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Total Factor Productivity and Energy Intensity in Indian Manufacturing: A Cross-Sectional Study[1]

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ABSTRACT: In recent climate change negotiations and debates, energy use pattern, efficiency and productivity cannot be overlooked and hence it is necessary to focus on these ascepts for Indian manufacturing industries. The objective of the paper is to estimate the transcendental logarithmic production function and analyse the relationship between energy intensity and total factor productivity (TFP). The estimation of TFP is based on four inputs model; labour, capital, material and energy. The findings suggest that labour and material inputs play major role as compared to the capital and energy input. Further, estimates suggest that age of the firm, export intensity and disembodied technology import are positively related to the TFP, where as ownership, energy intensity, embodied technology import and R&D intensity are negatively related to TFP of the Indian manufacturing industries. In addition, energy efficient firms also found to have high levels of TFP. This implies the need for fostering energy efficiency at firm level in Indian Manufacturing.

Keywords: *Production function, Total Factor Productivity, Energy Intensity, Indian Manufacturing Industries*
JEL classification: *D24, Q4, B3*

1. Introduction

In the early phases of industrialization, the productivity in the Indian manufacturing sector was limited by the Government policies, e.g., the reservation of production (a large amount of production items for small-scale sector), high custom tariff distorting resource allocation and prohibiting Indian industry's ability to compete in the international market, shutting down industries in response to normal competitive market forces and various types of distortion created by the structure of domestic trade taxes and excise duties. However, the situation has gradually changed since 1991 due to the liberalization policies. Over the years several measures were under taken by the Government of India for boosting up the industrial productivity. It has been more than two decades since India initiated the industrial liberalization. One of the important objectives of policy reforms was to improve the efficiency of industrial sectors, as productivity and efficiency growth are the key factors for the development of any industry. In this respect, this study focuses on estimating total factor productivity using transcendental logarithmic specification of production function, and further estimates the determinants of productivity for the Indian manufacturing industries using a cross-

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sectional data for the year 2008-09 collected from the Center for Monitoring Indian Economy (CMIE). The rest of the paper is organized as follows: Section-2 deals with the review of literature on productivity and substitution possibilities, Section-3 focuses on the model specification and econometric estimation, Section-4 deals with the empirical analysis of the estimation and Section-5 concludes the finding of the study.

2. Review of Literature

There are a wide range of studies focused on trends in total factor productivity growth in Indian industries. In addition, a large number of studies also focus on the substitution possibility between energy, capital and labour for any industry context. The debate is based on the issue whether energy-capital, energy-labour are substitutes or complementary to each other.

In the recent decades, several methodologies have been developed and applied to examine changes in productivity and technical change. A number of studies have estimated total factor productivity of Indian economy using statistical indices within the standard growth accounting framework such as Mongia and Sathaye (1998, 1998a) and Ahluwalia (1991). Ahluwalia (1991) attempts to analyses the long-term trends in total productivity and partial productivity in the organized manufacturing sector in India for 1959-60 to 1985-86. The study also explored the role of factor input growth and the growth in value added. The analysis conducted at a detailed level of disaggregation for 63 constituent industry groups at the three-digit level and also for the four "use-based" sectors of manufacturing, i.e., intermediate goods, consumer non-durables, consumer durables and capital goods. For almost all of the 63 industries, capital intensity showed a strong and significant positive growth for fewer industries accounting for 64 percent of the valued added in manufacturing. There were a few industries which even experienced a decline in labour productivity.

Study by Pradhan and Barik (1999) attempts to open a solution channel by considering TFPG as a result of interaction between economies of scale and technical change. Thus, it seeks to lay emphasis on proper management of scale economies and technical change for producing a desired TFPG. The study estimates TFPG using a translog cost function. The empirical findings of the exercise on data of aggregate manufacturing sector and eight selected industries of India indicate that both scale economies and technical change have registered a declining trend in recent years in the process of a declining TFPG.

Goldar (2000) found that the growth rate in employment in the organized manufacturing sector in India for 1990-91 to 1997-98 was 2.69 percent per annum which was well above the growth rate of 0.53 percent per annum achieved in the 1980s. He attributed two major reasons for this growth in employment: slowdown in growth of real wages in the 1990s and faster growth of small and medium-sized factories in organized manufacturing; which are more labour intensive as compared to large-sized factories. He also highlighted that the increase in employment in the organized manufacturing sector, which took place in the 1990s, was accounted for by private sector factories. Nagaraj (2004) pointed out that faster employment generation in organized manufacturing was restricted mainly to the first half of the 1990s. As the boom went bust, there was a steep fall in employment in the second half of the 1990s. Relative cost of labour did not seem to matter in employment decisions, as the wage-rental ratio declined secularly. According to him, about 1.1 million workers, or 15 percent of the workers in the organized manufacturing sector in the country, lost their jobs between 1995-96 and 2000-01.

