Parameter	Non-neutral Stochastic Frontier	
		Coefficient	t-ratio
Year * Dummy	δ_{41}	-0.0094	-0.6016
Year * PRIVATE	δ_{42}	0.0005	2.0583
Year * AGGLOM	δ_{43}	-0.0001	-0.9717
Variance Parameters	σ^2	0.3321*	12.4719
	γ	0.9071*	12.6703
Log likelihood Function		-330.8662	

* means significant at 5%
Source: Author's computation

Table 4: Maximum-Likelihood Estimates for Parameters of the Non-Neutral Stochastic Frontier of high productive industry

Variable	Parameter	Non-neutral Stochastic Frontier	
		Coefficient	t-ratio
Constant	β_o	6.5738*	4.0345
Capital	β_1	-0.3147	-0.4575
Manual Labor	β_2	2.3407	1.3537
Non-manual Labor	β_3	-0.6425	-0.4981
Year	β_4	-0.0080	-0.2920
$(\text{Capital})^2$	β_{11}	-0.0110	-0.5723
$(\text{Manual Labor})^2$	β_{22}	-3.4473*	-6.1180
$(\text{Non-manual Labor})^2$	β_{33}	-3.4360*	-6.0381
$(\text{Year})^2$	β_{44}	0.0033	2.3250
Capital * Manual Labor	β_{12}	0.0929	0.3773
Capital * Non-manual Labor	β_{13}	-0.0423	-0.2071
Manual Labor * Non-manual Labor	β_{23}	6.8150*	6.1259
Constant	δ_o	0.0757	0.1350
Dummy	δ_1	-0.3105	-0.2933
PRIVATE	δ_2	-0.1297*	-2.8469
AGGLOM	δ_3	0.1225*	4.0543
Capital * Dummy	δ_{11}	0.3812	1.4189
Capital * PRIVATE	δ_{12}	0.0055	1.6991
Capital * AGGLOM	δ_{13}	-0.0037	-2.4823
Manual Labor * Dummy	δ_{21}	-0.2532	-0.3348
Manual Labor * PRIVATE	δ_{22}	0.6149*	3.0581
Manual Labor * AGGLOM	δ_{23}	-0.0362*	-3.2890
Non-manual Labor * Dummy	δ_{31}	-0.2801	-0.3980
Non-manual Labor * PRIVATE	δ_{32}	-0.0625*	-3.3819
Non-manual Labor * AGGLOM	δ_{33}	0.0340*	3.6074

(Continued)

Table 4 (Continued)

Variable	Parameter	Non-neutral Stochastic Frontier	
		Coefficient	t-ratio
Year * Dummy	δ_{41}	0.3777	0.5333
Year * PRIVATE	δ_{42}	0.0010	1.2568
Year * AGGLOM	δ_{43}	0.0002	0.7575
Variance Parameters	σ^2	0.3407*	5.4264
	γ	0.8154*	15.8957
Log likelihood Function		-72.5871	

* means significant at 5%
Source: Author's computation

Table 5: Maximum-Likelihood Estimates for Parameters of the Non-Neutral Stochastic Frontier of low productive industry

Variable	Parameter	Non-neutral Stochastic Frontier	
		Coefficient	t-ratio
Constant	β_o	3.2380	0.9273
Capital	β_1	-0.7025	-1.8032
Manual Labor	β_2	12.6196*	14.5297
Non-manual Labor	β_3	-10.5008*	-12.6781
Year	β_4	0.0628*	3.4061
(Capital)^2	β_{11}	0.0323	1.0828
(Manual Labor)^2	β_{22}	-4.2781*	-7.3163
(Non-manual Labor)^2	β_{33}	-3.4084*	-6.5228
(Year)^2	β_{44}	0.0015	1.4693
Capital * Manual Labor	β_{12}	0.3343	1.3340
Capital * Non-manual Labor	β_{13}	-0.3801	-1.7865
Manual Labor * Non-manual Labor	β_{23}	7.6811*	7.1916
Constant	δ_o	0.2927	0.9944
Dummy	δ_1	0.1128	0.0814
PRIVATE	δ_2	0.0006	0.0368
AGGLOM	δ_3	0.0248*	3.2282
Capital * Dummy	δ_{11}	-0.0154	-0.1265
Capital * PRIVATE	δ_{12}	-0.0031	-1.4508
Capital * AGGLOM	δ_{13}	0.0002	0.2369
Manual Labor * Dummy	δ_{21}	-1.1526	-1.3178
Manual Labor * PRIVATE	δ_{22}	0.0248	1.0169
Manual Labor * AGGLOM	δ_{23}	-0.0053	-0.5011
Non-manual Labor * Dummy	δ_{31}	1.1507	1.3688
Non-manual Labor * PRIVATE	δ_{32}	-0.0215	-0.9494
Non-manual Labor * AGGLOM	δ_{33}	0.0036	0.3663

(Continued)

Table 5 (Continued)

Variable	Parameter	Non-neutral Stochastic Frontier	
		Coefficient	t-ratio
Year * Dummy	δ_{41}	0.0178	0.6601
Year * PRIVATE	δ_{42}	0.0007	1.5179
Year * AGGLOM	δ_{43}	0.0001	0.3172
Variance Parameters	σ^2	0.1759*	5.8981
	γ	0.9999*	27035.11
Log likelihood Function		-89.0826	

* means significant at 5%
Source: Author's computation

Table 6: Mean Technical Efficiency of Different Manufacturing Industry of Bangladesh

