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Technical Efficiency in the Indian Textiles Industry: A Nonparametric Analysis of Firm-Level Data

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Abstract

The Indian textiles industry is now at the crossroads with the phasing out of quota regime that prevailed under the Multi-Fiber Agreement (MFA) until the end of 2004. In the face of a full integration of the textiles sector in the WTO, maintaining and enhancing productive efficiency is a precondition for competitiveness of the Indian firms in the new liberalized world market. In this paper we use data obtained from the Annual Survey of Industries for a number of years to measure the levels of technical efficiency in the Indian textiles industry at the firm level. We use both a grand frontier applicable to all firms and a group frontier specific to firms from any individual state, ownership, or organization type in order to evaluate their efficiencies. This permits us to separately identify how locational, proprietary, and organizational characteristics of a firm affect its performance.

Journal of Economic Literature Classification: L67, C61

Keywords: Data Envelopment Analysis; Meta-Frontier; Technology Closeness ratio

TECHNICAL EFFICIENCY IN THE INDIAN TEXTILES INDUSTRY: A NONPARAMETRIC ANALYSIS OF FIRM-LEVEL DATA

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Introduction

The Multi-Fiber Agreement (MFA) introduced in 1974 exempted international trade in textiles and garments from the broad regulations of GATT and allowed countries to impose bilateral quotas on import of various categories of textile products. Designed primarily as a way to protect producers from the developed world against competition from cheaper imports from the developing countries, the MFA has eventually been phased out on January 1, 2005. This is a major change in the international trade scenario for textile manufacturers across the world offering opportunities for penetration into markets that have been off limits under the previous regime while at the same time posing threats of market loss in the face of competition from other countries. For India, in particular, performance of the textile industry in this new era can be of major significance for the economy as a whole. In 2000-01 the textiles industry accounted for about 4% of the GDP, 14% of industrial production, 18% of total industrial employment, and 27% of export earnings[1]. Maintaining and enhancing productive efficiency is a precondition for competitiveness in the new liberalized world market. India had bilateral arrangements under MFA with the developed countries like USA, Canada, countries of the European Union etc. Almost 70 per cent of India's clothing exports have gone to the quota countries of USA and the European communities. However, the Agreement on Textiles and Clothing (ATC), 1995 of WTO envisages the dismantling of the MFA over a ten-year period. Thus, after three decades textile industry has really been open to free competition at the international level from 1st January 2005. The Indian textiles industry is now at the crossroads with the phasing out of quota regime and the full integration of the textiles sector in the WTO. Most of the studies undertaken to estimate the impact of ATC expiry on textile trade share the finding that some Asian countries are most likely to

[1] Hashim (2004)

benefit from the dismantling of the quotas. They predict a substantial increase in market shares for China and India (see Government of India, 2004-05, pp. 144, for some discussion on this issue).

India has a natural competitive advantage in terms of a strong and large multi-fiber base and abundant cheap skilled labor. However, with prices being expected to fall in the post-quota regime presumably owing to increased international trade and competition, such an advantage may not be enough. Enhanced efficiency and productivity are a must to meet this emerging challenge of global competition. It is against this background that the performance of the Indian textile firms needs to be examined rigorously.

In the pre-Reform decades numerous regulations enforced through rigid bureaucratic control created a '*permit-license Raj*' that effectively stunted productivity growth and inhibited technical efficiency in Indian manufacturing. Various policies like reservation of production of a large number of items for the small scale sector, high customs tariffs distorting resource allocation and inhibiting the ability of Indian firms to compete in the global markets, restrictions on capacity expansion restraining firms from attaining efficient size, frictions faced in establishing and closing down of firms in response to normal competitive market dynamics and various distortions created by the structure of domestic trade taxes and excise duties discouraged efficiency and harmed productivity growth. Introduction of various reforms and gradual liberalization of both domestic and international trade marked the beginning of the end of the earlier regulatory regime and a recognition of the urgency on the part of the Indian industries to become efficient so as to be able to withstand successfully the pressure of foreign competition (Government of India, 2000-01, pp. 149). Over the years several measures have been taken by the government to help domestic industries achieve efficiency. These include both financial measures such as rationalization of excise duties, liberalization of tax laws and rates, reduction in interest rates and so on, as well as such physical measures as those meant to remove infrastructural constraints in the power, transport and telecommunications sectors.