Roy et *al*. (1999) report the analysis of productivity growth and input trends in six energy intensive sectors of the Indian economy, using growth accounting framework and econometric methods. The econometric technique estimates rates and factor price biases of technological change using a translog production model with an explicit relationship defined for technological change. Estimates of own-price responses indicate that raising energy prices would be an effective carbon abatement policy for India. At the same time, they found as with previous findings on the US economy, such policies in India could have negative long run effects on productivity in these sectors. Inter-input substitution possibilities are relatively weak, so that such policies might have negative short and medium term effects on sectoral growth. The study provides information relevant for the analysis of costs and benefits of carbon abatement policies applied to India and thus contribute to the emerging body of modeling and analysis of global climate policy.

Assuming a Translog specification of a four input (KLEM) production function, Mongia et *al*. (2001) use growth accounting framework to decompose the growth of output into growth of inputs and a residual; representing the productivity growth. A major finding of the paper is overall productivity growth in the industries was quite low during 1973-1994. However, there were significant deferences in productivity growth across industries during this time. These differences can to a large extent be explained by the nature and timing of policy changes in individual sectors. Using the growth accounting framework, they estimated the total productivity growth (TPG) for five energy intensive industries in India. The results show that total productivity growth in these industries during 1973-1994 was insignificant, although productivity growth varied across industries. It was significantly positive in the fertilizer industry, positive but low in aluminum and cement, and negative for iron & steel and paper industry. Productivity growth was not uniform over time either. The partial productivity growth of capital and energy appear to be significant determinants of total productivity growth. These in turn were crucially affected by capacity utilization. The analysis of results for two sub-periods, 1973-1981 and 1981-1994, shows that changes in technologies and production conditions triggered or induced by policy reforms helped increase productivity growth significantly in the cement and fertilizer industry. The effect of policy changes was less significant in the case of aluminum industries because of lumpiness of investment and because of the inherent nature of the technology. However, the removal of market constraints and the addition of a modern plant did raise the growth rate in the second sub-period significantly. Productivity growth was adversely affected in the case of iron and steel and paper industries, where due to lack of a clear long-term perspective, the positive effects of policy reforms were overwhelmed by institutional and market conditions, at least temporarily. According to the study, the policy reforms did not go far enough to significantly affect productivity growth in India's energy intensive manufacturing sectors.

Berndt et *al*. (1998) show that electricity is a weak substitute for both capital and labour in major Alabama industries and regulatory constraints are binding due to inelastic electricity demand. Mahmud (2000) finds very little substitution between energy and other inputs but weak substitution between electricity and gas in Pakistan manufacturing. Chang (1994) finds little difference between Translog and constant elasticity production functions in Taiwanese manufacturing and reports that energy and capital are substitutes. Yi (2000) finds substitution varies across Translog and Leontief production functions in Swedish manufacturing industries.

Ma et *al*. (2009) measures technological change, factor demand and inter-factor and inter-fuel substitutability measures for China. They use individual fuel price data and a two-stage approach to estimate total factor cost functions and fuel share equations. Both inter-factor and inter-fuel substitution elasticities are calculated and the change in energy intensity is decomposed into its driving forces. Their results suggest that energy is substitutable for capital regionally and for labour nationally. Capital substitutes for energy more easily than labour does. Energy intensity changes vary by region but the major drivers seem to be ‘‘budget effect’’ and the adoption of energy-intensive technologies, which might be embodied in high-level energy-using exports and sectors, capital investment and even old technique and equipment imports. They conclude that, after decomposing energy intensity, the budget effect and technological changes are the two major driving forces of the changes in energy intensity nationally. The variations in budget effect across regions are most likely related to the differences in regional economic growth and industrial structure. Further, they find that the technological changes or innovative activities can be embodied in capital investment, equipped labour, export goods and even sectoral shifts.

Based on the above discussion, we can observe that most of the research focuses on estimating productivity using different functional form and/or analyzing the substitution possibility between different inputs. This paper is an attempt to estimate the total factor productivity (TFP) of Indian manufacturing industries for 2008, with four inputs i.e. capital, labour, material and energy. In addition there is an attempt to find out factors that determine TFP other than the four inputs. Specifically, this study also tries to look at the relationship between the energy intensity and TFP.

