# Technical Efficiency of Small Scale Industry in India : Application of Stochastic Production Frontier Model

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# Technical Efficiency of Small Scale Industry in India

# : Application of Stochastic Production Frontier Model

Yuko Nikaido

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Yuko Nikaido †

**Abstract**

In India, the government has carried out various preferential policies for Small Scale Industry (SSI) since the 1950s. However, the main objective of the past policies was to protect SSI rather than to make it independent under competitive environment.

After the economic liberalization of 1991, however, SSI has increasingly been recognized as a growth engine of the national economy. In other words, by making use of its flexible and innovative nature, this sector is expected to work as a linkage/subcontracting industry or as an export-oriented industry. Thus, the government is urged to change the policies in accordance with such needs and situations.

In this paper, firstly, I measure technical efficiency of SSI by using a stochastic production frontier model. Secondly, I analyze the impact of firm size and industrial agglomeration effects on the measured technical efficiency. I got a result that industrial agglomeration has a positive effect on the technical efficiency. It implies that the government had better promote industrial agglomeration, keeping infrastructure in good conditions and supporting technological upgrading of SSI.

*Keywords*; technical efficiency, stochastic frontier, agglomeration, small and medium firms.

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## I. Introduction

The supporting policies for small and medium scale firms are common phenomena in many developing countries. India is not an exception. Since the 1950s the Indian government has supported Small Scale Industry (SSI)[1] to generate employment and to promote regional dispersal and equal income distribution.[2] The government has carried out various preferential policies for this sector, presupposing that SSI cannot get an adequate credit due to asymmetric information and SSI cannot enjoy scale economies in material purchases and marketing. Preferential policies for SSI consist of financial assistance from commercial banks and Development Financial Institutions (DFIs), tax exemption, reserved items for SSI, purchase preference by the government agencies, preferential access to materials, and providing infrastructural facilities. In the 1950s, these policies were regarded as temporary or transitional measures. But, actually these measures have resulted in protection of weak firms rather than resulted in the independence of firms under competitive environment. Such situations have continued until today.[3]

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1 Industrial classifications of India are divided into large/medium industry and small industry. Small industry comprises of the traditional sector and the modern sector. SSI belongs to the modern sector. Note that the term 'SSI' represents the sector itself in this paper.

2 Especially in the second five-year plan [1956-61], to counter-balance the industrialization depended on heavy industries which were capital intensive and offered limited scope for regional dispersal, the government emphasized the promotion of SSI. See more detail, Kashiyap (1988), Ahulwalia (1991), Goldar (1993), and Tendulkar and Bhavani (1993).

3 The number of reserved items that are exclusively produced by SSI is more than 800 items. But, indeed more than 550 items are now freely importable. Thus, foreign firms made products can be sold freely, while domestic large firms cannot produce them. That fact may imply the pool of inefficient small firms in the domestic market.

In India SSI is currently defined as units that the investment in fixed assets such as plant and machinery, whether held on ownership terms or on lease or on hire purchase, does not exceed Rs.10 millions[4]. This sector accounts for 40% of the gross turnover of the manufacturing sector, about 45% of the manufacturing exports, and about 35% of the total exports of India. The employment in this sector is around 17.2 millions: this contribution follows the agricultural sector.[5]

After the economic liberalization of 1991, the environment surrounding SSI changed dramatically. SSI faces severe competition with foreign firms. On the other hand, SSI has been increasingly expected as an engine of growth of the national economy. In other words, by making use of its flexible and innovative nature, SSI is expected to work as a linkage and subcontracting industry or as an export-oriented industry. Thus, the government is urged to change the policies in accordance with such needs and situations.

The aim of this paper is to get some policy implications. After reviewing empirical studies for SSI in section II, I measure technical efficiency of SSI by using a stochastic production frontier model in Section III. Section IV investigates the impact of firm size and geographical agglomeration on the measured efficiency. It is interesting to know that agglomeration has a positive effect on the technical efficiency. Conclusion is that the government had better promote SSI by promoting agglomeration economies, keeping infrastructure in good condition, and supporting technological upgrading, etc.

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[4] The definition of SSI has undergone changes over the years, taken care of inflation.

[5] GOI, *Economic Survey* (1999/2000), DC (1999).