So far as the structure of the textile industry is concerned, it continues to be predominantly cotton-based with about 65 per cent of raw material consumed being cotton. It has three sub-sectors – mills, power looms and handlooms. The latter two are jointly considered under the heading 'decentralized sector'. Over the years the government has taken several steps to facilitate its growth. It has granted many concessions and incentives to the decentralized sector with the result that the share of this sector in total production has increased phenomenally. For example, while the share of the mill sector in total fabric production was 76 per cent in 1950-51, it fell to 38 per cent in 1980-81 and further to just 4 per cent in 2001-02. The share of the decentralized sector rose correspondingly. In the decentralized sector, it is the power looms sub-sector that has grown at a faster pace, producing as much as 76.8 per cent of the total fabric output of this industry in 2001-02. The factors that have contributed to the fast development of the power loom sector include government's favorable policies on synthetic fabric industry as well as the ability of this sub-sector to introduce flexibility in the product mix in line with the market situation. In the mid-1980's, a new textile policy was announced to enable the industry to increase the supply of good quality cloth at reasonable prices for both domestic consumption and export. In addition, a Textile Modernization Fund of INR 7.5 billion was created to meet the modernization requirements of this industry. In the early 1990's textile industry was de-licensed thereby abolishing the requirement of prior government approval to set up textile units including power looms. A Technology Upgradation Fund Scheme (TUFS) was also launched in 1999 to enable the textile units to take up modernization projects, by providing an interest subsidy on borrowings.

The objective of this paper is to measure technical efficiency of Indian textile firms for selected years using DEA. We also use the concept of a *meta-frontier* production function introduced by Hayami (1969) and Hayami and Ruttan (1970, 1971) to examine whether technology indeed varies among different locations, ownership patterns, organizational patterns etc. of textile industry. Battese and Rao (2002) and Battese, Rao and O'Donnell (2004) provide frameworks for such comparisons when efficiency is measured using parametric stochastic frontier models. Rao, O'Donnell and Battese (2003) provide both frameworks and an empirical application using FAO agricultural data on 97 countries, comprise of about 99 per cent of both of global agricultural production as well as world population. They provide framework for both non-parametric DEA and parametric stochastic frontier methods as well. Das, Ray and

Nag (2007) use the concept of *meta-frontier* as a national or grand frontier in a nonparametric study of branch level labor-use efficiency of a major public sector bank in India.

In this paper we use firm level data from several different years of the Annual Survey of Industries (ASI) for the Indian textiles industry. The annual cross section data are used to construct a *meta-frontier* as well as separate group-specific frontiers for firms classified by regional location, type of ownership and organization type. This permits us to examine the proximity of any group frontier to the *meta-frontier* and measure such proximity by what we define as the technology closeness ratio (TCR) of the group. Most of the existing studies of productivity and efficiency in Indian manufacturing whether at the level of total manufacturing (e.g., Ray (1997, 2002), Ray and Mukherjee (2005), Mitra et al (2002), Krishna (2004)) or at the specific industry level (e.g., Trivedi (2004), Hashim (2004)) use state-level data. Although Ram Mohan (2003) uses firm level data to compare the performance of public and private sector firms, his data are constructed from financial statements of companies and are not very accurate measures of input and output *quantities*. This paper adds to the small number of studies that utilize input-output data at the establishment level. Our approach provides a relative measure of overall efficiencies of different groups (e.g., one state vis-à-vis another or public and private sector firms) through a comparison of their technology closeness ratios (TCRs). At the same time, we can evaluate the relative performance of individual firms within the constraints (like infrastructure and work culture) faced by all firms within a group.

The paper is organized as follows. In Section 2 we describe the non-parametric methodology of Data Envelopment Analysis (DEA) and explain the concept of a *meta-frontier* as distinct from a group frontier. Section 3 gives some justification behind such *meta-frontier* analysis to be considered for Indian industry and description of data and variables considered for the production function is given in Section 4. Section 5 summarizes our empirical findings and Section 6 concludes.

2. The DEA Models

The non-parametric method of DEA introduced by Charnes, Cooper, and Rhodes (1978) and further generalized by Banker, Charnes, and Cooper (1984) requires no parametric specification of the production frontier. Using a sample of actually observed input-output data and a number of fairly weak assumptions, it derives a benchmark output quantity with which the actual output of a firm can be compared for (output-oriented) efficiency measurement.

An input-output bundle (x, y) is *feasible* when the output bundle y (a nonnegative vector of quantities of outputs) can be produced from the input bundle x (a nonnegative vector of quantities of inputs). The set of all such feasible input-output bundles constitutes the production possibility set T:

$$T = \{(x, y): y \text{ can be produced from } x;\ x \geq 0;\ y \geq 0\} \tag{1}$$

In the single output case, the frontier or the graph of the technology is defined by the *production function* $g(x)$ representing the maximum quantity of y that can be produced using the input bundle x:

$$g(x) = \text{maximum value of } y, \text{ given } x, \text{ where } (x, y) \in T \tag{2}$$

The corresponding production possibility set is: $T = \{(x, y): y \leq g(x);\ x \geq 0,\ y \geq 0\}$.