3. Methodology and Econometric Specification

TFPG measures the amount of increase in total output which is not accounted for the increase in total inputs and thus measures shift in output due to the shift in the production over time, holding all inputs constant [Abramovitz (1956); Denison (1962, 1967, 1985); Hayami et *al*. (1979)]. This in turn implies an upward/downward shift in production/cost function, thereby leading to an increase in output. It has been widely acknowledged in the economic literature that industrial growth, no matters how impressive, will not be sustainable without improvement in productivity. TFPG can be measured by (i) Growth Accounting Approach; (ii) Econometric (Parametric) Approach (i.e. by estimating production function or cost function); (iii) Non-parametric Approach (i.e. through Data Envelopment Analysis (DEA)).

One of the approaches to compute the production function is using the Translog production function. This has both linear and quadratic terms with the ability of using more than two inputs. This function can be approximated by second order Taylor Series (Christensen et *al.* 1971). This study uses the Translog production function with four inputs (KLEM). Industrial energy demand for energy is essentially a derived demand as the firm's demand for energy is an input is derived from the demand for the firm's output (Berndt & Wood, 1975). Limited number of studies focuses on estimating production function for more than three inputs and taking energy as one of the important input for the production process of industries. This study is an attempt to estimate the production function using cross-section firm-level data for the Indian manufacturing industries. Further, there is an attempt to investigate the determinants of Total factor productivity using firm specific variables other than labour, capital and material.

The four-input Translog production function can be written in terms of logarithms as follows:

$$\begin{aligned} LnQ = {} & \alpha_0 + \beta_K \ln K + \beta_L \ln L + \beta_E \ln E + \beta_M \ln M + \tfrac{1}{2}\beta_{KK}(\ln K)^2 + \beta_{KL}\ln K \ln L \\ & + \beta_{KE}\ln K \ln E + \beta_{KM}\ln K \ln M + \tfrac{1}{2}\beta_{LL}(\ln L)^2 + \beta_{LE}\ln L \ln E + \beta_{LM}\ln L \ln M \\ & + \tfrac{1}{2}\beta_{EE}(\ln E)^2 + \beta_{EM}\ln E \ln M + \tfrac{1}{2}\beta_{MM}(\ln M)^2 \end{aligned} \tag{0.1}$$

Where, Q is the gross manufacturing output, *K* is stock of capital good, *L* is labour input, *M* is material input and *E* is energy input. α_0 is the intercept or the constant term. $\beta_{K,}$ $\beta_{L,}$ $\beta_{M,}$ and β_E are the first derivatives. $\beta_{KK,}$ $\beta_{LL,}$ $\beta_{MM,}$ and β_{EE} are the cross second derivatives. Net fixed capital has been taken as the measure of capital input, wages and salaries is taken as the labour input, cost of material is taken as the material input and cost of energy (from difference sources of energy consumed by the industries) is taken as the energy input in estimating equation (0.1).

We follow a two-step estimation procedure. The first step involves estimating Equation (0.1) using OLS. Once the OLS estimates are computed $\hat{Q}$ is generated from the regression output of (0.1). Where, $\hat{Q}$ measures the total factor productivity[2] of the industries. Then, the second step of the study involves estimating OLS using $\hat{Q}$ as the dependent variable with the firm specific variables for Indian manufacturing to find out the determinants of total factor productivity. The second equation takes the following functional form:

$$\begin{aligned} \hat{Q} = {} & \alpha + \beta_1 AGE + \beta_2 MNE + \beta_3 EI + \beta_4 ETI + \beta_5 RDI + \beta_6 EXPI + \beta_7 DETI + \beta_8 ID_1 \\ & + \beta_9 ID_2 + \beta_{10} ID_3 + \beta_{11} ID_4 + \beta_{12} ID_5 + \beta_{13} ID_6 + \beta_{14} ID_7 + \beta_{15} ID_8 + \beta_{16} ID_9 + \beta_{17} ID_{10} \\ & + \beta_{18} ID_{11} + \beta_{19} ID_{12} + \beta_{20} ID_{13} + \beta_{21} ID_{14} + \beta_{22} ID_{15} + \beta_{23} ID_{16} + \beta_{24} ID_{17} + \beta_{25} ID_{18} + u_i \end{aligned} \tag{0.2}$$

Where, AGE is age of the firm. Age of the firm is computed as the difference of year of data used to the incorporated year of the firm. Age is one of the major variables which may reflect the productivity of any firm. We assume older the age of the firm higher the productivity. MNE is the ownership of the firm. Ownership of any firm may affect of the performance of the firm, as foreign firms might have higher efficiency in production as compared to the domestic ones. This variable is

[2] "Technological progress or the growth of total factor productivity is estimated as a residual from the production function"[Statscan 13-568: 50-51, cross cited from Lipsey and Carlaw (2001)]

constructed as a dummy capturing 1 for the domestic firms and 0 for the foreign firms. Energy intensity (EI) is one of the important factors contributing the production process. Energy intensity of the firm is calculated as a ratio of cost of energy used (various sources of energy) to net sales of the firm.