## II. Analytical Framework and the Existing Studies for Indian Small Scale Industry

When discussing the performance of firms/production units, it is common to describe them in terms of "productivity" or "efficiency".[6] Though "productivity" and "efficiency" are not precisely the same things, both of them are good indicators to evaluate the performance of the firms/production units. Several approaches have been developed for measuring them. The major approaches are (1) Index numbers, (2) Least-squares, (3) Data Envelopment Analysis (DEA), and (4) Frontier. The former two approaches measure "productivity" under the assumption that all firms are technically efficient, while the latter two approaches do not make such an assumption. These four approaches are also distinguished in several other ways such as the data requirement, the behavioral assumption, and whether they are parametric or nonparametric.

Productivity means the ratio of the output to the input. This ratio is easy to calculate if a unit uses one input to produce one output. But, it is more common that a unit uses more than one input, so that these inputs must be aggregated in some sensible fashion. The latter two approaches go back to the pioneer work of Farrell (1957). He defined efficiency as the ratio of observed output to the maximum potential output that can be attained from given inputs. If a firm's actual output is below the maximum potential output, the shortage is regarded as an indicator of inefficiency. This interpretation of Farell may be ruled out by an orthodox microeconomics presupposing that there is no

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[6] For a detail discussion on productivity and efficiency literatures, see Cowing and Stevenson (1981), Fried, Lovell and Schmidt (1993), Coeli, Rao and Battese (1998), Pesaran and Schmidt (1997), and Kumbhakar and Lovell (2000).

inefficiency in a competitive market. However it seems appropriate to apply Farell's approach to developing countries like India where market failure is prevalent and the government deeply intervenes the market.

### Indian context

Table 1 represents a summary of the existing empirical studies for Indian small scale industry.[7] Goldar (1988), Ramaswamy (1993), GOI (1997) and SIDBI (1999) analyzed SSI performance using nonparametric, index number approach. Goldar (1988), GOI (1997) and SIDBI (1999) compared small-scale units with large units, although there was difference of approaches at aggregate or disaggregate level. Ramaswamy (1993) analyzed 4 industries belonging to SSI.

Little, Mazumdar and Page (1987) analyzed SSI by least-squares approach which is the econometric estimation of parametric function. Strictly speaking, they estimated it jointly with the factor share equations. The estimated parameters or function represent "average" technology passing through the middle of observations, because the error terms of both signs are not singled out for special treatment.

But calculations and estimations mentioned above presume a competitive market, under which the factors are paid according to their marginal product. However, in the context of India this assumption seems unrealistic. Because a part of SSI products are reserved exclusively and then large firms cannot enter the market, and SSI gets inputs

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[7] As you can see, in this context there are not any studies by means of DEA approach. Hence, I don't touch the approach here. And throughout this paper, I confine my discussion to single-output case.

preferentially. Thus, as Goldar (1997) pointed out, if that assumption is not valid, then the estimation of the production function may yield biased estimates of parameters.

On the other hand, Page (1984), Little, Mazumdar and Page (1987), Bhavani (1991), and GOI (1997) analyzed SSI by means of a deterministic frontier approach. According to frontier approach the inefficiency is identified with the error terms in a regression model. A deterministic frontier model can be written as

$$Y_i = f(\mathbf{X}_i, \boldsymbol{\beta}) \exp(-u_i). \qquad (1)$$

where $Y_i$ is a scalar output of producer (unit) $i$ $(i = 1, \ldots, I)$, $\mathbf{X}_i$ is a vector of inputs used by producer $i$ $(\mathbf{X}_i = (X_1, \ldots, X_n) > 0)$, $f(\mathbf{X}_i, \boldsymbol{\beta})$ is the deterministic frontier and $\boldsymbol{\beta}$ is a vector of parameters to be estimated. $u_i$ represents inefficiency and is assumed to be nonnegative random variable. Here the estimated parameters or function represent "best practice" technology rather than average technology, since a proper probability distribution for the error terms is assumed. Technical efficiency is defined as the ratio of observed output to the maximum potential output.

$$TE_i = \frac{f(\mathbf{X}_i, \boldsymbol{\beta}) \exp(-u_i)}{f(\mathbf{X}_i, \boldsymbol{\beta})} = \exp(-u_i), \qquad 0 < TE \leq 1. \qquad (2)$$

$Y_i$ achieves the maximum value of $f(\mathbf{X}_i, \boldsymbol{\beta})$ and $TE_i = 1$ if $u_i = 0$. Otherwise $u_i \neq 0$ provides the shortfall of observed output from the maximum potential output.

