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Abstract

In this paper we use the 2004-05 Annual Survey of Industries data to estimate the levels of cost efficiency of Indian manufacturing firms in the various states and also get state level measures of industrial organization (IO) efficiency. The empirical results show the presence of considerable cost inefficiency in a majority of the states. Further, we also find that, on average, Indian firms are too small. Consolidating them to attain the optimal scale would further enhance efficiency and lower average cost.

Journal of Economic Literature Classification: C61, D21, L60

Keywords: Data Envelopment Analysis; Efficient Production Scale; Industry Efficiency

ARE INDIAN FIRMS TOO SMALL? A NONPARAMETRIC ANALYSIS OF COST EFFICIENCY AND INDUSTRY STRUCTURE OF INDIAN MANUFACTURING

India's emergence as a major economic force in the global economy is generally attributed to business process outsourcing and the numerous call centers that have virtually saturated places like Bangalore, Hyderabad, and Pune and are now spreading to newer locations across the country. By comparison, India's manufacturing sector is usually written off as a lost cause. To those who are skeptical about the potential role that the manufacturing sector could play in helping India become an economic superpower, a recent CII-McKinsey Report assessing India's manufacturing export potential would come as a complete surprise. According to the McKinsey Report, India's manufacturing exports *could increase* from a negligible $40 billion in 2002 all the way up to $300 billion in 2015. This would translate into an increase in India's share in the world manufacturing trade from 0.8% to 3.5%. While expressing optimism about India's future role as a major manufacturing nation, the McKinsey Report grimly warns that to achieve this goal, Indian firms need to adopt a global mindset to build scale and achieve cost excellence.

What is interesting is that export-orientation aside, Indian manufacturing firms need to become more cost conscious even in their domestic mindset to withstand competitive pressure from out-of-state firms encroaching into their provincial turf. With significant liberalization of the Industrial Policy and end of the permit-licensing era, existing firms are under continuous threat from other firms emerging locally or moving from other parts of the country. Moreover, with an erosion of the tight control over regional allocation of investible resources that the Central government maintained in the Nehru-Gandhi years to pursue a social objective of balanced development, the different state governments are bending over backwards with favorable tax/subsidy packages to attract private investment to their own states. This is best illustrated by the way the Marxist-led United Front government in West Bengal laid out the red carpet for the Tata group (once their sworn enemy) to ensure that the small car plant would not be hijacked by another state. In a nationally integrated domestic market for manufactured goods, the output price varies little across states and a lower unit cost in any state implies a higher profit margin and makes it more attractive to investors. Indian manufacturing firms have to strive to achieve cost efficiency in order to survive *even domestically*.

While producing the observed output at a minimum cost amounts to full cost efficiency, when scale economies exist, average cost is not minimized unless the firm produces the scale efficient level of output. Industrial organization in any state is efficient only when it has the optimal number of firms each operating at the efficient scale. The general evaluation in the McKinsey Report is that Indian manufacturing firms are sub-scale. An implication of this assessment is that at present the manufacturing industry is crowded by too many firms that, on average, operate at a smaller scale than what is efficient.

In this paper we use the 2004-05 Annual Survey of Industries data to estimate the levels of cost efficiency of Indian manufacturing firms in the various states and also get state level measures of industrial organization (IO) efficiency as defined by ten Raa (2007). For this, we use the nonparametric method of Data Envelopment Analysis (DEA). This paper makes two important contributions to the literature – one methodological and the other empirical. First, we develop an appropriate DEA model to measure the organizational efficiency of an industry[1]. Second, we use neoclassical production economics as the analytical format to provide an empirical assessment of the cost efficiency of Indian firms and the organizational efficiency of the manufacturing industry in the individual states. The empirical results show the presence of considerable cost inefficiency in a majority of the states. Further, we also find that Indian firms are too small. Consolidating them to attain the optimal scale would further enhance efficiency and lower average cost.

The rest of the paper is organized as follows. Section 2 provides a brief overview of the nonparametric methodology and introduces the model for measuring industrial organizational efficiency. Section 3 presents the empirical findings and interprets the results. Section 4 is the conclusion.

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[1] The question of technically efficient organization of the US airlines industry was addressed by Ray and Hu (1997). Ray and Mukherjee (1998) examined the size efficiency of US banks and also determined the optimal number of banks. While those studies focused on output oriented technical efficiency, the model presented in this paper looks at cost efficiency of the industrial organization.

