Technical Efficiency of Domestic and Foreign Firms in Indian Manufacturing: A Firm Level Panel Analysis

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Abstract

The present paper attempted to find the firm level technical efficiency of the Indian manufacturing sector separately for the domestic and foreign firms with the use of panel data during the period from 2001-02 to 2010-11. By using the stochastic frontier analysis of Cobb-Douglas type, the finding indicated the greater mean technical efficiency of the foreign firms in the entire manufacturing sector over their domestic counterparts. The analysis at the sectoral level revealed that the mean technical efficiency of four large industry groups namely, chemical industry, machinery industry, electronics industry, and transport industry was greater for the foreign firms as compared to the domestic firms. On the other hand, the mean technical efficiency of the domestic firms was marginally greater in the food & beverage, basic metal, and textile industry groups.

Keywords: **technical efficiency, foreign firms, domestic firms, FDI, stochastic frontier**

JEL Classification: D22, D61, F21, L25, N65

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In the literature of productivity, be it partial or total factor productivity, the performance of a firm and industry have been estimated with the unstated assumption that all firms are efficient. In other words, the basic economic models indicate that the level of output by an economic entity depends only on the inputs used. On the contrary, the alternative approach that came up in few studies was based on the belief that not all producers are technically efficient, and involved the assessment of a frontier function to measure the efficiency of production. This estimation of frontier function uses two alternative methods, namely, data evolvement analysis (DEA) and the stochastic frontier analysis. While DEA uses a linear programming approach, the stochastic frontier involves the use of econometric methods to measure technical efficiency (TE). This stochastic frontier analysis hypothesizes the existence of technical inefficiencies of production in firms involved in producing a particular output.

Estimation of technical inefficiencies by the use of frontier production function has been given serious consideration ever since the path-breaking work of Farrel (1957). Later, Aigner, Lovell, and Schmidt (1977) formulated models on theoretical stochastic frontier production functions to measure the technical inefficiency effects with the use of appropriate explanatory variables. This provided a major contribution to the estimation of technical efficiency of firms. Fare and Lovell (1978) showed that Farell's concept lead to two distinct measures, which are equivalent if and only if the production function exhibits constant returns to scale: output technical inefficiency, which reflects the failure to produce optimal output given the quantity of inputs, and input technical inefficiency, which corresponds to higher input utilization given the output and input mix. In recent years, a great deal of attention has been given by several studies to find the efficiency of the manufacturing firms. Increasing availability of micro data has facilitated growing popularity for the measurement of efficiencies/inefficiencies. These measurements of efficiency and inefficiency have involved the estimation of frontier functions with the use

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of both cross-sectional and panel data. These studies considered various estimators for the parameters and made a number of distributional assumptions for the random variables. In the present context, this study attempts to ascertain the efficiency of the domestic and foreign firms to make an assessment of superiority of one over another in different industry groups.

Literature Survey

The concept of technical efficiency plays an important role in the application and use of appropriate econometric models. The term technical efficiency has been defined differently in different studies. Battese and Coelli (1992) defined "technical efficiency of a given firm (at a given time period) as the ratio of its mean production (conditional on its levels of factor inputs and firm effects) to the corresponding mean production if the firm utilized its levels of inputs most efficiently" (p. 154).

Performance is a relative term which is measured by comparing it with a benchmark. This paper analyzes the performance of manufacturing firms in terms of technical efficiency of the labour and capital input. A firm is believed to be efficient if it operates on the frontier of the production function. The level of inefficiency is measured by the gap between the realized output and the corresponding frontier output, conditional on a particular level of input. A formal definition of technical efficiency would be the ability and willingness of firms to produce the optimum level of output with a specified quantity of inputs, given the prevailing technology and environmental conditions.

A relevant question arises - which factors appear to be associated with efficiency of a firm ? The literature in this regard indicates several findings. To present a few, Carlsson's (1972) study on Swedish manufacturing concluded that several protections against competition affect the technical efficiency of a firm. Caves and Barton (1990) showed that a firm goes in for efficient technical choices to survive the intensive competition from its fellow competitors. Similarly, Hay and Liu (1997), based on the analysis of firms from 19 U.K. manufacturing groups, concluded that efficiency is strongly influenced by the competitive market environment. Lundvall and Battese (1998) attempted to find the link between firm size, firm age, and the technical efficiency of Kenyan manufacturing firms. The study included an unbalanced panel of 235 firms comprising of four sectors, that is, food, metal, textile, and wood. The use of stochastic production frontier approach revealed no significant link between firm age and efficiency. However, the study found evidence of an association between firm size and the technical efficiency in all sectors. Similarly, Goaied and Mouelhi (1999) tried to find the firm level efficiency of Tunisian textile industry from a pool of 630 firms during the period from 1983-1994. The findings revealed that there was technical regress during the period from 1983-1990. However, from 1991 onwards, the textile industry experienced technical progress with an annual increase of 1.5% starting 1993. They found workers' productivity differentials with different skills to be significant. The estimated firm level mean technical efficiency was observed to be 0.57 in the Tunisian textile industry.