However the crucial defect of deterministic frontier model is that the entire shortfall of observed output from the maximum output is attributed to technical inefficiency. Such a specification seems incomplete because the output must be affected not only by the producer's inefficiency but also by random shocks such as measurement errors and weather condition that are not under the control of producer. The frontier model has developed in two stages. First stage was the deterministic model, and the second stage was a more flexible stochastic model. Ramaswamy (1994) attempted a comparison of between the technical efficiency of 4 industries by using both deterministic and stochastic models. His estimates indicated substantially lower intra-industry variation in technical efficiency, considering random factors.

## III. Technical Efficiency in a Stochastic Frontier Model

### The model

In this paper, we analyzed SSI by means of a stochastic frontier model.[8] If reliable information on prices is available, it is possible to measure allocative efficiency and economic efficiency under a behavioral assumption such as cost minimization or profit maximization. But, it is difficult to get undistorted price information in Indian context, because the government intervenes in the market deeply. Therefore, it is appropriate to use a stochastic production frontier model and then measure the technical efficiency, because the model used herein dose not need such a behavioral assumption. A stochastic frontier model can be written as

$$Y_i = f(\mathbf{X}_i, \boldsymbol{\beta})\exp(v_i - u_i), \tag{3}$$

where $f(\mathbf{X}_i, \boldsymbol{\beta}) = A + \boldsymbol{\beta}'\mathbf{X}_i$, taking logarithm,

$$\ln Y_i = \alpha + \boldsymbol{\beta}'\mathbf{x}_i + v_i - u_i. \tag{4}$$

note $\alpha = \ln A$, $\mathbf{x}_i = \ln \mathbf{X}_i$. In this model, the error terms consist of two components; $v_i$ which represents the component beyond the control of a producer and $u_i$ which represents the inefficiency component. $v_i$ is symmetry random variable and i.i.d. $N(0, \sigma_v^2)$. $u_i$ is nonnegative, one-sided random variable and i.i.d. a proper probability

[8] A stochastic frontier model began with Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). I follow the model specification of the former.

distribution. $v_i$ and $u_i$ are distributed independently of each other and of $\mathbf{x}_i$. Here, a producer faces own stochastic frontier $f(\mathbf{X}_i, \boldsymbol{\beta})\exp(v_i)$; a deterministic part $f(\mathbf{X}_i, \boldsymbol{\beta})$ common to all producers and a producer-specific part $\exp(v_i)$. Thus, technical efficiency is given by

$$TE_i = \frac{f(\mathbf{X}_i, \boldsymbol{\beta})\exp(v_i - u_i)}{f(\mathbf{X}_i, \boldsymbol{\beta})\exp(v_i)} = \exp(-u_i), \qquad 0 < TE \leq 1. \qquad (5)$$

$Y_i$ achieves its maximum value of $f(\mathbf{X}_i, \boldsymbol{\beta})\exp(v_i)$ and $TE_i = 1$ if $u_i = 0$. Otherwise $u_i \neq 0$ provides the shortfall of observed output from the maximum potential output. The above equation can be estimated by Maximum Likelihood (ML) method. The problem to calculate $TE_i$, which requires a decomposition of the residuals into $v_i$ and $u_i$. It's not easy because they are not observed directly. As a solution for the problem, Jondrow *et al.* (1982) presents the point estimator of $u_i$, i.e., $E[u_i \mid \varepsilon_i]$, given observable $\varepsilon_i = \ln Y_i - (\alpha + \boldsymbol{\beta}'\mathbf{x}_i) = v_i - u_i$.

## Data

The data for this study are drawn from the Second All-India Census of Small Scale Units (the Second Census), published by Development Commissioner (SSI) in 1992.[9]

[9] Besides this census, another data sources, namely Annual Survey of Industries (ASI) and RBI (1979) have been often utilized in many earlier studies. But, they have also limitations. As for ASI, its coverage is confined to the factory sector (larger units of SSI) and we can't use it at disaggregated (industry) level, though it is conducted every year. As for RBI (1979), its coverage was confined to units which could get loan from commercial banks in reference year 1976/77, though we can use it at disaggregated level. Thus, when we analyze SSI by utilizing these published data, we are confronted with the limitations; (1) the coverage, (2) the sample period, and (3) the lack of disaggregated data. For more detail, see Table 1 and Nikaido (2001).

The limitation on this census is that the reference year is 1987/88, a little bit old. However, after the 1990s any census has not been conducted. Nevertheless, the reasons to utilize this census are (1) it covers small-scale units under the purview of Small Industries Development Organization (SIDO), which follows official definition truly, and (2) we can use disaggregate data, i.e., 2-digit industry-groups level.