Several previous studies have shown that importing firms are better performers or more productive than non-importing firms (Sachs and Warner, 1995). Generally higher importing firms receive technological transfers as well as better inputs because of access and exposure to foreign sources, which can potentially help the importing firms to enhance their productivity and export performance. Embodied technology intensity (ETI); disembodied technology intensity (DETI) and efficient use of energy (cost minimizing) can increase the productivity of any firm. We hypothesize that higher the productivity of firm, lesser the energy intensity. Embodied technology intensity is calculated as a ratio of expenditure on import of capital goods to net sales of the firm and disembodied technology intensity is calculated as the ratio of Royalty, and technical fees payments to net sales of the firm.

Export intensity (EXPI) of the firm is calculated as the ratio of export to net sales of the firm. The learning by exporting hypothesis, which claims that exporting to foreign market produces many positive learning effects by exposing the domestic firms to advanced technological innovations from international buyers and competitors and helps them to improve their productivity. This hypothesis for Indian industries is confirmed by Sharma & Mishra (2011) where they found a positive and significant impact of productivity on export. Hence the export intensity is assumed be a determinant of productivity. It is well established in the related literature that research and development (R&D) intensity is an important determinant of productivity and export performance of firms. In this concern the pioneering study of Griliches (1979) has shown in the R&D Capital Stock Model that this factor has a direct effect on the performance of firms. Empirical evidences reported by Lichtenberg and Siegal (1989) and Hall and Mairesse (1995) also provides strong support to Griliches's view. To capture the R&D activities of firms, the study considers the ratio of R&D expenditure to the firm's net sales. This variable is a measure of R&D intensity of firms and it is expected to have a positive impact on firms' productivity. Further to investigate the inter-industries difference of total factor productivity; we have defined 18 industries dummies ($ID_{1,}$ $ID_2 \ldots ID_{18}$) from 19 sub-industries. Data for the empirical investigation is collected from the CMIE PROWESS data base for 2008. The sample size is 2541 for 19 sub-industries in Indian manufacturing.

4. Empirical Results

This section of the study presents the empirical estimates of Indian manufacturing. Table 1 presents the descriptive statistics of select variables of the sample of firms. The sample size for the analysis is 2541 firms drawn from Indian manufacturing industries for the year 2008-09. Mean output is calculated to be ` 7700.49 Million with a higher standard deviation of 7133.29. The mean of capital, labour, energy and material inputs are calculated to be 401.90, 30.67, 26.04, and 372.33 respectively. This study is a two stage estimation of determinants of productivity for the Indian manufacturing. Therefore, as stated in Section-3, the firm specific variables are also included at the second stage estimation. The variables include age of the firm, energy intensity, embodied technology import intensity, disembodied technology import intensity, R&D intensity and export intensity of the firm. From table-1 we can observe that the mean age of the firms is 31 years. The mean energy intensity, embodied technology import intensity, R&D intensity, export intensity and disembodied technology import intensity are calculated to be 0.07, 0.004, 0.003, 0.151, and 0.081 respectively.

Table-2 gives the estimation result of the Translog production function. From the results we can see that the elasticity of capital is positively related to the output and statistically significant at 1%. This implies the higher the capital input of a firm higher is the output of the firm. The coefficient of the labour input carries a positive sign with the productivity and highly significant. This indicates that increase in labour input also increases the output of the firm. Energy input is considered as the third input in the TFP model. This variable carries a positive sign and significant at 1% level. Hence increase in energy consumption is increasing the output of firms. The fourth input of the model is the material used for production. This variable carries a positive relationship with the output of the firm. Detailed result of equation (0.1) is given in table-2.

Table 1. Descriptive statistics of selected variables

Variable	Mean	Std. Dev.	Min	Max
Output	770.49	7166.29	0.01	270582.40
Capital	401.90	2956.63	-12182.80	107932.30
Labour	30.67	202.16	0.00	8069.15
Energy	26.04	138.40	0.01	3399.91
Material	372.33	3227.14	0.00	101494.60
Age of the firm	31.42	44.39	1.00	118.00
Energy Intensity	0.074	0.23	0.00	8.00
Embodied Technology Import Intensity	0.004	0.09	0.00	4.53
R&D Intensity	0.003	0.02	0.00	1.19
Export Intensity	0.151	0.24	0.00	1.09
Disembodied Technology Import Intensity	0.081	0.16	0.00	4.66
Number of Observations	2541			

Source: Own estimates from CMIE, PROWESS data for 2008

Table 2. Estimation result of the Translog production function for Indian manufacturing