Martin - Marcos and Suarez-Galvez (2000) used the stochastic frontier approach to study the technical efficiency in 15 Spanish manufacturing sectors. A total number of 855 firms were considered for the study during the period from 1990 -1994. The study broadly looked at the overall firm level efficiency and concluded that Spanish firms were, on an average, 60% efficient. Similarly, Ali (2001) measured the levels of technical efficiency in the Irish manufacturing sector during the period from 1991-99. His study included two manufacturing industries - namely the electrical and optical equipment industry - to find the evidence of an increase in efficiency over the years. The study concluded that the two sectors - namely electronic valves & other electronic components and radio & television receivers experienced an increase in technical efficiency. On the other hand, the other sectors - namely electric motors & generators and medical & surgical equipment showed a decline in efficiency during the same period. The study attributed the role of investment intensity as an important determinant of technical efficiencies of a firm.

In contrast to positive efficiency, a study by Badunenko and Stephan (2004) (on the German industry) revealed a low efficiency in their study during 1995-2001. The use of the fixed effect model to the panel dataset of major

large German manufacturing firms revealed an inverse association of technical efficiency with the concentration indices. In contrast, technical efficiency was directly related to new firm formation and human capital proxies. A further detailed analysis revealed that the variables such as the expenditure on R&D, capital use, and firm size had no impact on the firm's technical efficiency.

In the Indian context, Pattnayak and Chadha (2005) studied the technical efficiency of the Indian pharmaceutical industry in the light of policy changes in the international and domestic environment since 1995 for 76 firms. The findings revealed that for the industry as a whole, there is evidence of time-varying technical efficiency for the sample firms. In addition, they found increasing returns to scale for the sub-sample of patenting firms, indicating that firms that successfully undertook R&D activities got high returns in developing countries like India. Their results also supported that the setting up of the WTO and the deregulation of the pharmaceutical industry in India improved the efficiency of the industry.

Bhandari and Ray (2007) used the DEA approach along with Hayami's (1969) meta-frontier production function to analyze the technical efficiency of the Indian textile firms. The important issues addressed in their paper relate to; first, the individual firm level technical efficiency; second, the firm-level technological difference across regions; third, the technological gap between the regional and the global frontier. The regional level technical efficiency was the highest for Tamil Nadu amongst the six states under consideration. On the other hand, the average grand efficiency was noticed to be the highest in case of West Bengal. The study found a trend of rising regional efficiency, narrowing down the technological gap over time. The latest study by Sahu and Solarin (2014) estimated the efficiency of the foreign and the domestic firms of the entire manufacturing sector before calculating the spillover. The study observed the higher efficiency of the foreign firms over the domestic firms in the entire manufacturing sector.

The above studies give a broad idea of the use of stochastic production frontier approach and its application on manufacturing. Depending upon the availability of a database, some studies used cross sectional data ; whereas, some other studies used panel data approach to analyze the efficiency. The present study, in this regard, uses firm level balanced panel to estimate efficiency.

Database

There are several sources of data available for the analysis of firm level efficiency in the Indian context. These include Annual Survey of Industries (ASI) provided by the Central Statistical organization, Stock Exchange official directory supplied by Bombay Stock Exchange (BSE), and PROWESS database supplied by the Centre for Monitoring Indian Economy (CMIE), and so forth. The present study used the PROWESS database which contains the information on more than 14,000 manufacturing firms registered with BSE. These firms comprise of public, private, cooperative, joint stock, listed, or otherwise. The data were collected and compiled from the companies' annual reports. The authenticity of the data was cross checked with the available database of the stock exchange official directory. The study also used the ASI database to compute the labour input as the PROWESS database reported the labour variable for a very limited number of companies.

↳ **Classification of Manufacturing Firms :** The classification of foreign and domestic firms is based on the promoter's equity holdings as reported in the PROWESS database. The study considered 10% promoter holdings for identifying FDI enterprises based on the IMF's Balance of Payments Guidelines, 1993. It was noticed in the database that several firms had not reported the data for all the periods considered for the study. Some firms had even re-entered the database after a gap of few years. Hence, these firms are excluded from the sample. To make the selection of firms simple, the study considers those manufacturing firms which had reported the data for the entire study period of 2001-02 to 2010-11. In this process, a total number of 1090 final sample firms were selected, which reported the foreign and domestic equity during the study period.

It is apparent from the Table 1 that the transport products industry group has the highest share of foreign firms followed by the machinery and equipment products industries. However, in absolute terms, the highest number of

Table 1. Manufacturing Firms in the Principal Industrial Category

Industry Groups	Domestic Firms	Foreign Firms	Total Firms	Foreign as % of total firms	Domestic firms as % of total firms
All Manufacturing	912	178	1090	16.3	83.7
Food and Beverages	114	12	126	9.5	90.5
Tobacco Products	6	2	8	25.0	75.0
Textile Products	121	8	129	6.2	93.8
Paper Products	34	6	40	15.0	85.0
Chemical Products	249	50	299	16.7	83.3
Basic Metal	96	12	108	11.1	88.9
Machinery and Equipments	74	28	102	27.5	72.5
Electronics Products	71	21	92	22.8	77.2
Transport	61	28	89	31.5	68.5

foreign firms are observed in chemical & chemical products industries. Similarly, the textile products industry group has the lowest share of foreign firms preceded by the food and beverages industry.