Variables such as production, the number of employment, fixed investment, capacity utilization and the number of units are utilized. In order to increase sample size industry-state-wise breakdown data are also utilized (see Appendix).

## Specification and Estimation

We assume that $f(X_i, \beta)$ takes the log-linear Cob-Douglas functional form with two inputs, labor (L) and capital (K). In order to avoid the multicollinearity from high correlation between the explanatory variables, we use the ratio form (per employee) as follows.

$$\left(\ln \frac{Y_i}{L_i}\right) = \alpha + (\beta_K + \beta_L - 1)(\ln L_i) + \beta_K \left(\ln \frac{K_i}{L_i}\right) + v_i - u_i \qquad (6)$$

Such a specification enables us to test directly on the hypothesis of constant returns to scale.[10] Next, we pool the data for the different industry-groups including the industry-state-wise breakdown. The pooling procedure allows us to have more numbers of observations and hence many more degrees of freedom. Thus, we assume that the different industry-groups within this sector have the identical maximum production function, while the intercept terms of production function are assumed to vary across

[10] Testing whether $\beta_K + \beta_L - 1$ is significantly different from zero amounts to whether returns

the industry-groups through the use of industry specific dummy variables.[11] Furthermore, in the White test and the Breusch and Pegan's LM test we could not accept the hypothesis of homoscedastic. Therefore, we use industry-state-wise capacity utilization as a weight variable.[12]

As a distribution of the error terms, we assume that $v_i$ follows the normal distribution and $u_i$ follows the half-normal distribution $|N(0,\sigma_u{}^2)|$, then the log likelihood function is[13]

$$l(\alpha,\beta,\sigma,\lambda) = I\ln 2 - \frac{I}{2}\ln 2\pi - I\ln\sigma + \sum_i \ln\Phi\left(\frac{-\varepsilon_i\lambda}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_i \varepsilon^2{}_i\,. \qquad (7)$$

where $I$ denotes the number of observations, $\varepsilon_i = v_i - u_i$, $\lambda = \sigma_u/\sigma_v$, $\sigma^2 = \sigma^2{}_v + \sigma^2{}_u$, and $\Phi(\bullet)$ is the cumulative distribution function of the standard normal distribution.

Once the point estimates of $u_i$ i.e., the following $E[u_i \mid \varepsilon_i]$ are obtained, the technical efficiency of each producer can be obtained from $TE_i = \exp(-u_i)$.

$$E[u_i \mid \varepsilon_i] = \frac{\sigma\lambda}{(1+\lambda^2)}\left[\frac{\phi(\varepsilon_i\lambda/\sigma)}{(1-\Phi(\varepsilon_i\lambda/\sigma))} - \frac{\varepsilon_i\lambda}{\sigma}\right] \qquad (8)$$

Note $\phi(\bullet)$ is the density function of the standard normal distribution.

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to scale are significantly different from being constant, i.e., $\beta_K + \beta_L = 1$.

[11] This specification follows Ahulwalia (1991).

[12] As a weight variable, we also nominated variables such as industry-state-wise the number of units, sate-wise State Domestic Product or population, and industry-wise capacity utilization. Then we tried Harvey's multiplicative heteroscedascity and the LM, LR and Wald test for each variable. As a result, industry-state-wise capacity utilization was the most proper variable. With regard to Harvey's multiplicative heteroscedascity, see Greene (2000).

[13] It is derived from the marginal density function $f(\varepsilon) = \frac{2}{\sqrt{2\pi}\sigma}\left[1-\Phi(\frac{\varepsilon\lambda}{\sigma})\right]\exp\left\{-\frac{\varepsilon^2}{2\sigma^2}\right\}$. As for the derivation of the equation (7)&(8), see Kumbhakar and Lovell (2000, ch3).

## Result of the estimation

Table 2 gives the maximum likelihood (ML) estimates by the stochastic production frontier model. Although information underlying production structure can be obtained by using the estimated parameters, it is not our direct concern. The results indicate that the estimated parameters including $\lambda$ and $\sigma$ as variance parameters are highly significant. The test for skewness of OLS residuals shows the presence of inefficiency, hence the justification of the model specification.[14] The fact that the labor coefficient is 0.116 and statistically significant implies that the hypothesis of constant returns to scale is rejected.[15] The average technical efficiency of all industries is 0.81, which indicates about 20% loss or inefficiency in production process.