2. The Nonparametric Methodology

Consider a production technology relating a scalar output y to a vector of m inputs, x. Any input-output combination (x, y) is feasible if y can be produced from x. The production possibility set can be defined as

$$T = \{(x, y): y \text{ can be produced from } x\}. \qquad (1)$$

In the single output case, when a production function is specified, T can be expressed as

$$T = \{(x, y): y \le f(x)\} \qquad (1a)$$

where $y^* = f(x)$ defines the maximum output producible from x. In parametric models, one selects some specific form of the production function (like the Cobb Douglas or the Translog) and estimates the parameters of the function applying appropriate econometric methods. One problem with a parametric approach is that if the functional form specified is incorrect, so would be the resulting construction of the production possibility set.

In a nonparametric approach one circumvents the specification problem by making a number of simple and fairly weak assumptions about the underlying production technology and then rely on the actually observed data to construct a production possibility set satisfying these assumptions. In Data Envelopment Analysis (DEA), a nonparametric method introduced by Charnes, Cooper, and Rhodes (1978) and further generalized by Banker, Charnes, and Cooper (1984), one assumes that (a) all actually observed input-output bundles are feasible, (b) the production possibility set is convex, and (c) both the output and all inputs are freely disposable. Of these assumptions, the first can be justified easily by the “seeing is believing” principle because an input-output pair can be observed only if the observed output is *actually producible* from the observed input bundle. Convexity implies that any weighted average of two feasible input-output bundles is also feasible. Free disposability of inputs implies that an increase in some input would not reduce output. In other words, if marginal productivity becomes negative at some stage, the input can be left idle. Similarly, free disposability of output implies that inputs can be left under-utilized so that a lower output is produced from the same input bundle. It should be noted that there are many different production technologies and corresponding production possibility sets that satisfy these assumptions. In econometric modeling, one uses maximizing the likelihood function as the criterion for choosing the parameters of a production function. In DEA one selects the *smallest* production possibility set that satisfies the assumptions stated above. The frontier of the resulting production possibility set is a piece-wise linear nonparametric production function that *envelops the data* most tightly from above.

Suppose that the sample consists of observed input-output data from N firms in an industry. The maintained hypothesis, of course, is that all of these data points are elements of the same production possibility set. Let (x^j, y^j) be the observed input-output bundle of firm $j\,(j = 1,2,...,N)$. Then, an empirical construct of the production possibility set based on the sample data would be

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

An alternative characterization of T would be in terms of the family of input requirement sets

$$V(y) = \{x : (x,y) \in T\}. \qquad (3)$$

For any specific output level y^0, the input requirement set corresponding to S above would be

$$V(y^0) = \left\{x : x \geq \sum_{1}^{N} \lambda_j x^j ; y^0 \leq \sum_{i}^{N} \lambda_j y^j ; \sum_{1}^{N} \lambda_j = 1; \lambda_j \geq 0\right\}. \qquad (4)$$

The input requirement set of the output level y^0 consists of all input bundles that can produce the output quantity y^0 or higher. In terms of standard textbook exposition, it would consist of all points on or above the isoquant for y^0.

Cost Efficiency and its Decomposition

Now suppose that an individual firm i produces output $y^i = y^0$ using the input bundle $x^i = x^0$. Assume further that it faces the input price vector $w = w^0$. Then, its actual cost is $C^0 = w^{0\prime}x^0$. The minimum cost of producing output y^0 at input price w^0 is

$$C(w^0, y^0) = \min w^{0\prime}x : x \in V(y^0). \qquad (5)$$

For any given data set $C(w^0, y^0)$ can be computed by solving the linear programming problem:

$$\min w^{0\prime}x$$

subject to

$$\sum_{1}^{N}\lambda_j x^j \le x;$$

$$\sum_{1}^{N}\lambda_j y^j \ge y^0; \qquad (6)$$

$$\sum_{1}^{N}\lambda_j = 1;\ \ x \ge 0; \lambda_j \ge 0;\ (j = 1,2,...,N).$$

The cost efficiency of firm *i* can be measured as

$$\gamma = \tfrac{C(w^0, y^0)}{C^0}. \qquad (7)$$

This measure of cost efficiency of a firm shows the factor by which the firm's actual cost of producing its observed level of output can be scaled down.

Farrell (1957) defined the (input-oriented) *technical efficiency* of the firm producing y^0 from input x^0 as

$$\beta = \min \theta : \theta x^0 \in V(y^0). \qquad (8)$$

In any empirical application, β can be obtained by solving the problem:

$$\beta = \ \min\ \theta$$

subject to

$$\sum_{1}^{N}\lambda_j x^j \le \theta x^0;$$

$$\sum_{1}^{N}\lambda_j y^j \ge y^0; \qquad (9)$$

$$\sum_{1}^{N}\lambda_j = 1;$$

$$\lambda_j \ge 0;\ (j = 1,2,...,N).$$

the *allocative efficiency* of the firm is obtained indirectly as

$$\alpha = \tfrac{\gamma}{\beta}. \qquad (10)$$

A value of β lower than unity shows how much all components of the input bundle x^0 can be equi-proportionately scaled down without violating the feasibility of the output y^0.