Measurement of Variables

Measurement of Capital : The real net capital stock at constant prices was estimated by using the perpetual inventory method (PIM) as indicated by Basant and Fikkert (1996). The use of PIM method assumes that the full depreciation of machinery takes about 16 years, with an annual average depreciation of 6%. In order to convert the net physical stock at the constant 2001-02 prices, I first calculated the average age of the firm as follows :

$$\text{Average Age } (AA) = \frac{\text{Accumulated Depreciation of firm in 2001}}{\text{(Gross Capital Stock of firm in 2000)/16}} \quad \ldots (1)$$

After computing the value of AA for each firm for the year 2001, the real capital stock was calculated by using a deflationary measure. The method for the same is as follows :

Suppose, we find AA for a particular firm is 8, now going 8 years backwards from the base year 2001 (i.e. 1994), we calculate the price index of machinery and the tools for the year 1994. Suppose, the value of WPI for machinery during 1994 is 0.72. Now :

$$\text{The real capital stock in 2001} = \frac{GCS}{0.72}$$

where,

GCS = gross capital stock

The net capital stock *(NCS)* in 2001 is :

$$NCS_{2001} = (GCS/0.72)\,(1-0.06)^{8} \quad \ldots (2)$$

Similarly, the net capital stock in the subsequent years is calculated as follows :

$$\text{The } NCS \text{ in 2001 } (NCS_{2002}) = NCS_{2001}\,(1 - 0.06) + \frac{(GCS_{2002} - GCS_{2001})}{WPI_{2002}} \quad \ldots. (3)$$

WPI_{2001} stands for the price index of machinery and the tools during the year 2001.

$$\text{The } NCS \text{ in 2002 } (NCS_{2002}) = NCS_{2002}\,(1 - 0.06) + \frac{(GCS_{03} - GCS_{2002})}{WPI_{03}} \quad \ldots. (4)$$

The net capital stocks for the rest of the years are calculated by using the preceding equation, giving a series of capital stock expressed in constant 2001-02 prices.

↳ **Measurement of Labour :** The number of employees or the number of mandays worked is widely used as a measure of labour inputs in the literature of productivity and efficiency. The limitation of the use of number of employees [1] allowed me to use the number of mandays work, which includes all types of workers namely, permanent, temporary, and the contractual.

The number of mandays work was derived with the use of PROWESS and ASI database as follows :

$$\text{Number of Mandays Work} = \frac{\text{Salary and wages of the firm}}{\text{Avg. labour compensation of that industry for that year}}$$

Salaries and wages data is taken from the PROWESS database and the average compensation of the industry is derived as follows :

$$= \frac{\text{Each industry's total emoluments to employees}}{\text{Total no. of mandays of that industry in the same year}}$$

Both the above components, that is, the total emoluments and total mandays of each industry group were taken from the ASI database to compute the average compensation of labour.

Methodological Framework

The study used stochastic production function approach with firm level panel data of Indian manufacturing. The measurement of technical efficiency is based on the time varying method of Battese and Coelli (1988). Based on Battese and Coelli, the general specification of frontier function is considered as follows :

$$\ln Y_{it} = X_{it}\beta_i + V_{it} - U_{it}$$

or

$$Y_{it} = \exp(X_{it}\beta_i + V_{it} - U_{it}) \quad \ldots (5)$$

Y_{it} corresponds to the output for the i^{th} firm in the t^{th} time period and X_{it} is a $(1 \times K)$ vector of inputs.
$\beta = (\beta_0, \beta_1 \ldots . \beta_k)$ is a $(K \times 1)$ vector of parameters to be estimated,
V_{it} is the error and other random factors, that is, weather, strikes, luck, and so forth, on the value of output. V_{it} assumes to be independently and identically distributed (*iid*) random error having zero mean and variance constant $(0, \sigma_v^2)$.

U_{it} are non-negative unobservable random variables with *iid* distribution and are associated with the technical inefficiency of production. This shows that for a given level of technology and inputs, the realized output falls

[1] This is because it does not take into consideration the variations in age, sex, skills, educational level, and so forth.

short of its potential output.
V_{it} and U_{it} are independent of each other and of the explanatory variables.

The above model represented in equation (5) is the stochastic production function. This is because the values of output are bounded by the stochastic (random) variables, exp ($X_{it}\beta + V_{it}$). The random error 'V_{it}' can be positive or negative so that the stochastic frontier outputs vary about the deterministic part of the frontier model, exp ($X_{it}\beta$). The ratio of the realized output relative to the potential output, defined by the frontier function is used to find the technical efficiency of the i^{th} firm in the t^{th} time period.

$$Te_{it} = \frac{Y_{it}}{\exp(X_{it}\beta)} = \frac{\exp(X_{it}\beta - U_{it})}{\exp(X_{it}\beta)}$$

$$TE_{it} = \exp(-U_{it})$$

The present study uses a frontier function approach with a simple version of Cobb-Douglas production frontier which estimates the maximum possible output that is obtainable from a given combination of labour and capital. The logarithm form of the Cobb-Douglas type stochastic frontier function is represented as follows:

$$\text{Ln}(Y_{it}) = \beta_0 + \beta_1 \text{Ln}(L_{it}) + \beta_2 \text{Ln}(K_{it}) + V_{it} - U_{it} \quad \ldots (6)$$
$$\text{Or } Y_{it} = \text{Exp}[\beta_0 + \beta_1 \text{Ln}(L_{it}) + \beta_2 \text{Ln}(K_{it}) + V_{it} - U_{it}]$$

where,
Ln signifies the natural logarithm,
Y shows the level of output,
L represents the mandays labour,
K represents the capital expenditure,
$V_{it} - U_{it}$ represents the random variable (explained above).