Next, we compare the technical efficiency indices among industry-groups. But, it is worth noting that we have a limitation on comparing them directly, because these industries are not under the same production environments. From Table 3 and Figure 1, chemical & chemical products (31), non-metallic mineral products (32), electrical machinery & parts (36) and metal products (34) are relatively more efficient. The fact that metal products (34) is relatively efficient is consistent with the result of Bhavani (1991). The result of the lower intra-industry variation in technical efficiency is consistent with that of Ramaswamy (1994).

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[14] See Schmidt and Lin (1984)

[15] Ahulwalia (1991) and Ramaswamy (1993) do not clarify why the hypothesis of constant returns to scale is rejected or why increasing returns to scale exists.

## IV. The Sources of Technical Efficiency

The measured technical efficiency might be affected by some factors such as firm size and location. Here we evaluate the sources of efficiency by regression analysis. Because the efficiency indices are bounded between zero and one, we use a tobit regression model to evaluate it. As we described above, we use industry-state-wise data in order to increase the number of observations. Therefore, we can consider a spatial perspective. We use the following two variables as the explanatory variables, which are also drawn from the Second Census. First, to evaluate the effects of the firm size on technical efficiency, we choose the number of employment per unit as a proxy to firm size. Second, we use Location Quotient (LQ) according to Lall & Rodrigo (2000) to evaluate the effects of industrial agglomeration or clustering on technical efficiency. LQ is defined as follows;

$$LQ_{IS} = \frac{\sum E_{I,S} / \sum E_S}{\sum E_I / \sum E}$$

where $E$ indicates employment, subscript $I$ and $S$ indicate industry and state respectively. The LQ in excess of 1 means that the industry is concentrated in the region compared to the size of the industry in the national economy as a whole. We expect the positive effect of LQ on the efficiency, taking into account that locating in close proximity to other firms in the same industry brings about the spillover effect of knowledge and easy access to industry-specific specialized labor force.

### Result of the estimation

The results of tobit regression are presented in Table 4. Let's consider the effect of firm size on efficiency first. The coefficient on the number of employment per unit is negative and significant at the 1% level. The Indian government has implemented preferential policies for SSI in order to promote employment generation. However, this result indicates the aim of employment generation is not compatible with that of efficient production. In addition, the high factor share of capital shown in Table 2 predicts that firms prefer investing in plants and machinery to employing more labors. The reason might be that the government has provided priority loan and hire purchase scheme for SSI. We must recognize that there is a limitation on overcoming social problem of unemployment through an industry policy.

The coefficient on LQ is positive and also significant at the 1% level, which indicates the concentration of firms has beneficial effects. This result also gives a helpful insight toward a new policy direction, a departure from the existing regulatory and protective policies.

## V. Conclusion

This paper has examined the technical efficiency of 2-digit industry-groups belonging to SSI and the relationship between the measured technical efficiency and firm size and location. Using industry-state-wise data from the Second Census, it became clear that on average they operate at 80% of the potential maximum production frontier, although the diversification among industry groups is observed.

The agglomeration of firms has a positive effect on the measured technical efficiency, while the firm size has a negative effect on it. The result with regard to LQ is especially interesting in view of recent developments in the theory of industrial agglomeration and clusters. The Abid Hussain Committee, which was constituted by the government, has had a great interest in the development of clusters as a new policy direction. Locating closely to other firms can enable the government to reduce the unit cost of infrastructure and of monitoring. On the other hand, it can lead to accretion of skills and lowering input cost, and then SSI can enjoy external economies.[16]

The past policies, which have discriminated in favor of SSI through regulating and restricting economic activities of all firms including not only domestic large firms and foreign firms but also small-scale firms themselves, might have invoked invisible cost and disadvantage. Under the environment which the government has protected SSI from competition with large firms and foreign firms and has ensured them the markets, SSI has not had incentive to grow up into larger firms and ignored the quality of goods. In other words, the supporting policies themselves might have prevented potential capacity and innovative nature of SSI. That is incompatible with a recent expectation for SSI. It is time the government changed the protective and regulatory policies for SSI.

However, the promotion of clusters is not a magic wand. We must consider the disadvantage of it. The agglomeration of firms engaged in similar related activities is vulnerable to exogenous shift in production and technology and the problem will be deteriorated in case of such clusters being isolated or distant from markets. Actually according to the Abid Hussain Committee Report [GOI (1997)], spontaneous clusters in India have suffered a lot. Considering these cases, the first thing to do for the

[16] GOI (1997), Schmitz and Nadvi (1999).

government is to support infrastructure around clusters and to upgrade technology. Simultaneously the government should promote links with external agents such as buyers and export traders. Such agents can provide management know-how, good quality, good design and new technologies for SSI.