In the more general, multiple-output multiple-input, case, under the assumptions of convexity of the production possibility set along with free disposability of both inputs and outputs, the production possibility set can be empirically constructed as

$$T = \left\{(x, y): x \geq \sum_{j=1}^{N} \lambda_j x^j;\ y \leq \sum_{j=1}^{N} \lambda_j y^j;\ \sum_{j=}^{N} \lambda_j = 1;\ \lambda_j \geq 0;\ (j = 1, 2, ..., N)\right\} \tag{1a}$$

where (x^j, y^j) is the observed input-output bundle of an individual firm j in a sample of N firms in the data.

The Group and Meta-Frontiers

Before one proceeds to construct the production frontier using the DEA in order to measure the technical efficiency of a firm, it is necessary to recognize that all of the observed firms may not have access to the same technology. Rather, different firms or categories of firms may face different production technologies. A variety of geographical, institutional, or other factors may give rise to such a situation. Constructing a single production frontier based on all the data points would, in such cases, result in an inappropriate benchmark technology. A way to measure the impact of technological heterogeneity across groups is to construct a separate *group frontier* for each individual group alongside a single *grand* or *meta-frontier* that applies to firms from all the groups.

In order to construct different production possibility sets for different groups, we first group the observed input-output bundles by the locations of the corresponding firms. Suppose N firms are observed and these firms are classified, according to some criterion, into H number of distinct and exhaustive groups, g^{th} group containing N_g number of firms $\left(N = \sum_{g=1}^{H} N_g \right)$. Define the index set of observations $J = \{1, 2, ..., N\}$ and partition it into non-overlapping subsets

$$J_g = \{ j : \text{firm } j \text{ belongs to group } g; (g = 1, 2, ..., H) \}.$$

In this case, the production possibility set for group g will be

$$T^g = \left\{ (x, y) : x \geq \sum_{j \in Jg} \lambda_{gj} x^j ; y \leq \sum_{j \in Jg} \lambda_{gj} y^j ; \sum_{j \in Jg} \lambda_{gj} = 1; \lambda_{gj} \geq 0 \}; \right\} (g = 1, 2, ..., H).$$

The set T^g is the free disposal convex hull of the observed input-output bundles of firms from group *g*. Suppose, that the observed input-output bundle of firm k in group g is (x_g^k, y_g^k). A measure of the *within-group* (output-oriented) technical efficiency of the firm *k*, is

$$TE_g^k = \frac{1}{\varphi_g^k}$$

where φ_g^k solves the following linear programming (LP) problem:

$$\left(P_g^k\right) \qquad \varphi_g^k = \max \ \varphi$$

$$\text{s. t.} \sum_{j \in J_g} \lambda_{gj} y_g^j \geq \varphi y_g^k ;$$

$$\sum_{j \in J_g} \lambda_{gj} x_g^j \leq x_g^k ; \sum_{j \in J_g} \lambda_{gj} = 1;$$

$$\lambda_{gj} \geq 0 \, (j = 1, 2, ..., N_g); \ \varphi \text{ unrestricted.}$$

The above LP problem is solved for each firm k in the g^{th} group.

Next we consider the technical efficiency of the same firm k from group g relative to a *grand* technological frontier, or what is called the *meta-frontier*. The *meta-frontier* is the outer envelope of all of the *group* frontiers. It consists of the boundary points of the free disposal convex hull of the input-output vector of *all firms* in the sample. The (*grand*) *technical efficiency* of the firm k from group g is measured as

$$TE_G^k = \frac{1}{\varphi_G^k}$$

where

$$\varphi_G^k = \max \quad \varphi$$

$$\text{s. t.} \sum_{g=1}^{H} \sum_{j \in J_g} \lambda_{gj} y_g^j \geq \varphi y_g^k;$$

$$\sum_{g=1}^{H} \sum_{j \in J_g} \lambda_{gj} x_g^j \leq x_g^k;$$

$$\sum_{g=1}^{H} \sum_{j \in J_g} \lambda_{gj} = 1;$$

$$\lambda_{gj} \geq 0 \, (j = 1,2,...,N_g;\ g = 1,2,...,H); \varphi \text{ unrestricted.}$$

In view of the fact that the *grand* production possibility set contains every *group* production possibility set, it is obvious that $\varphi_g^k \leq \varphi_G^k$ and, hence, $TE_g^k \geq TE_G^k$, for every k and g. In other words, firms cannot be *more* technically efficient when assessed against the *meta-frontier* than when evaluated against a *group* frontier.