Variables	Coefficients	Standard Error	t Statistics
β_K	0.174	0.020	8.660***
β_L	0.220	0.026	8.470***
β_E	0.065	0.022	3.030***
β_M	0.515	0.020	25.540***
β_{KK}	0.000	0.000	3.370***
β_{KL}	0.040	0.007	5.570***
β_{KE}	-0.049	0.007	-7.010***
β_{KM}	0.009	0.006	1.450
β_{LL}	0.000	0.000	-0.590
β_{LE}	0.000	0.006	-0.070
β_{LM}	-0.046	0.007	-6.520***
β_{EE}	0.000	0.000	-0.560
β_{EM}	0.049	0.005	10.410***
β_{MM}	0.000	0.000	0.200
α_0	1.415	0.058	24.490
R^2	0.835		
Prob > F	0.000***		
Root MSE	0.493		
Number of observations	2541		

Source: Own estimates from CMIE, PROWESS data for 2008
*Note: ***: Statistically significant at 1%*

Once the TFP is estimated based on a Translog specification, we tried to calculate the mean TFP for 19 sub-industries. In addition, the mean energy intensity is also calculated for the full sample. From the result we can see that, the diversified manufacturing reported to be higher TFP as compared to all other industries and the agricultural product industries have the least TFP. Figure-1 presents the result where the horizontal line represents the mean TFP and the bars represent the TFP for each industry. We can observe from the figure that, only nine sub-industries out of 19 sub-industries have TFP greater than the mean TFP. The ranking of the sub-industries in terms of TFP are given in table-3.

Table 3. Mean Total factor productivity and energy intensity in Indian manufacturing

Symbol used	Sub-Industries	Number of observation	Mean Total Factor Productivity	Mean Energy Intensity	Ranking based on TFP*	Ranking Based on Energy Intensity*
ID_1	Food Products	6	4.81	0.07	14	13
ID_2	Agricultural products	87	3.18	0.07	1	12
ID_3	Petrochemical	31	5.55	0.03	18	3
ID_4	Other Food Products	54	5.03	0.05	15	8
ID_5	Beverages and Tobacco Products	159	4.75	0.04	11	6
ID_6	Textile	321	4.53	0.11	10	17
ID_7	Lather and Lather Products	14	4.15	0.03	5	5
ID_8	Wood and Wood Products	14	3.58	0.08	3	15
ID_9	Paper and Paper Products	83	4.30	0.11	7	18
ID_{10}	Chemical and Chemical Products	390	4.49	0.09	9	16
ID_{11}	Rubber and Plastics Products	165	4.22	0.05	6	10
ID_{12}	Non-Metallic Mineral Products	129	4.80	0.15	12	19
ID_{13}	Basic Metal and Metal Products	283	5.19	0.06	16	11
ID_{14}	Machinery and Machinery Products	129	4.49	0.02	8	1
ID_{15}	Heavy Machinery	115	4.80	0.02	13	2
ID_{16}	Electronics	93	4.14	0.03	4	4
ID_{17}	Transport Equipments	181	5.32	0.04	17	7
ID_{18}	Other Miscellaneous Manufacturing Products	36	3.30	0.05	2	9
ID_{19}	Diversified Manufacturing	28	6.42	0.08	19	14
	Total	2318	4.63	0.07		

Source: Own estimates from CMIE, PROWESS data for 2008
*Note: *: Ranking of the variable takes higher value for higher TFP and higher energy intensity. Mean TFP of full sample, lies between rank 10 and 11, whereas Mean Energy intensity lies between rank 12 and 13.*

As this study also tried to look at the energy intensity of the firms, and in the second stage regression, energy intensity is considered as a determinant of productivity, we tried to look at the mean energy intensity of the 19 sub-industries and the mean energy intensity of the full sample. Table-3 gives the result of this exercise. Table-3 also gives the ranking of the sub-industries based on the energy intensity of the firms. Figure-2 presents the mean energy intensity of each sub-industries and mean energy intensity of the full sample. The horizontal line parallel to the X-axis in figure-2 gives the mean energy intensity. From the figure we can observe that the non-metallic mineral product industries are higher energy intensives as compared to all other 18 sub-industries and the machinery and machinery product industries are the least energy intensives. Further, we can observe that seven out of 19 industries are above the mean energy intensity. However, as compared to the mean TFP the fluctuation is higher in case of the energy intensity for the sub-industries. The next attempt of this paper is to investigate the determinants of TFP using firm specific variables other than labour, capital and material. Hence, we have tried the estimation of the determinants of inter-firm differences in the productivity.