Industry	Technical Efficiency
Food Manufacturing (311-312)	0.605
Beverage Industry (313)	0.854
Tobacco Manufacturing (314)	0.711
Manufacture of Textiles (321-322)	0.283
Wearing Apparel Expt. Footwear (323)	0.409
Leather and its Products (324)	0.588
Foot Wear Expt. Vulcanize/Mold (325)	0.581
Ginning, Press & Baling of FIB. (326)	0.669
Wood & Wood Cork Products (331)	0.455
Furniture & Fixtures Mfg. (332)	0.493
Mfg. Paper & its Products (341)	0.560
Printing & Publishing (342)	0.515
Drugs & Pharmaceutical Products (351)	0.881
Industrial Chemicals (352)	0.621
Other Chemical Products (353)	0.699
Mfg. Rubber Products (356)	0.502
Mfg. Plastic Products (357)	0.566
Pottery, China &Earthenware (361)	0.444
Mfg. Glass & its Products (362)	0.479
Non-metallic Mineral Products (369)	0.551
Iron & Steel Basic Inds. (371)	0.617
Fabricated Metal Products (381-382)	0.402
Non-electrical Machinery (383)	0.415
Electrical Machinery (384)	0.651
Mfg. Transport Equipment (385)	0.622
Photographic, & Optical Goods (387)	0.589
Mean	0.568

Note: Numbers in parentheses are industrial codes according to the Bangladesh Standard Industrial Classification (BSIC).

Source: Author’s computation

References

Audretsch, D. (1998), “Agglomeration and the location of innovative activity,” *Oxford Review of Economic Policy* ,14: 18-29.

Battese, G. E. and Coelli, T. J. (1988), “Prediction of Firm-Level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data,” *Journal of Econometrics* ,38: 387-399.

Battese, G.E. and Coelli, T.J. (1992), “Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India,” *Journal of Productivity Analysis* ,3: 153-169.

Beeson, P. (1987), “Total factor productivity growth and agglomeration economies in manufacturing 1959-73,” *Journal of Regional Science* ,27: 36-52.

Bhaskar, V. and Khan, M. (1995), “Privatization and Employment: A Study of the Jute Industry in Bangladesh,” *American Economic Review* ,85: 267-273.

Coelli, T.J. (1996a), “Measurement and Sources of Technical Efficiency in Australian Coal-fired Electricity Generation,” Working Paper no. 1/96. Centre for Efficiency and Productivity Analysis, Department of Econometrics, University of New England.

Coelli, T.J. (1996), “A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation,” CEPA Working Papers no. 7/96. Centre for Efficiency and Productivity Analysis, School of Economics, University of New England, Armidale.

Driffield, N. and Munday, M. (2001), “Foreign Manufacturing, Regional Agglomeration and Technical Efficiency in UK Industries: A Stochastic Production Frontier Approach,” *Regional Studies* ,35 (5): 391-399.

Guimaraes, P., Figueiredo, O. and Woodward, D. (2000), “Agglomeration and the Location Direct Investment in Portugal,” *Journal of Urban Economics* ,47: 115-135.

Head, C.K., Ries, J.C. and Swenson, D.L. (1999), “Attracting Foreign Manufacturing: Investment Promotion and Agglomeration,” *Regional Science and Urban Economics* ,29:197-218.

Huang, C. J. and Liu, J. T. (1994), “Estimation of a Non-neutral Stochastic Frontier Production Function,” *Journal of Productivity Analysis* ,5: 171-180.

Jondrow, J., Lovell, C.A.K., Materov, I. and Schmidt, P. (1982), “On the estimation of technical inefficiency in the stochastic frontier production function model,” *Journal of Econometrics* ,13: 233-238.

Kalirajan, K.P. and Flinn, J.C. (1983), “The Measurement of Farm Specific Technical Efficiency,” *Pakistan Journal of Applied Economics* ,2: 167-180.

Kodde, D. A. and Palm, A.C. (1986), “Wald Criteria for Jointly Testing Equality and Inequality Restrictions,” *Econometrica* ,54: 1243-1248.

Krugman, P. and Venables, A.J. (1995), “Globalization and the inequality of nations,” *Quarterly Journal of Economics* ,110: 857-880.

Kumbhakar, S.C. (1993), “Production risk, technical efficiency and panel data,” *Economics Letters* ,41: 11-16.

Lovell, C. A. K. (1993), Production Frontiers and Productive Efficiency, in Harold. O. Fried et. Al. (ed.) *The measurement of Productive Efficiency: Techniques and Application.,* New York: Oxford University Press.

Porter, M. E. (1990), *The competitive advantage of nations,* New York: Free Press.

Scott, A. (1988), Flexible production systems and regional development: the rise of new industrial spaces in North America and Western Europe, *International Journal of Urban and Regional Research* 12: 171-86.

Shapiro, C. Willig, R. (1990), Economic Rationales for the Scope of Privatization, in The Political Economy of Public Sector Reform and

Privatization, B. N. Suleiman and J. Waterbury, (eds.) London: Westview Press.

Shleifer, A and Vishny, R. (1994), “Politicians and Firms,” *Quarterly Journal of Economics* ,109: 995-1025.

Vickers, J. and Yarrow, G. (1988), *Privatization: An Economic Analysis.* MIT Press Series on the Regulation of Economic Activity. Cambridge, Mass and London: MIT Press.