Technology Closeness Ratio

When, for any firm k in group g, the *group* efficiency and the *grand* efficiency measures are close, we may argue that evaluated at the input bundle x_g^k, the relevant *group frontier* is close to the *meta-frontier*. In stead of evaluating the proximity of the *group frontier* to the *meta-frontier* at individual points, it is useful to get an overall measure of proximity for the group as a whole. For this, we first define an average technical efficiency of the firms in the group (i.e., relative to the *group frontier*) by the taking a geometric average of such individual technical efficiencies. For the group g this will be given by

$$TE_g(g) = \left(\prod_{k=1}^{N_g} TE_g^k \right)^{1/N_g}.$$

Similarly, the average technical efficiency of group g, measured from the *meta-frontier*, will be

$$TE_G(g) = \left(\prod_{k=1}^{N_g} TE_G^k \right)^{1/N_g}.$$

For group g, an overall measure of proximity of the *group frontier* to the *meta-frontier* is its technology closeness ratio

$$TCR(g) = \frac{TE_G(g)}{TE_g(g)}.$$

TCR increases if the *group frontier* shifts towards the *meta-frontier*, ceteris paribus, and is bounded above by unity which would be realized if and only if *group frontier* coincides with the *meta-frontier*.

We illustrate these concepts in Figure 1 for the case of a single input – single output – two groups of firms - group *p* and group *q*. Let the points P_1 through P_4 show the input-output bundles of four firms from group *p and* Q_1 through Q_4 be the input-output bundles of firms from group *q*. The group frontiers are shown by the broken line $AP_1P_3P_4C$ for group *p* and by the broken line $BQ_1Q_2Q_3D$ for group *q*. By contrast, the grand frontier is the outer envelop of the two frontiers shown by the broken line AP_1P_3 Q_2Q_3D. Note that the points within the triangle P_3EQ_2 lie above both the group frontiers, but (by virtue of convexity) are within the grand frontier. While judged against their own group frontier the technical efficiency of each of the points Q_1, Q_2, and Q_3 equals unity while the that of Q_4 is JQ_4/JK. When judged against the grand frontier or the *meta-frontier*, TE of each of the points, Q_2 and Q_3, remains unity. However, the technical efficiency of Q_1 falls from unity to BQ_1/BN, while that of the (inefficient) point Q_4 is the same as that with respect to its group frontier viz. JQ_4/JK. Thus the average technical efficiency of group *q* (measured from its *group frontier*) is given by, $TE_q(q)$ = $(JQ_4/JK)^{1/4}$ and that (measured from the *meta-frontier*) is given by $TE_G(q)$ =

$\left(\left(BQ_1/BN\right)\left(JQ_4/JK\right)\right)^{1/4}$, which is obviously smaller than $TE_q(q)$. The ratio of the two measures the technology closeness ratio (TCR) of this group.

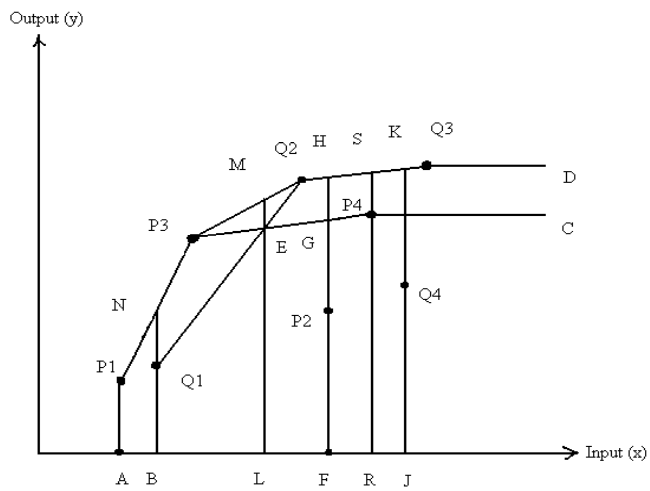

Figure 1. Group and Meta-Frontiers

3. Justification of Such Analysis in the Context of Indian Industry

India is a vast country with a number of states and union territories with their distinct sociological, economic, political and infrastructural features. Easy access to natural resources and other infrastructural facilities helpful in achieving lower cost per unit of output is not evenly distributed all over the country. Sates differ widely in respect of stability of government formed by different political parties, democratic nature of the overall political environment, political and economic agenda of the political parties in power, and the level of militancy of labor unions. Work culture of the people of the states like Gujarat and Maharashtra is far more conducive to productive efficiency than what one finds in states like West Bengal (Das et al, 2007). All these factors are important determinants of the level of technical efficiency of a firm located in any particular region. Although the core production function for different regions need not be different, these environmental factors cause the underlying production function to shift away from the *global* or *meta-frontier*. It is, therefore, proper to treat the production technology itself as different for different regions of the country.