Figure 1. Comparison of Mean TFP of Full sample with 19 sub-industries sample

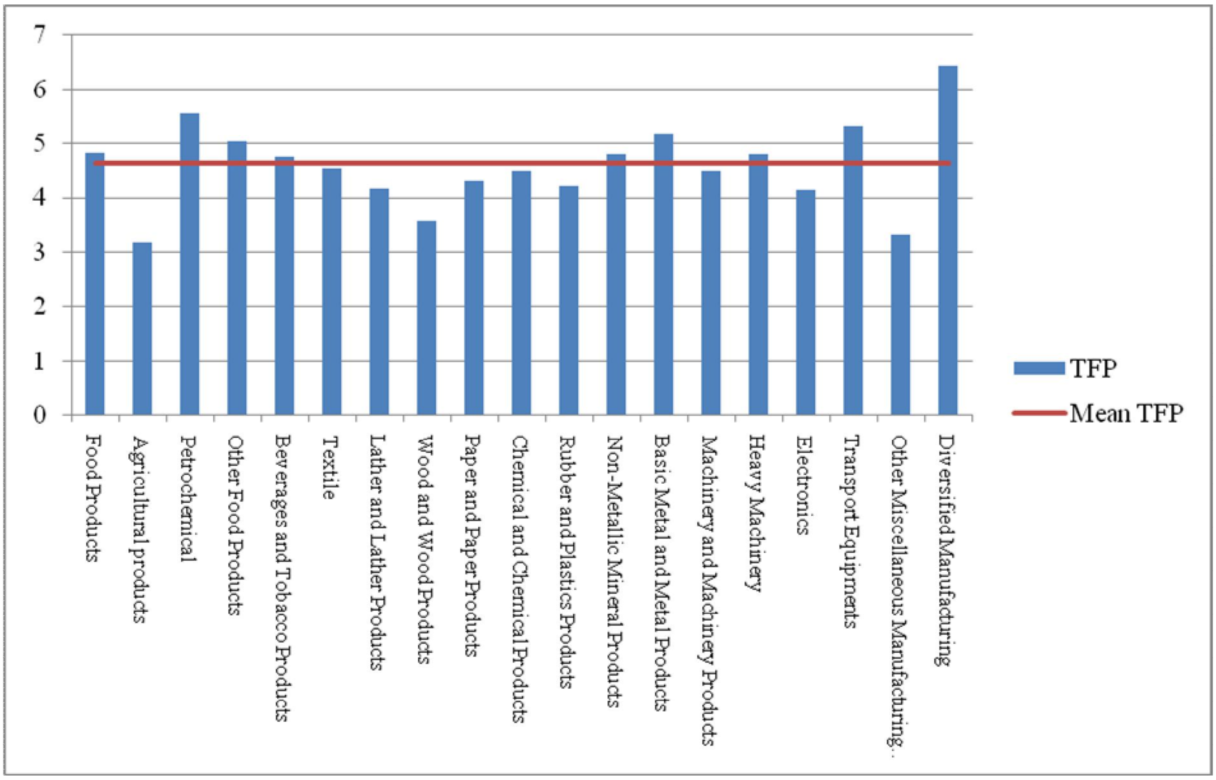
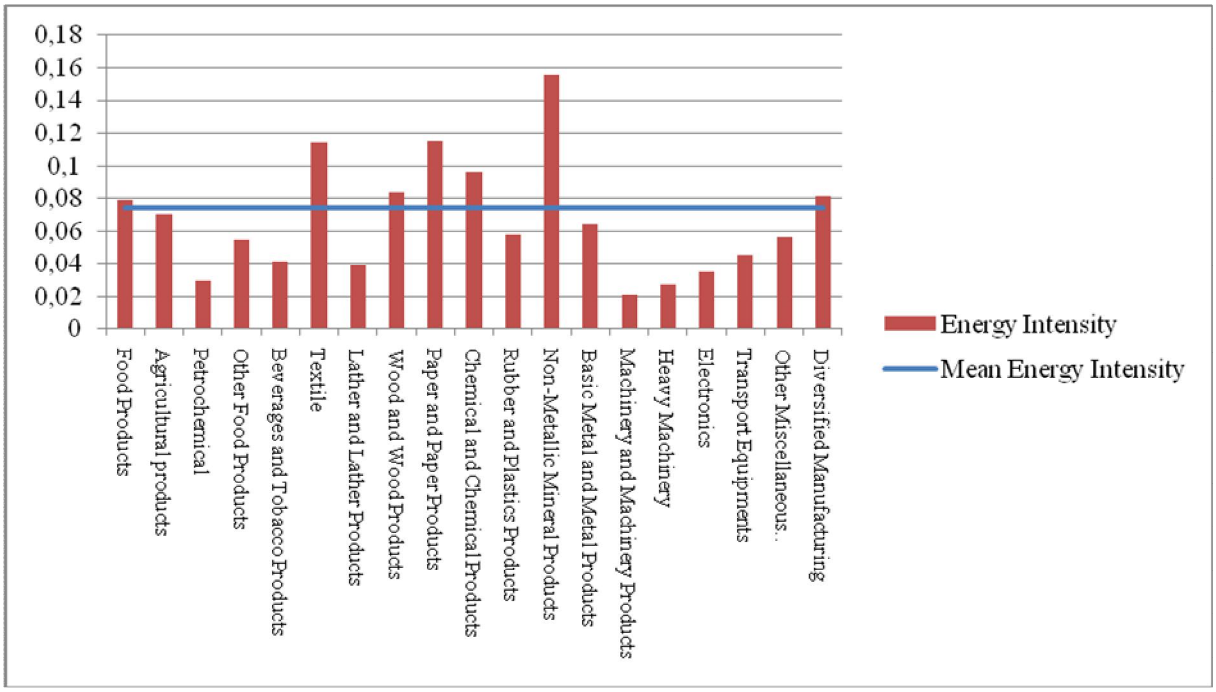