This would lower the cost from C^0 by the factor β. On the other hand, allocative efficiency represents any *further cost reduction* that could be attained by altering the input proportions and moving from one point to another on the isoquant for y^0. Thus, the cost efficiency of the firm can be multiplicatively decomposed into technical and allocative efficiency as

$$\gamma = \beta . \alpha . \qquad (11)$$

Industry Efficiency

We now look at the total industry output $Y \equiv \sum_1^N y^j$ and the total input bundle $X \equiv \sum_1^N x^j$. At this point assume that all firms in the industry face the same input prices. Then the total (actual) cost of producing the industry output, Y, is $C_I^0 = w^0{}'X = \sum_1^N C_i^0$. If each firm in the industry could attain full cost efficiency, the efficient cost for the industry output would be $C_I^* = \sum_1^N C(w^0, y^i)$. A simple measure of the *total cost efficiency* of the industry as a whole would be

$$\gamma_I = \frac{\sum_1^N C(w^0, y^i)}{\sum_1^N C_i^0} = \frac{C_I^*}{C_I^0}. \qquad (12)$$

It is clear that

$$\gamma_I = \sum_1^N \delta_i \gamma_i \qquad (12a)$$

where $\delta_i = \frac{C_i^0}{C_I^0}$ is the share of the actual cost of firm *i* in the total industry cost. Thus, γ_I would increase if the shares of the more efficient firm in the total cost of the industry increased even though none of the individual firms improved in efficiency.

Efficient Organization of the Industry

An industry is deemed to be efficiently organized when the total output is produced at the minimum possible cost at the applicable input prices. When all firms in the industry face the same prices of inputs and have access to the same production technology, every firm would have the same cost function. Unless constant returns to scale holds globally, the average cost curve has the usual U-shape and its minimum point corresponds to the efficient scale of production for an individual firm. In a competitive market with free entry and exit, price will be equal to the minimum of the average cost so that each firm staying in the market would earn zero economic profit. Industry output would be entirely demand determined. The number of firms in the industry would be such that the market demand is exactly met by the total output of these firms while each individual firm operates at the efficient scale of production. Let y^E be the efficient scale of production. Then

$$ac^E = \frac{C(w^0, y^E)}{y^E} \qquad (13)$$

is the minimum average cost . The optimal number of firms (N^E) is such that the market demand, Y, is exactly matched by the combined output of these many firms. Thus,

$$N^E = \frac{Y}{y^E}. \qquad (14)$$

The benchmark for overall efficiency of the industry is

$$C_I^E = N^E.C(w^0, y^E). \qquad (15)$$

This is what would be the cost of producing the industry output when it is produced by N^E firms each producing the efficient output quantity at full cost efficiency. Thus the *overall cost efficiency* of the industry is

$$\gamma_I^E = \frac{C_I^E}{C_I^0}. \qquad (16)$$

This can be further decomposed as

$$\gamma_I^E = \frac{C_I^E}{C_I^0} = \frac{C_I^E}{C_I^*}.\frac{C_I^*}{C_I^0}. \qquad (17)$$

The second factor on the right hand side is the *total cost efficiency* γ_I defined above. The first factor is the *efficiency of the industrial organization*

$$\gamma_I^O = \frac{C_I^E}{C_I^*}. \qquad (18)$$

Finding the Optimal Number of Firms

In a parametric model of the cost function, $C^* = C(w^0, y)$, one can easily determine the efficient output scale, y^E, by solving the first order condition for a minimum of the average cost

$$\frac{\partial C(w^0, y)}{\partial y} = \frac{C(w^0, y)}{y}. \tag{19}$$

In DEA, however, we do not obtain a cost function in a parametric form and cannot use the first order condition in (19) to determine y^E. We therefore follow an indirect approach. Note that C_I^E is the minimum cost of producing the industry output Y, when there are N^E firms, each producing the efficient output level y^E at input price w^0. Suppose that the input bundle used by the representative firm is x^E. Then the aggregate input bundle is $X^E = N^E.x^E$. The corresponding cost is $C_I^E = N^E.C(w^0, y^E) = w^{0\prime} X^E$. It is possible to obtain C_I^E as

$$\min\ w^{0\prime} X : X = N^E x^E; N^E y^E = Y; (x^E, y^E) \in T. \tag{20}$$

The DEA problem for (20) would be

$$C_I^E = \min w^{0\prime} X$$

subject to

$$\begin{aligned}
&\sum_1^N \lambda_j x^j = x^E; \\
&\sum_1^N \lambda_j y^j = y^E; \qquad\qquad (21)\\
&N^E x^E = X; \\
&N^E y^E = Y; \\
&\sum_1^N \lambda_j = 1; \\
&\lambda_j \ge 0;\ (j = 1,2,\ldots,N); x^E, y^E \ge 0; N^E \in \{1,2,,\ldots\}
\end{aligned}$$