While geographical factors play the most important role in creating differences in the technology across groups of firms, such differences may also arise due to differences in ownership type and in the organizational structure of a firm. For example, a firm in the public sector may perform differently from another firm in the private sector even though they both might be located in the same state. Even among public sector firms, those own by the central government have different types of working norms and management styles than those that are owned by a state government. Similarly, even within the private sector, a firm owned and operated by a public limited company might perform differently from owned by a private limited company or a partnership.

In our empirical analysis, we examine the extent of systematic differences in the technical efficiency levels of firms due to geographical location, ownership type, and organizational patterns. We investigate how far variation in the above three factors namely state, ownership pattern and organizational pattern affects the levels of technical efficiency of individual firms. We also examine whether the production technology itself varies across groups due to variation in such factors by comparing respective TCRs.

4. Description of Data and Variables Used

In this study we use micro-level data for our study. Each observation in our data set includes the information on a number of variables for different individual industrial units covered by the Central Statistical Organization (CSO), Government of India through its Annual Survey of Industries (ASI). The data used are for the years 1985-86, 1990-91, 1996-97, 1998-99, 1999-00 and 2001-02 for firms drawn from the entire textile industry. The units relate to the production of cotton, woolen, silk, synthetic (e.g., terry cotton), and other natural fibers (like jute, coir, and mesta).

We conceptualize a 1-output, 3-input technology. The output is measured by the total ex-factory value of products and by-products produced by the firm during the production year. The inputs are labor (measured by the total number of man-days worked), capital (measured by the net value of fixed assets of the firm at the beginning of a year) and intermediate inputs (measured by the nominal value of material inputs (both indigenous and imported) and energy (power, fuels etc.).

5. Empirical Findings

In order to perform *meta-frontier* analysis for studying the effects of difference in location, we focus on six major textile-producing states namely *Gujarat*, *Maharashtra*, *Punjab*, *Rajasthan*, *Tamil Nadu* and *West Bengal*. Observations from the rest of the country contribute to the construction of the *meta-frontier* but are not analyzed as a single group for measuring TCR. Similarly, we consider two types of ownership: *private* (i.e., wholly privately owned firms) and *public* (i.e., all of the remaining categories of firms are combined into this group). Almost 90% of firms in the data set are under private ownership in each of the years covered in the sample. Further, we consider six different organization patterns: *individual proprietorship (IP), partnership (Part), public limited company (PULC), private limited company (PRLC), co-operative society (COOPS)* and the remaining are clubbed into '*others'* category.

Average technical efficiency measured relative to either *frontier* as well as TCR for different states are shown in Table 1a. In 5 out of the 6 years analyzed, West Bengal had the highest level of average *grand* efficiency i.e., technical efficiency measured relative to the *meta-frontier*. In the remaining year (1996-97) Punjab had the highest grand efficiency. Two things need to be recognized in this context, however. First, relatively few of the firms in the sample (between 3% and 5.21% in any given year) came from West Bengal. Second, In 3 out of the 5 years, the average, although the highest for the year across groups, was around 20%. Only in the last year (2001-02) did it reach a respectable level of 60%. Hence, the West Bengal firms, although better generally than others, are, nonetheless, quite inefficient overall.

Coming to the *group efficiency* i.e., technical efficiency measured against the *group* frontier of each state, again West Bengal is found to be best performing with averages ranging from 0.66 (in 1985-86) and 0.84 (in 2001-02). During the year 1996-97, Punjab performed best relative to its state frontier with an average group efficiency score of 0.63. Moreover, judging by the coefficient of variation (CV) in the year-wise group efficiency levels, West Bengal (32.13%) and Punjab (32.51%) had the lowest yearly average degrees of variability in technical efficiency across firms with the state. By contrast, Gujarat (84.19%), Rajasthan (73.47%), Maharashtra (64.43%), and Tamilnadu (63.79%) showed much greater variability in efficiency within the group. Thus, with highest mean and lowest variability in the levels of efficiency, the West Bengal firms appear to have performed in a superior fashion in most of the years.