Figure 2. Comparison of Mean Energy Intensity of Full sample with 19 sub-industries sample



It is now interesting to check whether the energy intensity and the TFP of the Indian manufacturing industries have any relationship among themselves. In this connection we have tried to check the correlation coefficients between the energy intensity and the TFP at firm level. For a detail analytical purpose, we have classified the sample in the following sub-classifications, (i) classification based on the ownership pattern of the firms, (ii) classification based on the aggregate industries classification (as in CMIE), and (iii) classification based on the energy intensity. Initially we have tried the correlation and further we have also calculated the rank correlation coefficient between the set of variables. The result of this exercise is given in table-4. From the table we can observe that, except for non-metallic mineral product and for the diversified manufacturing industries rest all the sub-industries classification turned out to be negatively related to the TFP. However, a detail observation in between the sub-groups, for example between the ownership of the firms (either foreign or domestic) gives the result that the domestic firms are highly correlated with the TFP as compared to the foreign firms. In the aggregate industries classification, we can also see that there is inter-industries difference in correlation coefficients. To check whether there is any relation between energy intensity and TFP we further divided the data into two groups. One group contains firms those energy intensity is greater than the mean of the energy intensity of the sample (here defined as the less energy efficient firms) and firms those energy intensity is less than that of the energy intensity of the full sample (defined as the energy efficient firms). The correlation result shows that, firms those are highly energy efficient are bearing a higher significant level in the correlation coefficient as compared to the less energy efficient firms.

Table 4. Correlation coefficient of Energy intensity and TFP across groups

SL No	Description of the sample	Sample Size	Correlation Coefficient	Rank Correlation Coefficient
1	Full sample	2318	-0.152	0.230
2	Foreign	89	-0.002	0.303
3	Domestic	2229	-0.151	0.230
4	Food Products	6	-0.807	0.770
5	Agricultural products	87	-0.127	0.252
6	Petrochemical	31	-0.593	0.600
7	Other Food Products	54	-0.305	0.593
8	Beverages and Tobacco Products	159	-0.316	1.000
9	Textile	321	-0.251	0.801
10	Lather and Lather Products	14	-0.251	0.864
11	Wood and Wood Products	14	-0.481	0.947
12	Paper and Paper Products	83	-0.020	0.830
13	Chemical and Chemical Products	390	-0.162	0.857
14	Rubber and Plastics Products	165	-0.018	0.927
15	Non-Metallic Mineral Products	129	0.081	0.867
16	Basic Metal and Metal Products	283	-0.048	0.913
17	Machinery and Machinery Products	129	-0.288	0.946
18	Heavy Machinery	115	-0.272	0.934
19	Electronics	93	-0.140	0.953
20	Transport Equipments	181	-0.269	0.877
21	Other Miscellaneous Manufacturing Products	36	-0.489	0.973
22	Diversified Manufacturing	28	0.218	0.860
23	Highly Energy Efficient	1886	-0.161	0.240
24	Less Energy Efficient	432	-0.080	0.362

Table-5 gives the detailed result of the estimates of equation (0.2). From the estimate of determinants of productivity (TFP) we can observe that, age of the firm is positively significant with the TFP of the firms. This suggests that older firms are more productive as compared to the younger ones. The positive relation between the age of the firm and the TFP is as expected earlier and supports our hypothesis. Energy intensity has turned out to be negatively related to the TFP. This result suggests that lesser energy intensive firms (higher energy efficiency firms) are more productive as compared to the higher energy intensive firms. This is as according to our hypothesis, as firms minimize energy input in producing output and energy is a derived demand for the industries, the higher energy efficient firms are more productive when compared to the less energy efficient firms.