The stochastic frontier approach used in this paper is useful in an analysis of production units. However, this is ideal with more disaggregated data as the firm level. Finally, it is interesting future research to find out how the economic liberalization has affected the technical efficiency of SSI or the intra-industry variation in technical efficiency.

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**Table 1 The existing studies for Indian SSI**

| | Approach | Period | Industry-groups | Comparison | Definition of SSI* | Data Sources | Results |
|---|---|---|---|---|---|---|---|
| Page (1984) | Deterministic frontier | 1979-81 (partly 1979-80) | Shoes, Printing, Soap and Machine tools | Intra- SSI | Workers | Specially commissioned survey | Printing and machine tools industries are more efficient relative to other sectors. |
| Little, Mazumdar and Page (1987) | 1. Least-squares<br>2. Deterministic frontier | Same to Page (1984) | Shoes, Printing, Soap, Machine tools and Metal casting | Same to Page (1984) | Same to Page (1984) | Same to Page (1984) | 1. In soap, machine tools and metal casting, the additional experiments of employee increases productivity. In all sectors (except printing), the additional age of capital stock decreases productivity by 2-3%.<br>2. Above descriptions apply to the efficiency context. |
| Goldar (1988) | Index number | 1976-77 | 37 industries (at 3-digit level) | SSI vs Large in industry group- wise | (S): investment in Plant & Machinery<br>(L): Workers | (S): RBI (1979)<br>(L): ASI | SSI industries are less productive than large ones. |
| Bhavani (1991) | Deterministic frontier | 1972 | 4 metal industries (at 4-digit level) | Intra-SSI | Investment in Plant & Machinery | DC First Census (1977) | They operate close to their maximum potential level (Technical efficiency = more than 0.7). |
| Ramaswamy (1993) | Index number | 1976-77 | Motor vehicle parts, Agricultural machinery & parts, Machine tools & parts, and Plastic products (at 3-digit level) | Intra-SSI | Investment in Plant & Machinery | RBI (1979); original, unpublished data | The relative efficiency indices don't show a systematic relationship with firm size. |
| Ramaswamy (1994) | Deterministic & Stochastic frontier | Same to (1993) | Same to (1993) | Same to (1993) | Same to (1993) | Same to (1993) | Considering random factors (stochastic model), the intra-industry variation in technical efficiency decreases. Profitability is positively related to technical efficiency. |
| Government of India (1997) | 1. Index number<br>2. Deterministic frontier | 1984-85 | 1. 17 industries (at 3-digit level)<br>2. 16 industries (at 3-digit level) | SSI vs Large in industry group- wise | Investment in Plant & Machinery | (S) & (L): ASI | 1. Most SSI industries (except leading-export sectors, etc) are less productive than large ones.<br>2. Most SSI industries are less efficient than large ones. |
| SIDBI (1999) | Index number | 1980-94 | SSI Factory sector** (at aggregate level) | SSI vs Large in overall | Workers | (S) &(L): ASI | SSI is more productive consistently than large industry through the sample period. |

Note: * SSI is officially defined in terms of investment ceiling. But due to a data limitation, some studies distinguish between small and large in terms of workers.

** The factory sector means units employing more than 10 workers with power or more than 20 workers without power. (S): Small Industry or SSI, (L): Large Industry.

Table 2 ML Estimates of Stochastic Production Frontier

| Variables | Coefficient |
|---|---|
| Industry20&21dummy | 0.6894* |
| | (0.166) |
| Industry22dummy | 0.3254*** |
| | (0.175) |
| Industry23dummy | 0.7511* |
| | (0.171) |
| Industry24dummy | 0.761* |
| | (0.165) |
| Industry25dummy | 1.1289* |
| | (0.160) |
| Industry26dummy | 0.2802*** |
| | (0.161) |
| Industry27dummy | 0.3036*** |
| | (0.174) |
| Industry28dummy | -0.1568 |
| | (0.167) |
| Industry29dummy | 0.6405* |
| | (0.159) |
| Industry30dummy | 0.3115 |
| | (0.194) |
| Industry31dummy | 0.8521* |
| | (0.174) |
| Industry32dummy | -0.1851 |
| | (0.177) |
| Industry33dummy | 0.7553* |
| | (0.192) |
| Industry34dummy | 0.2780 |
| | (0.196) |
| Industry35dummy | -0.0706 |
| | (0.214) |
| Industry36dummy | 0.8660* |
| | (0.175) |
| Industry37dummy | 0.2146 |
| | (0.193) |
| Industry38dummy | 0.1746 |
| | (0.166) |
| lnL | 0.1163* |
| | (0.013) |
| ln(K/L) | 0.6916* |
| | (0.049) |
| Variance Parameter | |
| $\lambda$ | 1.1548* |
| | (0.262) |
| $\sigma$ | 0.7167* |
| | (0.043) |
| Log Likelihood function | -432 |
| Number of Observations(Nobs) | 505 |
| All Industries Techinical Efficiency | |
| Mean | 0.8115 |
| Std.Dev. | 0.0205 |
| Mini | 0.7708 |
| Max | 0.9006 |