A high level of TCR *does not* imply that firms in a specific state are, on an average, more efficient. As explained in an earlier section, the TCR of any group is an index of the proximity of the *group* frontier to the *grand* or *meta-frontier* over the relevant range of variation in the input bundles. Bounded naturally between 0 and 1, a high value of the TCR for any state implies that, on average, the maximum output producible from an input bundle by a firm required to produce within the state would be almost as high as what could be produced if the firm could choose to locate anywhere else in the country. This, in its turn, implies only that there are no significant production infrastructural constraints (e.g., physical, legal, cultural, etc.) that hinder productivity in that state relative to the nation as a whole. This is best illustrated by the examples of Gujarat in the year 1996-97 and West Bengal in 1985-86. In the case of Gujarat, in the relevant year the TCR was as high as 91% showing that the *group* frontier for the state was quite close to the *grand* frontier. However, relative to either frontier, the average technical efficiency was particularly low – only 0.09 and 0.10. Thus, even though, the state faced no particular disadvantage, the firms performed poorly. The case of West Bengal was the opposite. The average level of group efficiency in 1985-86 was a respectable 66%. But the grand efficiency was as low as 15%. The corresponding TCR of 0.23 shows that from an average input bundle a firm in West Bengal could at most produce only 23% of what would be feasible elsewhere in India. The West Bengal firms were doing reasonable well relative to a state benchmark but infrastructural constraints hindered efficient production.

Another point to note is that for all states the TCR appears to have improved, although not monotonically, over the years. This shows that in the post-Reform years, market forces have been at work to remove the hurdles faced in the different states bringing the state frontiers closer to the grand frontier.

Table 1b shows that except in the year 1985-86, levels of (grand) technical efficiency of the private sector firms equal (in 1990-91) or exceed (in the other four years) those of the public sector firms. In a parallel study using the stochastic frontier approach, Bhandari and Maiti (2007) obtain similar results for the Indian textile industry.

Moreover, the grand frontier is supported primarily by firms from the private sector. This is evident from the high levels of TCR for the private sector as a group and is especially true in 1996-97 and the later years. The TCR of the public sector firms during this period, although considerably lower than unity, has been improving. This suggests that, as group, public sector firms have improved their productive *potential* in the more recent years.

As for organization type, public limited companies (identified as PULC in Table 1c) have higher (grand) technical efficiency as well as superior technology (as shown by TCR) relative to all other organizational types of firms in our sample. This is broadly consistent with the widely held belief that accountability of the corporate management to the shareholders contributes to better performance.

It is evident from Tables 1a-1c that there are significant differences across groups when firms are classified by any single criterion (region, ownership type, or organization type) *without controlling the other factors.* But exclusive focus on a single criterion may hide the consequences of variations in any other characteristic. For an example, it is not obvious from Table 1a that the superior performance of West Bengal firms is due to their location only. The partial effect of differences in any one category can be accurately measured only within a multiple regression model incorporating all the relevant explanatory variables.

Table 2 reports the estimated regressions for the different sample years using yearly cross section data. The dependent variable is the measured level of (grand) technical efficiency of an individual firm for the particular year. The dummy variables *Gujarat D* through *West Bengal D* are the state dummies. The category "all other states" is treated as the reference group. In the ownership classification, *Public D* is the dummy variable for public sector firms with private ownership is the reference category. In the organization type category, the dummy variables identify firms as individual proprietorship (*IP D*), partnership (*Partnership D),* public limited companies (*PULC D*), private limited companies (*PRLC D*), and cooperatives (*Coops D*). Firms of other organization types constitute the reference group. Apart from the various categorical variables, also included as regressors, are the size of a firm and its age. Size is measured by the nominal value of its intermediate inputs. Age is measured in years. Because the data set does not identify individual firms, it was not possible to estimate a panel regression. In stead, annual cross section data were used to estimate separate regressions for individual years. Of the 36 coefficients associated with the state dummy variables, 20 are significant at the 5% (or lower) levels. In general, their signs and magnitudes are consistent with what one could derive from the difference of means for the individual states in any year with the "catch all" group (identified as "all others" in Table 1a). Nonetheless, further insights beyond what is obtained from Table 1a can be gained from a careful perusal of the regressions reported in Table 2. For an example, consider the case of West Bengal for the year 1990-91. In Table 1a, it has the highest average level of (grand) technical efficiency exceeding the corresponding measure for overall by 0.07. In the regression for the relevant year reported in Table 2, the coefficient of the West Bengal dummy variable is only 0.016. Moreover, it is not even statistically significant! By contrast, for the same year, the difference for Punjab is 0.04 in Table 1a and the coefficient of the Punjab dummy variable in 1990-91 in Table 2 is a comparable 0.045. This shows that controlling for other factors some times (though not always) could portray a different picture about technological differences across states. As for the other (non-categorical) variables, the coefficient of size (*I*), is uniformly positive and highly significant. This implies that efficiency increases with firm size. By contrast, the coefficient of age is significantly positive in the first two years but becomes statistically insignificant thereafter.

The main findings of our empirical analysis can be summarized as follows.

- Firms from the state of West Bengal performed at higher average levels of technical efficiency with respect to both their state frontier and a grand frontier applicable to firms from all states.
- There were significant technological differences across states. However, firms from states with more productive technologies often ended up performing at low levels of efficiency as is evident from the case of Gujarat in the year 1990-91.
- There is some evidence that states with less productive technologies are gradually catching up to the national benchmark.
- Private sector firms were more efficient than and also technologically superior to firms from the public sector.