One problem with this model is that because N^E, y^E, and x^E are all unknown, some of the constraints are non-linear. However, we may define the variables

$$\mu_j = {}_{N}^{E}.\lambda_j \; (j = 1,2, \ldots,N). \qquad (22)$$

The DEA problem in (21) can then be reformulated as the following mixed integer programming problem

$$C_I^E = \min w^{0}{}'X$$

subject to

$$\sum_{1}^{N} \mu_j x^j \le X;;$$

$$\sum_{1}^{N} \mu_j y^j = Y; \qquad (23)$$

$$\sum_{1}^{N} \mu_j = N^E\,;$$

$$\mu_j \ge 0;\ (j = 1,2,\ldots,N); X, \ge 0; N^E \in \{1,2,,\ldots\}$$

Once the optimal number of firms N^E is obtained from (23), the efficient production scale (y^E) is obtained from the industry output, Y. Several points may be highlighted about the problem in (23). First, because the total and average costs depend on the vector of input prices, the efficient production scale will depend on w. Second, without the restriction that the μ_js should sum to an integer, (23) would have been a standard cost minimization problem under the assumption of constant returns to scale[2]. In that case, the optimal production scale would be

$$y_{CRS}^{E} = \frac{Y}{\sum_{1}^{N} \mu_j^{*}}.$$

But in that case, the implied optimal number of firms might not be an integer. Because we require N^E to be a whole number, the optimal output size of the firm will differ slightly from y_{CRS}^{E}.

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[2] See Ray (2004) for an exposition of the DEA model for cost minimization under constant returns to scale.

3. The Empirical Analysis

We conceptualize a 1-output, 5-input production technology for the Indian manufacturing industry. The data are constructed from Table 3 of the Annual Survey of Industries for the year 2004-5. The single output *(y)* is measured by the gross value of production. Because of the cross sectional nature of the data, if we assume that there are no inter-state differences in the output price, the nominal value becomes proportional to the output quantity. The inputs included are (i) production labor, (ii) non-production labor, (iii) capital, (iv) energy (measured by fuels consumed), and (v) materials. Production and non-production workers are measured by the number of persons employed of the relevant category. For individual states, the wage rates of the two different categories of labor are computed by dividing the total wages paid (including benefits) by the number of workers in the respective categories. Capital is measured by the value of gross fixed assets. The user cost of capital is measured by the sum of interest, depreciation, and rent paid per unit of the gross value of fixed assets. The tariff paid for electric power by industrial users in the different states (reported in the *Economic Survey 2007-08*) is used as a proxy for the price of energy[3]. The expenditure on fuels consumed is deflated by this energy price to obtain a measure of the quantity of the energy input. The material input is measured in value terms. By implication, the price of materials is set equal to unity.

One major limitation of the data reported in the relevant ASI table is that for each individual state, the input and output information provided are the aggregate values of the inputs and outputs of all firms (establishments) from the state that are covered in the Survey. This poses a conceptual problem for the analyst. The actual input-output quantities of the individual firms are all feasible bundles even though they have not been separately reported in the Survey. By contrast, the *total input-output* bundle is merely the *sum* of those feasible bundles. It is neither an actually observed bundle nor any *weighted average* of feasible bundles. Therefore, convexity of the production possibility set is not enough to ensure that the aggregate input-output bundle is itself a feasible bundle. For that we need to assume constant returns to scale in which case the technology would be

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[3] This is admittedly a very crude measure of the price of energy. But in the absence of any other information relating to inter-state variation in fuel prices, it is the best we could get. The alternative would be to ignore inter-state differences in energy prices altogether.

additive. But if constant returns to scale is assumed, the average cost curve is horizontal and the entire question of a unique efficient production scale is superfluous. At the same time, when the total input-output bundles are *not treated as data points*, how can we construct the production possibility set nonparametrically? One possible solution is to use the *per firm* or average input-output bundle for any state as a feasible input-output combination and to use them as the basis for constructing the nonparametric frontier. Note that the *per firm* input-output bundle is an equally weighted average of the unobserved input-output bundles of the individual firms from that state. Hence, by convexity, each of these *per firm* input-output bundles is feasible. Therefore, we can use them as 'observed' data points for the DEA even though they are not *actually observed* bundles.. This would avoid having to assume constant returns to scale. Although the resulting production possibility set would be smaller than what it would have been if all the firm level input-output data were available, all points in this production possibility set would still be feasible points[4].