Table 5. Estimates of Determinants of Total Factor Productivity for Indian Manufacturing

Variables	Coefficients	Standard Error	t Statistics
AGE	0.003	0.001	4.030***
MNE Dummy	-0.659	0.188	-3.500***
EI	-4.461	0.677	-6.590***
ETI	-3.687	1.622	-2.270***
RDI	3.791	1.282	2.960***
EXPI	0.417	0.155	2.700***
DETI	2.160	0.225	9.580***
ID_1	-1.161	0.776	-1.500
ID_2	-3.168	0.376	-8.430***
ID_3	-1.205	0.452	-2.670***
ID_4	-1.336	0.402	-3.320***
ID_5	-1.558	0.353	-4.410***
ID_6	-1.743	0.342	-5.090***
ID_7	-2.415	0.568	-4.250***
ID_8	-2.944	0.565	-5.210***
ID_9	-1.852	0.379	-4.880***
ID_{10}	-1.988	0.339	-5.870***
ID_{11}	-2.225	0.353	-6.300***
ID_{12}	-1.502	0.363	-4.140***
ID_{13}	-1.213	0.342	-3.540***
ID_{14}	-2.008	0.360	-5.580***
ID_{15}	-1.699	0.364	-4.670***
ID_{16}	-2.598	0.373	-6.960***
ID_{17}	-1.171	0.351	-3.340***
ID_{18}	-3.146	0.435	-7.230***
α	6.867	0.377	18.240***
F(26, 2291)	17.150		
Prob > F	0.000***		
R^2	0.163		
Adj R^2	0.154		
Number of observations	2541		

Source: Own estimates from CMIE, PROWESS data for 2008
*Note: ***: Statistically significant at 1%*

The embodied technology import intensity has a negative relationship with the TFP of the firms. This result suggests that firms those import lesser embodied technology are more productive. Research and development intensity of the firms are positively related to the TFP of the firms. Hence, higher the research and development expenditure of the firm higher productive they are. The export intensity has also turned out with a positive relation with the TFP of the firms. Hence, export oriented firms are also more productive. As against the result of the embodied technology import, the disembodied technology import intensity of the firms is found to be positively related to the TFP of the firms. This result suggests that firms importing higher disembodied technology are less productive as compared to their counterparts.

To capture the industry specific characteristics in the inter-firm differences in TFP, we have created 18 dummies in equation (0.2). Except Food Products industries all other industry dummies have turned out to be significant. As the coefficient of the constant has also turned out to be significant we can interpret the dummy coefficients and compared to the Diversified Manufacturing (the excluded industry in dummy). In addition to the industry dummy the MNE dummy is too significant in the result. Hence in addition to the constant coefficient the result suggests that the foreign owned firms are higher productive as compared to the domestic firms. The result of the dummied (17, except the Food Products industries) conform the estimation result. Further, we can observe that the TFP is higher for the Diversified Manufacturing (as the benchmark) as compared to all other sub-industries.

5. Conclusion

The objective of the paper is to estimate the Translog production function and analyze the determinants of inter-firm differences in the level of TFP. We used a two-stage regression using OLS to estimate the Translog production function for four inputs for the Indian manufacturing industries for the year 2008. Further, the determinants of TFP were carried out using firm specific characteristics and energy intensity. The findings of the paper suggest that labour and material inputs play major role as compared to the capital and energy input. Age of the firm, ownership, energy intensity, embodied and disembodied technology imports, research and development and exports were considered as the possible determinants of the TFP in the second stage regression. The finding of the estimates suggest that age of the firm, export intensity and disembodied technology import are positively related to the TFP, whereas ownership, energy intensity, embodied technology import and R&D intensity are negatively related to the TFP of the firms for Indian manufacturing. Energy efficient firms also have high levels of TFP.

From the mean TFP we can observe that the diversified manufacturing industries has higher TFP as compared to other eighteen sub-industries and the agricultural product industries turned out to have the least TFP for Indian manufacturing. Beyond measuring the TFP, this work attempts to understand the determinants of TFP for the Indian manufacturing industries and compares across sub-industries. One more value addition of the paper is that it takes energy as the fourth input in the production function. In recent climate change negotiations and debates, energy cannot be overlooked and there is a necessary to focus on productivity and energy use in Indian industries, more specifically in the manufacturing industries. The results have vital policy implications. One specific implication is the need to foster energy efficiency at firm level in all the manufacturing industries in India. The Government could think of introducing fiscal incentives for achieving higher energy efficiency.

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