The technical efficiency of the i^{th} farm in the t^{th} year of observation can be calculated as the ratio of the observed output for the i^{th} firm in t^{th} time period, relative to the potential output, defined by the frontier function.
With the above input vector, the technical efficiency of the i^{th} firm is :

$$TE_{it} = \frac{Y_{it}}{\exp[\beta_0 + \beta_1 \text{Ln}(L_{it}) + \beta_2 \text{Ln}(K_{it}) + V_{it}]}$$

$$TE_{it} = \frac{\exp[\beta_0 + \beta_1 \text{Ln}(L_{it}) + \beta_2 \text{Ln}(K_{it}) + V_{it} - U_{it}]}{\exp[\beta_0 + \beta_1 \text{Ln}(L_{it}) + \beta_2 \text{Ln}(K_{it}) + V_{it}]}$$

$$TE_{it} = \exp(-U_{it}) \quad \ldots (7)$$

Following the model U_{it} in a time varying model can be defined as proposed by Battese and Coelli (1992) :

$$U_{it} = \{\exp[-\gamma(t - T)]\} Ui \quad \ldots (8)$$

where,
γ is an unknown parameter to be estimated,
U_i, $i = 1, 2 \ldots N$, are non- negative random variables assumed to be $iid(0\ \sigma^2)$,
T = Last time period of the panel,
$\gamma = \sigma^2 / \sigma^2_s$
$\sigma^2_s = (\sigma^2 + \sigma^2_v)^2$

where,
σ^2 and σ^2_v are the two variance parameters of U_{it} and V_{it}.

Change in U_{it} with an increase in *'t'* depends upon the value of γ (i.e. $\gamma > 0$, $\gamma = 0$, or $\gamma < 0$). This is an output oriented time varying measure of technical efficiency of a firm which takes the value zero and one, and is inversely related to the level of the technical inefficiency effect. The parameters of the stochastic frontier production function defined by the equation (6) are estimated using the computer programme which calculates the maximum likelihood (ML) estimator that is based on its conditional expectation (Battese & Coelli, 1992).

Once the parameters of the model are estimated, the calculation of technical efficiency of individual firms is based on Battese and Coelli (1988). Accordingly, the best predictor for $-U_{it}$ is the conditional expectation of U_{it}, given the value of V_{it}-U_{it} [2] . This is obtained as :

$$E[\exp(-U_{it}) \mid e_{it}] = \frac{1-\varphi(\sigma_A + \gamma e_{it}/\sigma_A)}{1-\varphi(\gamma e_{it}/\delta_A)} \exp(\gamma e_{it} + \sigma^2_A/2) \quad \ldots.(9)$$

where,

$$\sigma_A = \sqrt{\gamma\ (1-\gamma)\sigma^2_S}$$

$$e_{it}(V_{it} - U_{it}) = \text{Ln}(Y_{it}) - [\beta_1 \text{Ln}(L_{it}) + \beta_2 \text{Ln}(K_{it})] \text{ (obtained from eqn 6)}$$

and $\varphi(\ldots)$ is the density function of the standard normal random variable.

The individual firm level technical efficiency was obtained by the use of a computer programme, where it replaced the unknown parameters in equation 9 with their *ML* estimators.

The mean technical efficiency of an industry or for the foreign and domestic firms was estimated by the arithmetic average of the predictors for the individual technical efficiencies of the sample firms. Since the sample firms are of different sizes [3], the mean technical efficiency might not represent the true mean efficiency of the industry or the sub groups. Looking at the shortcomings, I have represented the results of minimum/ maximum efficiency and the percentile figure along with the mean.

Empirical Analysis and Results

The firm-level technical efficiency of the entire manufacturing sector and for each major sector is estimated separately on the basis of the model indicated above for the domestic and foreign firms. The estimation procedure takes a balanced panel dataset during the period from 2001-02 to 2010-11. The present study first estimated the technical efficiency for the entire manufacturing sector and its subgroups (i.e. foreign and domestic firms) before making a detailed analysis of efficiency at the industry level. It employs the time variant method for the above-said period to estimate the efficiency of 1089 firms, which includes 911 domestic and 178 foreign firms. The results are depicted in the Table 2.

The results indicate that the foreign firms, which account for about 16.4% of the total manufacturing sector, show significantly higher level of mean efficiency over the domestic firms. The mean efficiency of all firms in the entire manufacturing sector in time variant method is about 32% ; whereas, the segregation shows 37% mean efficiency for the foreign firms as against 31% for the domestic firms. The range of efficiency for the domestic firms lies between 8% and 99% as compared to 14% to 88% for the foreign firms. This shows a wide gap in efficiency amongst the domestic firms over their foreign counterparts. On the other hand, the efficiency amongst

[2] This result was first recognized and applied in the stochastic frontier model by Jondrow, Lovell, Materov, and Schmidt (1982).

[3] In the study, the size of the firm is considered on the basis of the net sale of the industry group. In other words, the highest net sale of the firm in the industry group is the largest firm.