For the present study we include 21 states and the union territory of Chandigarh[5]. For each state, the number of firms covered by the 2004-05 Survey, the gross output and total cost per firm (both in Lakhs of Rupees), and the average cost (in rupees) are reported in Table 1. The actual output size of an average firm in a state varies from approximately Rupees 657.5 lakh (Rs. 65.75 million) in Kerala and Andhra Pradesh to Rs. 2977.37 lakh (Rs. 297.73 million) in Goa. The actual average cost is lowest (at 56.1 paise per rupee) in Jharkhand and the highest in Bihar (95.7 paise per rupee).

There are three main sources of difference in average cost across states. These are: (i) differences in cost efficiency, (ii) differences in input prices, and (iii) differences in output scale. If the average cost is higher in one state compared to another state, it does not automatically follow that former state is less cost efficient than the latter. Table 2 reports the levels of cost efficiency in each state. In computing the minimum cost, the existing number of firms in a state is considered as given and, hence, the output produced by the firm is also unchanged. Table 2 portrays a much better picture of the relative performance of firms across states. In this table, the column labeled 'min cost' shows the

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[4] Using average bundles as data points leads to an underestimation of the frontier and, hence, efficiency is over-estimated. When actual firm level data are not available, this bias is unavoidable.

[5] Hereafter we loosely describe Chandigarh as a 'state' although it is, in reality, a union territory.

minimum cost of producing the output quantity shown in the ‘output’ column at the input prices prevailing in the relevant state. The ratio of the minimum and the actual cost of producing the given output level is shown in the ‘efficiency’ column. Compare, for an example, the average costs in Chhattisgarh and Goa. The actual average cost in Goa is 74.1 paise per rupee compared to 65.8 paise per rupee in Chhattisgarh. This might suggest that firms in Goa are, on average, less efficient than firms in Chhattisgarh. But as shown in Table 2, cost efficiency in Goa is 100% while that in Chhattisgarh is only 86.3%. Thus, even though the cost per unit is higher in Goa, firms in Chhattisgarh are, on average, less efficient. Of the 22 states in our sample, Jharkhand (JH), Delhi (DE), and Goa (GO) are fully cost efficient. Two other states, Chandigarh(CH) and Chhattisgarh (CT), have less than 15% cost inefficiency. At the other end, cost efficiency in Bihar (BI) and Gujarat (GU) is lower than 68%. Thus, in both of these states, the average cost could be lowered by over 32%. In fact, given the perception of Gujarat as an advanced industrial state, this comes as a surprise. But if cost inefficiency could be eliminated, average cost in Gujarat (GU) would be lower than what it is in Delhi (DE). Another surprise is Punjab (PU) which has higher observed average cost and lower cost efficiency than all of the so called BIMARU (Bihar, Madhya Pradesh,, Assam, Rajasthan, and Uttar Pradesh) states except Bihar (BI). It is interesting to note that if all states operate at 100% cost efficiency, the average cost will be the highest in Goa (GO). Because there is no identified cost inefficiency in Goa, such high average cost can only come from IO inefficiency and/or higher input prices.

The Farrell decomposition of cost efficiency into technical and allocative efficiency components is shown in Table 3. For 13 of the 22 states in our study, we find no evidence of technical inefficiency. It would not be possible to scale down *every input* and still produce the observed levels of output in any of these states. Somewhat surprisingly, states like Gujarat (GU), Bihar (BI) and Kerala (KE) are found to be technically efficient even though their levels of cost efficiency are quite low. West Bengal (WB) has the lowest level of technical efficiency (at 86%). The observed output level of the average firm in this state would be producible from an input bundle where every input is reduced by 14%.Other states with technical efficiency less than 0.90 are Himachal Pradesh (HP), Madhya Pradesh (MP), and Uttaranchal (UT). It is clear that in most states, levels of cost efficiency are determined primarily by allocative efficiency. That is, failure to minimize costs is caused mostly by the choice of inappropriate input-mix rather than by the inability of firms to make full use of the inputs.