Table 3 Technical Efficiency of Each Industry

| NIC No. | Industry-group | Mean TE |
|---|---|---|
| 20&21 | Food Products | 0.8150 |
| 22 | Beverage, Tobacco &Tobacco Products | 0.8074 |
| 23 | Cotton Textiles | 0.8122 |
| 24 | Wool, Silk & Synth. Fibre Textiles | 0.8033 |
| 25 | Jute, Hemp and Mesta Textiles | 0.8081 |
| 26 | Hosiery and Garments | 0.8050 |
| 27 | Wood Products | 0.8059 |
| 28 | Paper Products & Printing | 0.8136 |
| 29 | Leather Products | 0.8104 |
| 30 | Rubber & Plastic Products | 0.8192 |
| 31 | Chemical & Chemical Products | 0.8261 |
| 32 | Non-Metallic Mineral Products | 0.8260 |
| 33 | Basic Metal Industries | 0.8121 |
| 34 | Metal Products | 0.8210 |
| 35 | Machinery & Parts Except Elect | 0.8147 |
| 36 | Electrical Machinery & Parts | 0.8221 |
| 37 | Transport Equipments & Parts | 0.8126 |
| 38 | Other manufacturing | 0.8021 |

(Note): Values within parentheses indicate the standard error.

*significant at the 1% level

***significant at the 10% level

Skewness statistics: $\sqrt{b_1} = -0.29095$

See Table34B in Pearson and Hareley (1966), we can reject the null hypothesis at the 1% level.

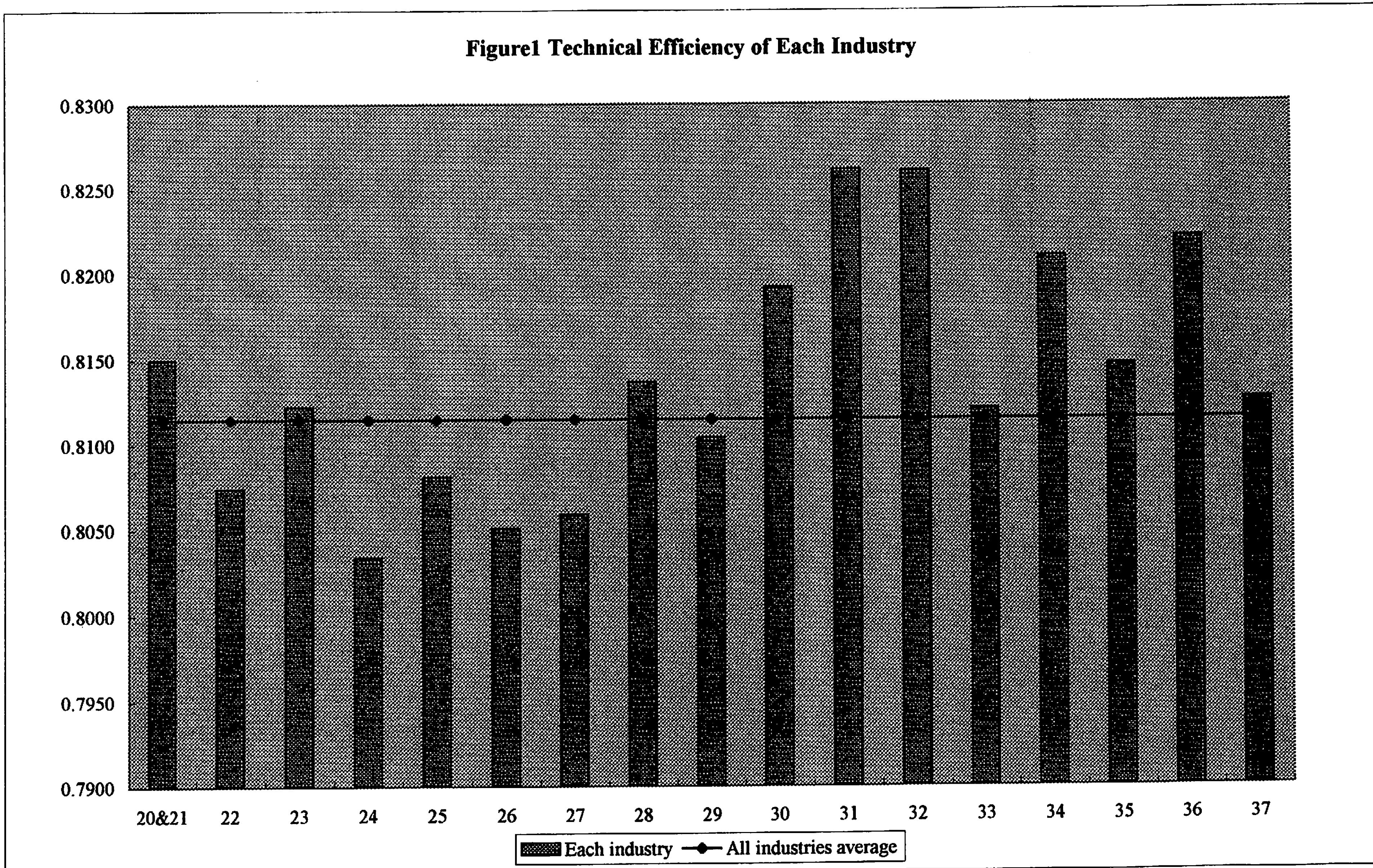
Figure1 Technical Efficiency of Each Industry
0.8300
0.8250
0.8200
0.8150
0.8100
0.8050
0.8000
0.7950
0.7900
20&21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
Each industry
All industries average