Table 2. Time Variant Technical Efficiency: All Manufacturing

Industry	Firm	No. of Observations	mean Efficiency	Minimum Efficiency	Maximum Efficiency	10th %ile	50th %ile	95th %ile
Entire Manufacturing	Domestic	8199	0.314	0.080	0.986	0.142	0.269	0.584
	Foreign	1602	0.372	0.142	0.882	0.181	0.320	0.699
	Total	9801	0.321	0.080	0.986	0.152	0.281	0.609

Source: Estimated using the equation (9)

Figure 1. Annual Mean Technical Efficiency of All firms: Time Variant

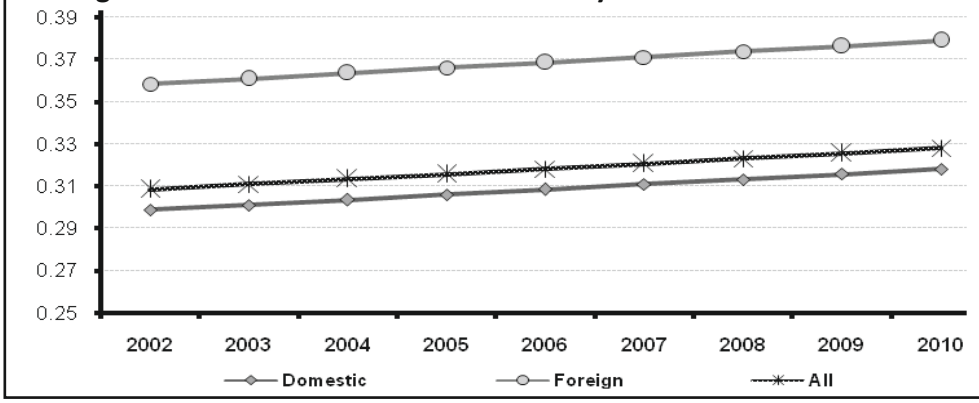

Table 3. Technical Efficiency of Foreign and Domestic Firms in Major Industry Groups

Industry Groups	Firms	No. of Observations	Mean Efficiency	Minimum Efficiency	Maximum Efficiency	10th%ile	50th%ile	95th%ile
Food and Beverages	Domestic Firms	1026	0.445	0.129	0.09	0.274	0.401	0.834
	Foreign Firms	108	0.423	0.197	0.829	0.211	0.417	0.827
	Total Firms	1134	0.442	0.129	0.900	0.262	0.401	0.828
Textile Products	Domestic Firms	1089	0.191	0.121	0.455	0.151	0.181	0.272
	Foreign Firms	72	0.190	0.150	0.437	0.150	0.183	0.247
	Total Firms	1161	0.191	0.121	0.455	0.151	0.181	0.270
Chemical Products	Domestic Firms	2241	0.292	0.086	0.947	0.185	0.317	0.613
	Foreign Firms	450	0.331	0.096	0.783	0.194	0.374	0.671
	Total Firms	2691	0.306	0.096	0.947	0.188	0.318	0.622
Basic Metal	Domestic Firms	864	0.309	0.069	0.819	0.142	0.279	0.601
	Foreign Firms	108	0.295	0.091	0.607	0.178	0.261	0.607
	Total Firms	972	0.306	0.066	0.819	0.143	0.278	0.592
Machinery and	Domestic Firms	666	0.229	0.149	0.597	0.170	0.221	0.484
Equipments	Foreign Firms	252	0.233	0.145	0.347	0.163	0.226	0.341
	Total Firms	918	0.230	0.145	0.597	0.166	0.203	0.343
Electronics Products	Domestic Firms	639	0.460	0.116	0.744	0.13	0.357	0.425
	Foreign Firms	189	0.462	0.121	0.822	0.132	0.361	0.447
	Total Firms	828	0.461	0.116	0.822	0.131	0.358	0.434
Transport	Domestic Firms	549	0.581	0.106	0.894	0.351	0.58	0.859
	Foreign Firms	252	0.646	0.294	0.948	0.372	0.631	0.878
	Total Firms	801	0.597	0.106	0.948	0.363	0.598	0.866

Source: Estimated using the equation (9)

the foreign firms is comparatively close to each other. The maximum efficiency of the foreign firms is found to be low as compared to the domestic firms. It is observed that 95% of the entire firms' mean efficiency is estimated below 61%, this compares to 70% and 58% for the foreign and domestic firms, respectively. The median value of efficiency for all firms is approximately 28% for the entire manufacturing sector as compared to an estimated 32% for the foreign and 27% for the domestic manufacturing firms. The annual mean efficiency of the domestic and the foreign firms is depicted in the Figure 1.

It is observed from the findings that the average annual mean efficiency of the foreign firms as a whole is more than it is for the domestic firms. The higher efficiency of this set of firms may be explained from the following characteristics of the domestic and foreign firms.