Table 4 reports the efficient output scale and the optimal number of firms for the individual states along with the actual output scale and the observed number of firms. Jharkhand (JH) is the only state where the actual number of firms equals the optimal number so that the average firm operates at the optimal scale. In all other states except Goa (GO) the average firm size (measured by the scale of production) is too small compared to the efficient scale of production. In Delhi (DE), for example, the actual output scale is Rs.554.89 Lakh whereas the optimal scale is Rs.2,338.05 Lakh. Thus, the efficient production scale is 4.214 times the actual scale of production. This can be found in the last column in Table 4 ('optimal scale ratio') which shows the ratio of the efficient scale to the actual scale. Other states that need to drastically increase the production scale of an average firm and reduce the number of firms to less than one-third are Chandigarh (CH), Tamilnadu (TN), Andhra Pradesh (AP), Punjab (PU), Kerala (KE), and Bihar (BI). By contrast, Goa (GO) has less than the optimal number of firms and the actual production scale exceeds the efficient scale by 27.4%. Firms in Goa operate in the region of diseconomies of scale. In Jharkhand (JH), firms operate at the efficient scale. In all other states, there are unexploited scale economies and firm size should be increased. It may be noted that the efficient scale of output reported in Table 3 varies slightly across states. This is due to two factors. First, input prices differ across states and as a result the total and average cost functions also would vary. Second, because the optimal number of firms has to be an integer, the efficient output scale shown in Table 3 differs slightly from the exact point where the average cost reaches a minimum (i.e., locally constant returns to scale holds).

It is reassuring to note that despite small variation across states, the efficient production scale is remarkably similar for all the states.

Table 5 reports the average costs that would correspond to the situation where the manufacturing industry was efficiently organized in the sense it had the optimal number of firms each producing the efficient scale of output along with the actual and efficient average costs reported above in Table 3. For the country as a whole, the actual average cost is 76 paise per rupee of gross output. If each state succeeded in eliminating cost inefficiency, even with the existing numbers of firms, the all-India average cost would decline to 58.6 paise per rupee. This would result in lowering the average cost by nearly 23%. If actually implemented, this would be a major step towards making Indian manufacturing considerably more competitive in the export market. Thus, there is overwhelming evidence in favor of the assessment by the CII- McKinsey Report that Indian firms are cost inefficient. As shown in the last column of Table 4, when the states appropriately restructure their manufacturing sector by reducing the number of firms by consolidation (Goa is a lone exception), a further reduction in average cost by 2.7 paise per rupee of output could be achieved at the all-India level.

Table 6 shows the overall cost efficiency for the individual states and also at the all-India level. Jharkhand (JH) is the only state where overall cost efficiency is 100%. It has the optimal number of firms for the total manufacturing output produced in the state and the average firm is both cost efficient and scale efficient. Delhi (DE) is the only other state with overall cost efficiency in excess of 90%. As already noted, the average firm in Delhi is cost efficient for its actual production scale, But the output scale should be increased and the number of firms correspondingly reduced to achieve 100% IO efficiency. Goa (GO), the other state with 100% cost efficiency (at the prevailing output scale), has an overall cost efficiency lower than 75%. This shows that by restructuring the industry, the average cost in that state can be reduced to about ¾th of the observed level. It is the only state where the actual number of firms is less than the optimal and the output scale of an average firm should be reduced by increasing the number of firms. In three other states – Chandigarh (CH), Andhra Pradesh (AP) and Kerala (KE) the level of IO efficiency is less than 0.90. In each of these states the average cost can be lowered by more than 10% (even after cost efficiency is eliminated at the firm level) simply by restructuring the industry and increasing the production scale of the average firm. At the all-India level, IO efficiency is 95.5%. Thus, less than 5% reduction in cost can be achieved by altering the production scale.

The main findings of this study can be summarized as follows:

- For the country as a whole, cost efficiency quite low and the average cost can be reduced by about 23% if the existing firms can attain full cost efficiency. Among the individual states, Bihar (BI) and Gujarat (GU) are the worst performers. At the other end, firms in Jharkhand (JH), Delhi (DE), and Goa (GO) show no inefficiency. Of the remaining states, only Chhattisgarh (CT) and Maharashtra (MH) achieve efficiency over 80%. For all other states, costs can be reduced by at least 20% without reducing the level of output.

- About ⅔rds of the states (13 out of 22) show no evidence of technical inefficiency. Even some states that perform at low levels of cost efficiency (like Gujarat (GU) and Bihar (BI)) are technically efficient. The primary source of cost inefficiency is inappropriate choice of input proportions that is manifest in the low levels of allocative efficiency.
- There is overwhelming evidence that the average firm in any Indian state is too small and produces below the optimal scale. The only exception is Goa, where the average firm size is too large even though firms are cost efficient *at their existing scale.* Delhi (DE) provides an extreme example, where the average firm, although cost efficient, is at a scale that is than ¼th of the efficient production scale. Industry restructuring can lower the average cost by more than 7% in Delhi.
- Although there is ample room for reducing the average cost in Indian manufacturing, such cost savings would come primarily from eliminating cost inefficiency *at the firm level*. While it is found that the manufacturing industry is not efficiently organized in any state except Jharkhand (JH), restructuring of the industry will make only a modest contribution towards reducing average cost any further.
- Because of differences in input prices, the average cost at the efficient scale (i.e., the minimum average cost) does vary considerably from a low of 50.9 paise per rupee in Assam (AS) to a high of 62.4 paise per rupee in Delhi (DE). By contrast, the efficient production scale itself shows little variation across the states. This suggests that input price differences are scale neutral so far as the average cost is concerned.