Table 4 The Sources of Technical Efficiency

| Variables | Coefficient |
|---|---|
| Constant | 0.8208* |
| | (0.00) |
| Employees per Unit | -0.0057* |
| | (0.00) |
| LQ | 0.0022* |
| | (0.00) |
| Nobs | 505 |
| Log Likelihood function | 1257 |

Note: Results are based on a Tobit regression censored below at 0 and above at 1. Values within parentheses indicate the standard error.

* significant at 1% the level.

Appendix Data

| NIC No. | Industry-group | Nobs. |
|---|---|---|
| 20&21 | Food Products | 32 |
| 22 | Beverage, Tobacco &Tobacco Products | 26 |
| 23 | Cotton Textiles | 21 |
| 24 | Wool, Silk & Synth. Fibre Textiles | 20 |
| 25 | Jute, Hemp and Mesta Textiles | 19 |
| 26 | Hosiery and Garments | 30 |
| 27 | Wood Products | 32 |
| 28 | Paper Products & Printing | 31 |
| 29 | Leather Products | 28 |
| 30 | Rubber & Plastic Products | 32 |
| 31 | Chemical & Chemical Products | 28 |
| 32 | Non-Metallic Mineral Products | 32 |
| 33 | Basic Metal Industries | 27 |
| 34 | Metal Products | 31 |
| 35 | Machinery & Parts Except Elect | 27 |
| 36 | Electrical Machinery & Parts | 30 |
| 37 | Transport Equipments & Parts | 29 |
| 38 | Other Manufacturing | 30 |
| | All Industries sum | 505 |

Note: NIC No. are based on DC(1992).

| The detail of observations | |
|---|---|
| 1 | Each Industry Aggregate |
| 2 | Andhara Pradesh |
| 3 | Assam |
| 4 | Bihar |
| 5 | Gujarat |
| 6 | Haryana |
| 7 | Himachal Pradesh |
| 8 | Jammu & Kashimir |
| 9 | Karnataka |
| 10 | Kerala |
| 11 | Madhya Pradesh |
| 12 | Maharashtra |
| 13 | Manipur |
| 14 | Meghalaya |
| 15 | Nagaland |
| 16 | Orissa |
| 17 | Punjab |
| 18 | Rajasthan |
| 19 | Tamil Nadu |
| 20 | Tripura |
| 21 | Uttar Pradesh |
| 22 | West Bengal |
| 23 | Sikkim |
| 24 | Andaman & Nicobar |
| 25 | Arunachal Pradesh |
| 26 | Chandigarh |
| 27 | Dadra & Nagar Haveli |
| 28 | Delhi |
| 29 | Goa |
| 30 | Mizoram |
| 31 | Pondicherry |
| 32 | Daman & Diu |