First, the rate of growth of capital use for all sample 1089 firms during the period from 2001-02 to 2010-11 is measured to be 8.9% ; whereas, the same for the foreign and domestic firms is at 6.6% and 9.2%, respectively. However, the growth of capital per unit of mandays labour is much higher for the foreign firms as compared to the same for the domestic firms. Similarly, the rate of increase in labour for domestic firms stands higher at 4.3% against 4.1% for all firms and 3.4% for foreign firms. Second, the detailed analysis of data shows that the share of GVA of the foreign firms to the total increased marginally from 17% to 17.9% during the same period. Third, the relative firm size of the foreign firms is larger as compared to that of the domestic firms. This is estimated at 4% (of the largest firm) for the foreign firms as compared to 3% for the domestic firms. The larger is the firm size, the higher is the chance of accommodating modern technology and better economies of scale, which implies better chance of efficiency gain. These inter-firm differences in technical efficiency due to the differences based on firm size, capital utilization, MNE affiliation, and so forth are well supported by several existing studies (viz. Bhandari & Ray, 2007 ; Sahu & Krishnan, 2014).

These characteristics of the domestic and foreign firms reveal that even though the rate of increase in labour and capital utilization by the domestic firms is marginally higher than it is in case of foreign firms, but the efficiency of the foreign firms is estimated to be greater. This may be due to the larger firm size and higher utilization of per-capita capital of the foreign firms over their domestic counterparts.

Industry Wise Analysis of Efficiency

Technical efficiency of the foreign and domestic firms in the major industry groups is analyzed on the basis of the model shown in the methodology section. The estimated technical efficiency through the time variant method during the period from 2001-02 to 2009-10 is shown in the Table 3.

(1) Food and Beverage Industry : A total of 126 food and beverage firms were considered as sample to study the technical efficiency (TE) of the industry separately for the domestic and foreign firms. Data for this industry group reveals that during 2001-02, the average capital used per unit of mandays labour stood at ₹ 1069. Over the period, there was an increase in capital per unit of mandays labour and the same attained a figure of ₹ 1764 during 2009-10. This shows that the entire industry group has become more capital intensive over the years.

The estimated technical efficiency reveals that on an average, the domestic firms were 44.1% technically efficient, marginally higher than the estimated 42.3% in case of the foreign firms. The range of efficiency for domestic firms varies from nearly 13% to 90% in comparison to nearly 20% to 83% , respectively for the foreign firms. This shows that the minimum levels of efficiency achieved by foreign firms was nearly 1.5 times that of domestic firms. However, the mean efficiency of the total firms is slightly above 44%, where the domestic firms' mean efficiency is estimated to be nearly 3% points higher over the foreign firms. The median value of the technical efficiency score for the total foreign firms is 0.40. Similarly, in case of 95% of total firms, the technical efficiency score is 0.83 or less.

(2) Textile Industry : The textile industry is represented by 121 domestic and eight foreign firms. In this industry group, the R & D expenditure for all firms increased at an annual average rate of 5.7% as compared to the annual average growth of 6.2% in sales. The estimated findings reveal that the mean efficiency of the domestic firms is

marginally higher as compared to that of the foreign firms. This industry group shows a higher minimum level of efficiency achieved by the foreign firms as compared to the domestic firms ; whereas, the maximum level of efficiency achieved by domestic firms is little more than three times of the foreign firms. The median values of the technical efficiency score for domestic firms and foreign firms are a low 18.1% and 18.3%, respectively. Similarly, 95% of the domestic firms have a technical efficiency score of 0.27 or less.

(3) Chemical Industry : A total of 299 firms of the chemical products industry comprising of 249 domestic and 50 foreign firms were considered as sample to study the technical efficiency (TE) of the industry separately for the domestic and foreign firms. Analysis of the firm level data shows that the average capital used per unit of labour declined marginally (at an annual average rate of 0.67%) during the period from 2001-02 to 2010-11. In other words, the chemical industry has become more labour intensive over the years. However, at a disaggregated level, it is observed that the foreign firms' average capital used per unit of labour increased ; whereas, the same for the domestic firms declined over the years. This shows that as compared to the domestic firms, the foreign firms are more capital intensive. On the contrary, the analysis reveals that the R&D expenditure and the sales of the domestic industry grew much faster, estimated at 30.4% and 11.5% as compared to the low growth of 17.5% and 6.7%, respectively for the foreign firms.

In the estimation process, it is observed that the range of efficiency for the domestic firms varies from nearly 8.6% to 94.7%. In contrast to this, the efficiency of foreign firms ranged from 9.6% to 78.3%. In other words, the minimum level of efficiency achieved by foreign firms is greater than what is achieved by domestic firms, but the maximum level of efficiency for the domestic firms was greater than it was for the foreign firms. Similarly, the mean efficiency of the total firms is reported close to 31% ; whereas, the foreign firms' mean efficiency is estimated to be nearly 5% points greater than it is for the domestic firms. From the percentile figure, it can be said that 50% of total firms have a technical efficiency score of 0.32 or less, and the same for the domestic and foreign firms is estimated to be 0.32 and 0.37, respectively.

(4) Basic Metal Industry : The database of a total of 108 firms (96 domestic firms and 12 foreign firms) was used to find the technical efficiency of the basic metal industry. This industry group shows an increased use of capital, which is estimated at an average growth of 4.5% over the years, making the industry more capital intensive. The average firm size (compared to the largest firm in the industry) of this industry was estimated to be 0.024, which increased to 0.038 during the study period. This industry group reported a wide gap between the size of the largest firm (a domestic firm) and other firms. During the study period, the expenditure on R&D increased at an annual average growth rate of nearly 10%.