4. Conclusion

Using the nonparametric method of Data Envelopment Analysis we find considerable evidence of cost inefficiency in Indian manufacturing. Although cost efficiency varies across states, it stands at a disturbingly low level of 77.1% at the all-India level. In fact, an additional 4% inefficiency arises out of inefficient organization of the industry in terms of firm size. The 2004-05 data reveal that the average manufacturing firm in India operates at a scale that is well below the optimal production scale. But cost inefficiency rather than scale inefficiency is a matter of bigger concern. The presence of significant cost inefficiency implies that there is, indeed, a potential for Indian firms to become far more cost-competitive which could enable them to gain a larger share of the world market even within the capabilities defined by the current technology. There is reason for optimism on this count. At the same time, one must recognize that eliminating the existing inefficiencies would be a major challenge and a bright future for Indian manufacturing is far from assured.

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Table1 Summary of *per firm* Data for Individual States

State	**Number**	**Ouput (Rs. Lakh)**	**Cost (Rs. Lakh)**	**Average cost (Re)**
Jharkhand (**JH**)	1607	2338.640	1312.637	0.561
Chhattisgarh(**CT**)	1343	2070.013	1362.575	0.658
Delhi(**DE**)	3156	554.879	368.499	0.664
Maharashtra(**MH**)	18912	1897.629	1285.449	0.677
Assam(**AS**)	1710	1289.475	893.564	0.693
Chandigarh(**CH**)	287	686.868	485.498	0.707
Goa(**GO**)	518	2977.373	2204.784	0.741
Orissa(**OR**)	1749	1331.847	999.319	0.750
Karnataka(**KA**)	7596	1432.945	1081.397	0.755
Rajasthan(**RA**)	5740	781.917	596.725	0.763
Himachal Pradesh(**HP**)	653	1404.913	1072.663	0.764
Madhya Pradesh (**MP**)	3028	1551.140	1193.043	0.769
Tamilnadu(**TN**)	21053	757.645	593.050	0.783
Uttaranchal(**UT**)	752	1339.559	1050.117	0.784
Uttar Pradesh (**UP**)	9582	1138.997	897.537	0.788
Andhra Pradesh (**AP**)	15572	657.491	524.829	0.798
Haryana(**HA**)	4339	1745.090	1404.808	0.805
West Bengal (**WB**)	6105	1186.288	957.198	0.807
Gujarat (**GU**)	13603	1916.846	1573.211	0.821
Punjab(**PU**)	7575	700.276	579.773	0.828
Kerala(**KE**)	5493	657.557	580.535	0.883
Bihar(**BI**)	1674	730.089	698.612	0.957

Notes: Output and cost refer to an individual firm.
Average cost is per Rupee of gross output produced.

Table2 Cost Efficiency with Existing Numbers of Firms: By State

State	number	output	Cost	min. cost	efficiency	ac	ac*
JH	1607	2338.64	1312.637	1312.637	1	0.561282	0.561282
CT	1343	2070.013	1362.575	1176.38	0.863351	0.658244	0.568296
DE	3156	554.8793	368.4987	368.4987	1	0.664106	0.664106
MH	18912	1897.629	1285.449	1077.033	0.837865	0.677397	0.567568
AS	1710	1289.475	893.5643	693.0628	0.775616	0.692968	0.537477
CH	287	686.8676	485.4983	439.7444	0.905759	0.706829	0.640217
GO	518	2977.373	2204.784	2204.784	1	0.740513	0.740513
OR	1749	1331.847	999.319	761.2111	0.76173	0.750326	0.571546
KA	7596	1432.945	1081.397	847.5082	0.783716	0.754667	0.591445
RA	5740	781.9172	596.7247	476.6257	0.798736	0.763156	0.60956
HP	653	1404.913	1072.663	768.7198	0.716646	0.763509	0.547166
MP	3028	1551.14	1193.043	892.8072	0.748345	0.769139	0.575581
TN	21053	757.6451	593.0503	466.6227	0.786818	0.782755	0.615886
UT	752	1339.559	1050.117	763.1622	0.72674	0.783928	0.569712
UP	9582	1138.997	897.5366	669.8896	0.746365	0.788006	0.58814
AP	15572	657.491	524.8293	403.1125	0.768083	0.79823	0.613107
HA	4339	1745.09	1404.808	1040.896	0.740952	0.805006	0.596471
WB	6105	1186.288	957.1975	709.1351	0.740845	0.806885	0.597777
GU	13603	1916.846	1573.211	1066.685	0.67803	0.820729	0.556479
PU	7575	700.276	579.7725	428.6936	0.739417	0.82792	0.612178
KE	5493	657.5567	580.535	410.3041	0.706769	0.882867	0.623983
BI	1674	730.089	698.6117	447.6921	0.640831	0.956886	0.613202

Note: For full names of states see Table 1.