- Firms organized as public limited companies performed better than firms of other organizational types.
- Technical efficiency tends to increase with firm size.
- Despite some initial evidence of positive impact, the age of a firm did not appear to be significantly influencing technical efficiency in the later years in our sample.

6. Conclusion

In this paper we have measured the levels of technical efficiency of firms from the Indian textiles industry in different years. Our study allows one to separately identify the contribution of technological differences across groups of firms towards the overall measure of technical efficiency. Superior performance of public limited companies in the private sectors suggests that this should be encouraged as a preferred organizational form. Also, consolidation of smaller firms into larger entities would enhance efficiency. Our measures of technical efficiency suggest considerable room for increasing output without requiring any additional inputs. Hence, even without an increase in allocative efficiency through appropriately changing the input mix, average cost of production in the textiles industry could be lowered significantly – often by 40% or more. This would greatly help the competitive position of Indian firms in the world market.

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Table 1a: Mean Technical Efficiency and TCR for Different States

State	Criterion	Year					
		1985-86	1990-91	1996-97	1998-99	1999-00	2001-02
Gujarat	% of Firms	16.73	16.55	16.26	10.42	12.99	12.30
	Grand TE	0.10	0.35	0.09	0.15	0.31	0.44
	Group TE	0.28	0.50	0.10	0.52	0.64	0.60
	CV (in %)*	88.20	40.76	253.42	45.15	37.24	40.35
	TCR	0.35	0.70	0.91	0.29	0.48	0.74
Maharashtra	% of Firms	17.94	14.29	8.56	9.71	11.45	9.94
	Grand TE	0.09	0.33	0.11	0.14	0.30	0.46
	Group TE	0.33	0.50	0.36	0.30	0.51	0.63
	CV (in %)	72.09	51.61	83.04	98.45	45.23	36.14
	TCR	0.28	0.66	0.31	0.48	0.59	0.73
Punjab	% of Firms	8.64	7.73	6.81	5.85	4.99	4.66
	Grand TE	0.10	0.37	0.21	0.14	0.38	0.49
	Group TE	0.47	0.70	0.63	0.81	0.60	0.80
	CV (in %)	50.38	24.43	29.91	23.58	42.86	23.92
	TCR	0.22	0.53	0.33	0.18	0.64	0.61
Rajasthan	% of Firms	7.14	8.48	8.78	10.35	7.78	7.53
	Grand TE	0.09	0.35	0.14	0.15	0.33	0.48
	Group TE	0.13	0.50	0.42	058	0.66	0.60
	CV (in %)	214.02	48.64	64.36	39.71	32.95	41.11
	TCR	0.68	0.70	0.34	0.26	0.50	0.80
Tamil Nadu	% of Firms	18.10	18.40	22.10	25.98	27.00	28.62
	Grand TE	0.08	0.31	0.13	0.13	0.33	0.47
	Group TE	0.40	0.57	0.32	0.18	0.46	0.57
	CV (in %)	68.79	34.51	77.31	111.37	58.71	32.03
	TCR	0.20	0.54	0.40	0.76	0.71	0.82
West Bengal	% of Firms	3.30	3.05	3.00	5.21	4.77	4.77
	Grand TE	0.15	0.40	0.13	0.20	0.49	0.60
	Group TE	0.66	0.77	0.53	0.69	0.69	0.84
	CV (in %)	33.18	26.28	58.20	31.36	25.31	18.46
	TCR	0.23	0.51	0.24	0.29	0.71	0.72
Overall	% of Firms	100	100	100	100	100	100
	Grand TE	0.089	0.33	0.13	0.15	0.33	0.47
	TCR	1	1	1	1	1	1
** CV indicates Coefficient of Variation in individual TE within the Respective Group*							

Table 1b: Mean Technical Efficiency and TCR for Ownership Variation

Ownership	Criterion	Year					
		1985-86	1990-91	1996-97	1998-99	1999-00	2001-02
Public	% of Firms	11.67	12.19	11.26	16.20	14.89	10.93
	Grand TE	0.11	0.33	0.09	0.11	0.28	0.39
	Group TE	0.18	0.46	0.42	0.36	0.59	0.58
	CV (in %)	133.76	62.48	70.04	69.18	41.83	39.34
	TCR	0.62	0.72	0.21	0.29	0.46	0.67
Private	% of Firms	88.33	87.81	88.74	83.80	85.11	89.07
	Grand TE	0.09	0.33	0.1417	0.1550	0.3356	0.485
	Group TE	0.11	0.36	0.1427	0.1556	0.3358	0.486
	CV (in %)	176.55	49.65	141.30	118.95	75.43	38.35
	TCR	0.79	0.921	0.993	0.996	0.999	0.998