The time variant technical efficiency reveals the following results - the range of efficiency for domestic firms varies from nearly 7% to 82% against 7% to 57% in case of the foreign firms. This shows that the maximum level of efficiency of the domestic firms is higher than that of the foreign firms. Similarly, the mean efficiency of the total firms is close to 31%, and the domestic firms' mean efficiency is estimated to be more than 2% points higher over the foreign firms. The median value of the technical efficiency score for the total foreign firms is 0.28. Similarly, 95% of total firms have a technical efficiency score of 0.59 or less.

It is clear from the findings that the mean efficiency of the domestic firms is greater than that of the foreign firms. The high efficiency of domestic firms may be due to the following reasons - first, nine out of the top 10 firms in the industry belong to domestic ownership. Second, it is interesting to observe that the domestic firms are more capital intensive than the foreign firms. In other words, during the study period, the rate of capital per unit of labour increased at the rate of 4.7% for the domestic firms ; whereas, it declined by -3.8% for the foreign firms. Third, the R&D expenditure by the domestic firms is seen to be higher than it is in case of the foreign firms (during the study period).

(5) Machinery and Equipment Industry : The study considers a total of 102 machinery and equipment manufacturing firms, of which 27.5% firms are foreign. The dataset pertaining to this industry group reveals that

the average annual growth of capital utilization during the study period increased by 2.8%. However, the growth of labour and the capital labour ratio increased by 0.8% and 2.6%, respectively. It is seen that the rate of increase in labour for the foreign firms was higher than it was for the domestic firms.

The analysis in time variant method reveals that the maximum efficiency of the domestic firms is greater by almost two times as compared to the foreign firms. It also shows that the minimum efficiency of the foreign firms is lesser as compared to the domestic firms. Despite the higher range of efficiency of the domestic firms, the mean technical efficiency of the foreign firms is estimated to be marginally greater over the domestic firms. The percentile figure reveals that 95% of total firms have a technical efficiency score of 0.34 or less ; whereas, the estimates are 0.48 and 0.34 for the domestic and foreign firms, respectively.

(6) Electronics Industry : A total number of 92 firms (71 domestic and 21 foreign firms) were considered to study the efficiency of the electronics industry. The foreign firms reported marginally greater mean technical efficiency of 46.2% as compared to 46% for the domestic firms. The median value of the technical efficiency score for the foreign firms is found to be greater than it is for the domestic firms. Both the minimum and maximum efficiency of the domestic firms is lesser as compared to the foreign firms. An estimated 95% of foreign firm's technical efficiency lies below 45% as compared to 42% in case of the domestic firms.

The marginally high efficiency of the foreign firms may be due to the following reasons. First, the average firm size of the foreign firms increased by 1% point from 12% to 13% during the period from 2001-02 to 2010-11 ; whereas, the same for the domestic firms declined to 4% from 6% during the same period. The firm size increases the economies of scale and division of labour and hence, the efficiency. Similarly, during the study period, there was an increase in the total mandays of labour in the foreign firms ; whereas, the same in the domestic industry recorded a decline. The volume of sales for the domestic firms increased by 8.2% as compared to 15.3% in case of the foreign firms.

(7) Transport Industry : The data for this industry group comprises of 89 manufacturing firms (61 domestic and 28 foreign firms). Our estimated results reveal that the range of efficiency for domestic firms varies from nearly 11% to 89% as against 29% to 95% in case of the foreign firms. This shows that the maximum and minimum level of efficiency achieved by foreign firms is greater than what was achieved by the domestic firms. Similarly, the mean efficiency of the total firms is close to 60%, and the foreign firms' mean efficiency is estimated to be nearly 6% points greater than it is for the domestic firms. The median value of the technical efficiency score for the total firms is 0.60 as compared to 0.63 for the foreign and 0.58 for the domestic firms. Similarly, 95% of the foreign firms have a technical efficiency score of 0.88 or less, and this estimates a score of 0.86 or less for the domestic firms.

It is seen from the dataset that even though the rate of increase in capital and labour during the study period was high for the domestic firms, but the foreign firms' technical efficiency in this industry group is greater as compared to that of the domestic firms. This may be due to the bigger firm-size of the foreign firms. The large firm size could have increased the efficiency of the industry through division of labour and the economies of scale.

Conclusion

Foreign-owned firms exhibit superior efficiency results when compared to domestic ownership is supported by many recent findings. This finding is in line with the general key findings of Estrin, Hanousek, Kočenda, and Svejnar (2009) and Hanousek, Kocenda, and Mašika (2012), whosupported the beneficial effects of FDI at the firm level. Furthermore, the findings also reveal that simple majority of foreign shareholding does not necessarily imply the efficiency of the foreign firms over their domestic counterparts. This is evident in case of the food & beverage industry and the basic metal industry group, where the efficiency of the domestic firms is marginally higher than that of its foreign counterparts in the same industry. Similarly, in case of the textile industry group, the mean technical efficiency of domestic firms and foreign firms are estimated to be almost equal to each other. On

the other hand, it is observed that in the entire manufacturing sector and four large industry groups, the mean technical efficiency is greater for foreign firms as compared to the domestic firms. Overall, a better mean technical efficiency of foreign firms is observed in the larger industry groups - chemical industry, machinery industry, electronics industry, and transport industry. An insight within the major sectors reveals that the mean efficiency of the entire transport industry group is the highest followed by electronics and food & beverage industry groups. However, surprisingly, the machinery products industry reported the lowest mean efficiency over the period. It is evident from the findings that despite the fact that the foreign firms are technically efficient in many industry groups, the domestic firms are not lagging too behind the foreign firms. In some cases, the efficiency level of domestic firms is much higher than it is for the foreign firms, though the range of efficiency between the domestic firms is higher.