Table 3 Decomposition of Cost Efficiency: By State

State	Technical Efficiency	Allocative Efficiency	Cost Efficiency
JH	1.000	1.000	1.000
CT	1.000	0.863	0.863
DE	1.000	1.000	1.000
MH	1.000	0.838	0.838
AS	1.000	0.776	0.776
CH	1.000	0.906	0.906
GO	1.000	1.000	1.000
OR	0.931	0.818	0.762
KA	0.979	0.800	0.784
RA	1.000	0.799	0.799
HP	0.879	0.816	0.717
MP	0.870	0.860	0.748
TN	0.984	0.800	0.787
UT	0.888	0.819	0.727
UP	0.905	0.825	0.746
AP	1.000	0.768	0.768
HA	1.000	0.741	0.741
WB	0.860	0.861	0.741
GU	1.000	0.678	0.678
PU	0.957	0.772	0.739
KE	1.000	0.707	0.707
BI	1.000	0.641	0.641

Table 4 Optimal Number of Firms and Efficient Scale: By State

State	Actual number of firms	Optimal number of firms	Actual output scale	Optimal output scale	Optimal scale ratio
JH	1607	1607	2338.64	2338.64	1.000
CT	1343	1189	2070.013	2338.123	1.130
DE	3156	749	554.8793	2338.049	4.214
MH	18912	15346	1897.629	2338.587	1.232
AS	1710	943	1289.475	2338.284	1.813
CH	287	85	686.8676	2319.188	3.376
GO	518	660	2977.373	2336.786	0.785
OR	1749	997	1331.847	2336.409	1.754
KA	7596	4655	1432.945	2338.27	1.632
RA	5740	1920	781.9172	2337.607	2.990
HP	653	393	1404.913	2334.372	1.662
MP	3028	2009	1551.14	2337.905	1.507
TN	21053	6821	757.6451	2338.47	3.086
UT	752	431	1339.559	2337.234	1.745
UP	9582	4667	1138.997	2338.52	2.053
AP	15572	4378	657.491	2338.614	3.557
HA	4339	3238	1745.09	2338.463	1.340
WB	6105	3097	1186.288	2338.485	1.971
GU	13603	11150	1916.846	2338.552	1.220
PU	7575	2269	700.276	2337.854	3.338
KE	5493	1545	657.5567	2337.838	3.555
BI	1674	523	730.089	2336.843	3.201

Table 5 Actual and Efficient Average Cost: By State

State	Actual	Cost Efficient	Overall Efficient
JH	0.561	0.561	0.561
CT	0.658	0.568	0.563
DE	0.664	0.664	0.624
MH	0.677	0.568	0.559
AS	0.693	0.537	0.509
CH	0.707	0.640	0.572
GO	0.741	0.741	0.555
OR	0.750	0.572	0.544
KA	0.755	0.591	0.573
RA	0.763	0.610	0.560
HP	0.764	0.547	0.523
MP	0.769	0.576	0.561
TN	0.783	0.616	0.561
UT	0.784	0.570	0.542
UP	0.788	0.588	0.559
AP	0.798	0.613	0.545
HA	0.805	0.596	0.588
WB	0.807	0.598	0.572
GU	0.821	0.556	0.549
PU	0.828	0.612	0.559
KE	0.883	0.624	0.552
BI	0.957	0.613	0.571
All-India	0.760	0.586	0.559

Table 6 Decomposition of Overall Cost Efficiency: By State

State	Total Cost Efficiency	IO Efficiency	Overall Cost Efficiency
JH	1.000	1.000	1.000
CT	0.863	0.991	0.856
DE	1.000	0.939	0.939
MH	0.838	0.985	0.826
AS	0.776	0.948	0.735
CH	0.906	0.893	0.809
GO	1.000	0.749	0.749
OR	0.762	0.951	0.724
KA	0.784	0.969	0.760
RA	0.799	0.918	0.733
HP	0.717	0.956	0.685
MP	0.748	0.974	0.729
TN	0.787	0.911	0.717
UT	0.727	0.952	0.692
UP	0.746	0.951	0.710
AP	0.768	0.889	0.683
HA	0.741	0.985	0.730
WB	0.741	0.956	0.708
GU	0.678	0.987	0.669
PU	0.739	0.912	0.675
KE	0.707	0.885	0.625
BI	0.641	0.931	0.596
All India	0.771	0.955	0.736