Table 1c: Mean Technical Efficiency and TCR for Organizational Variation

Organization	Criterion	Year					
		1985-86	1990-91	1996-97	1998-99	1999-00	2001-02
IP	% of Firms	14.84	15.35	10.89	7.14	6.97	5.11
	Grand TE	0.06	0.26	0.18	0.15	0.22	0.47
	Group TE	0.28	0.40	0.30	0.52	0.76	0.76
	CV (in %)	93.50	64.35	98.06	40.34	23.21	24.26
	TCR	0.20	0.65	0.60	0.28	0.30	0.63
Part	% of Firms	31.72	34.91	24.57	17.13	15.85	13.45
	Grand TE	0.08	0.31	0.15	0.13	0.27	0.47
	Group TE	0.11	0.49	0.24	0.25	0.31	0.49
	CV (in %)	183.57	30.34	104.27	105.34	87.48	39.21
	TCR	0.69	0.63	0.63	0.53	0.86	0.96
PULC	% of Firms	10.85	14.17	26.15	41.40	43.14	39.66
	Grand TE	0.24	0.50	0.17	0.18	0.42	0.52
	Group TE	0.49	0.54	0.18	0.25	0.46	0.57
	CV (in %)	44.41	35.33	110.45	85.75	43.35	31.52
	TCR	0.48	0.94	0.96	0.72	0.91	0.90
PRLC	% of Firms	12.75	16.59	23.71	18.63	21.13	29.71
	Grand TE	0.14	0.38	0.10	0.13	0.31	0.45
	Group TE	0.37	0.56	0.27	0.16	0.46	0.57
	CV (in %)	55.98	33.79	90.94	142.50	51.23	37.06
	TCR	0.39	0.68	0.35	0.82	0.67	0.79
COOPS	% of Firms	6.85	6.59	5.00	6.14	5.28	5.11
	Grand TE	0.06	0.26	0.13	0.13	0.27	0.42
	Group TE	0.24	0.59	0.49	0.65	0.71	0.74
	CV (in %)	111.49	37.24	55.12	36.19	26.54	24.00
	TCR	0.26	0.44	0.26	0.20	0.38	0.57
Others	% of Firms	22.99	12.38	9.67	9.56	7.63	6.95
	Grand TE	0.08	0.32	0.09	0.09	0.23	0.37
	Group TE	0.13	0.43	0.36	0.53	0.61	0.58
	CV (in %)	152.07	63.42	82.79	51.95	45.83	42.65
	TCR	0.62	0.73	0.24	0.18	0.37	0.64

Table 2: Regression Results Explaining (Grand) Technical Efficiency Score using Different State, Ownership and Organization Dummies

Independent Variable	*Estimated Coefficient*					
	1985-86	1990-91	1996-97	1998-99	1999-00	2001-02
Gujrat D	0.011**	0.022***	- 0.051***	- 0.002	- 0.028	- 0.035**
Maharashtra D	0.008	0.018**	- 0.058***	- 0.017	- 0.007	- 0.012
Punjab D	0.015**	0.045***	0.015	- 0.051***	0.051**	- 0.017
Rajasthan D	0.020***	0.032***	- 0.042***	- 0.013	0.038*	0.001
Tamil Nadu D	- 0.002	- 0.011*	- 0.072***	- 0.033***	0.003	- 0.022**
West Bengal D	0.022**	0.016	- 0.024	0.050**	0.110***	0.102***
Public D	0.035***	0.015*	- 0.069***	- 0.046***	- 0.035*	- 0.071***
IP D	- 0.033***	- 0.039***	0.058***	0.076***	- 0.012	0.057**
Partnership D	- 0.007	- 0.007	0.033**	0.036*	0.033	0.047**
PULC D	0.103***	0.091***	- 0.029**	0.006	0.098***	0.043**
PRLC D	0.059***	0.047***	- 0.056***	0.014	0.050*	0.025
Coops D	- 0.039***	- 0.059***	0.010	0.008	0.012	0.028
$\left(I/10^8\right)$	0.152***	0.071***	0.019***	0.022***	0.018***	0.014***
$\left(Age/10^2\right)$	0.058***	0.082***	0.007	0.008	- 0.036	0.015
Constant	0.094***	0.320***	0.238***	0.155***	0.308***	0.465***
R^2 (in %)	46.89	30.18	15.28	25.22	24.22	17.23
$\bar{R}^2$ (in %)	46.75	29.97	14.95	24.46	23.44	16.55
, ** and * indicates significant at 10%, 5% and 1% respectively in a two-tailed test.*						