Policy Implications

FDI plays a significant role in the development and growth of a host country, particularly the manufacturing sector, in strengthening the export competitiveness, building up the human capital, increasing the domestic wage rate, and positive spillover (Basu, Chakraborty, & Reagle, 2003 ; Nunnenkamp & Stracke, 2007 ; Patra & Sahu, 2012 ; Sahu & Solarin, 2013). Looking at its success and increased expectation, the government has simplified the earlier multi-channels FDI approval system to a simplified automatic approval system. This increased the inflow to a greater extent through the automatic channel. The removal of the sectoral cap in equity participation has allowed 100% FDI in most of the manufacturing industries, except some strategic sectors. Despite such steps, the overall FDI inflow to India, particularly in the manufacturing sector, is low as compared to some emerging economies. It is in the interest of the country that the government should provide a healthier investment climate, better infrastructural facilities, lessen the regional disparity, improve the institutional setup, and moreover, provide a clear interpretation on various rules and regulations to increase the FDI inflow into the country, and into the manufacturing sector, in particular.

The concentration of FDI in the manufacturing of a few relatively advanced regions may have prevented FDI effects from spreading across the Indian economy and sectors. As foreign investors in India strongly prefer locations that are relatively advanced in terms of per capita income and infrastructure, it is a challenge in the hands of the government to increase the infrastructure and other economic parameters to attract more FDI across different sectors and states.

There is much evidence that has demonstrated that political intervention impacts firms, as it affects their business decisions. In this context, Nee and Opper (2012) conducted a survey by considering 72 firms listed on the Shanghai Stock Exchange. They found that the involvement of government bureaucrats and party authorities in all the decisions of the firms was negatively associated with firms' returns on assets and equity. With this evidence, it is important to note that the Indian government should undertake precautionary measures and enforce policies to safeguard the interests of the firms as well as their people with least involvement to the maximum possible extent.

Foreign investors do respond to the exchange rate of the host country. As devaluation reduces the price of the asset abroad, a fall in the domestic currency attracts more inward FDI. However, volatility of the exchange rate and expected devaluation signals economic and political uncertainty, which, in turn, discourages the flow of inward FDI. The recent fall in the Indian currency would help the manufacturing sector to attract more FDI, provided the government and the Reserve Bank implement the necessary policy action to control the volatility in the exchange rate.

Improvement in the efficiency of the firms is not automatic ; rather, it depends upon several factors - investment in new technology, knowledge, and R&D activities. Hence, a firm's absorptive capability, conducive circumstances, and motivation to learn are essential. It is in the interest of our country that our government provides a sound and encouraging economic environment and public policies to the domestic firms to get more and more benefit from foreign investments.

From the empirical results, it is seen that the food & beverage and basic metal industries have shown a better mean technical efficiency in case of the domestic firms over the foreign firms. Whereas, in the other sectors, the efficiency of the foreign firms was estimated to be higher. Hence, selective encouragement must be extended to the domestic firms in the sectors where the foreign firms' efficiency is estimated to be higher.

Limitations of the Study and Scope for Further Research

The most dominant characteristics of Indian manufacturing is the presence of small, unorganized sectors. The manufacturing belonging to these sectors is not covered in the present study due to their non-listing on the BSE. Similarly, the present empirical findings may not represent the true results for all India manufacturing, as I omitted many firms due to the unavailability and the lack of time-series data. Choice of the methodology for measuring the efficiency is undertaken differently in different studies, each one with its own strengths and weaknesses. The present paper uses the maximum likelihood (ML) estimates of stochastic frontier production functions developed by Battese and Coelli (1992) for panel data over the non-parametric data evolvement analysis (DEA). The stochastic production approach has limitations as it requires an explicit imposition of a particular parametric functional form representing the underlying technology and also an explicit distributional assumption for the inefficiency terms. However, I chose to use the stochastic frontier approach as it considers stochastic noise in data and also allows for the statistical testing of hypotheses concerning production structure and degree of inefficiency. Given the limitations of the data and methodology, the study took utmost care in minimizing the errors that may have occurred while choosing the final sets of samples and the methodology for the present exercise. Although there is much that remains to be done, the present study generates important findings of efficiency on the basis of the ownership pattern. Measurement of firm level efficiency has received considerable attention from theoretical and applied economics in recent years. The present paper estimates the technical efficiency of foreign and domestic firms by using the stochastic frontier analysis of Cobb-Douglas type.

There are not many studies that have examined the efficiency of the foreign and domestic firms with reference to the Indian manufacturing sector. Given the above, there lies ample scope for future researchers to estimate the efficiency of the foreign and domestic firms, and they may apply the random co-efficient model for the purpose as the use of conventional stochastic frontier models is not quite sensible under some circumstances. There is a need for more in-depth sub-sector analysis with wider coverage of firms and other methodological frameworks, that is, the constant elasticity of substitution production function and variable elasticity substitution production function.

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