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Productivity, Energy Intensity and Output:
A Unit Level Analysis of the Indian Manufacturing Sector

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Abstract
This study examines the Total Factor Productivity (TFP) growth of the pre-existing units on a balanced sample for ten years (1998-1999 to 2007-2008) following the Levinsohn and Petrin (2003) technique. This study uses data from the Annual Survey of Industries at factory level. The results of the study indicate that most of the industries achieved positive TFP growth except a few; and thus within plant efficiency exists in Indian manufacturing sector. A further analysis of determinants of energy intensity using panel data model shows that productive plants in terms of TFP, are energy efficient. It is also observed that medium low-tech and high-tech industries on the basis of OECD classifications are energy efficient compared to the low-tech and the medium high-tech industries. The study also validates the "productivity dilemma hypothesis" for the sample firms indicating TFP and plant output are the major determinants of energy intensity.

Keywords: Total Factor Productivity, Energy Intensity, Indian Manufacturing Sector
JEL Codes: D22, Q4

1. Introduction

The importance of Indian manufacturing sector can be realized in the terms of providing employment to the less skilled workers and thus, contributing in inclusive growth. Therefore, to reap the benefits, it is important to apply the policies related to this sector effectively i.e. proportion of investment in each sector. Total Factor Productivity (TFP) is considered to be one of the plausible routes and thus comes handy as a measure of welfare of the economy. It can be understood as the unaccounted part of output growth and an appropriate, for technological change and efficiency. The present study, therefore, pertains to examine whether the prevalent technological conditions in Indian manufacturing do really act as a stumbling block in generating growth and further, extended to determine the factors of energy intensity/efficiency in this sector. This study concentrates on two objectives. This first objective is to examine whether pre-existing plants experienced rapid growth and second is to find the determinants of energy intensity using TFP as one of the major variables of interest.

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There are a fairly large number of studies that attempted to estimate the productivity for Indian manufacturing but the methods of estimation are still debatable. An exhaustive survey of the major studies, are presented in the literature review. The first objective of the study is to calculate TFP with four motivations. Firstly, the study is focused at absolute unit level which is important for understanding the microeconomic phenomenon like TFP. Secondly, we are computing TFP and TFP growth for the pre-existing units on a balanced panel using Annual Survey of Industries (ASI) data for ten years which is one of the first attempts in this domain and, therefore, adds to the literature. Thirdly, we use Levinsohn and Petrin (2003) approach for the estimation and thus taking care of the selection bias and simultaneity problem. Fourthly, the time period chosen from 1998-1999 to 2007-2008, includes the globalization effect of the economy. For the second objective, the study is unique in the sense that it uses a better estimation of TFP while arriving at the determinants of energy intensity. In this line, many studies are attempted those use TFP index, which does not take care of the selection bias and simultaneity problem due to unobserved productivity shocks. Thus, it is expected that estimates would be robust than the earlier studies. This study is divided into five sections. Section two presents the review of literature. Section three discusses the data and methodology, section four gives the empirical estimates and section five concludes the study.

2. Literature Review

2.1 Issues in the Measurement of Total Factor Productivity (TFP)

TFP can be understood as an overall measure of the degree of technological advancement of an economic entity. Formally, it can be defined as portion of the increase in output which cannot be explained by the increase in input. It is widely acknowledged that growth in productivity is the only plausible route to increase standard of living and therefore, it is considered as a measure of welfare (Kathuria *et* al., 2013). There are many factors which are responsible for the increase in productivity and productivity growth i.e. infrastructure, R and D, human capital, business environment etc. Analysis of TFP provides an answer to the question, "what is the quantity of input required to produce a given amount of output?" It basically can be considered as an assessment of the efficiency with which output is produced from a given set of inputs. In other words, growth in TFP may imply a smaller quantity of inputs is required to produce a given level of output. This is the reason; most of the researchers support that sustained output growth in the long run can only achieved by TFP growth given the laws of diminishing returns and scarcity of resources. The level of TFP can be measured by dividing total output by total inputs. Growth in TFP is therefore, the growth rate in total output less than the growth rate in total inputs. Alternatively, it is the amount of growth in real output that is not explained by the growth in inputs. As a matter of concern, TFP levels are sensitive to the units used in the measurement of output and inputs and therefore, care should be taken while interpreting it. Instead, TFP growth is free from such complications and hence, preferred (Kathuria *et* al., 2013).

There are many studies dealing with the measurement of TFP and TFP growth of the Indian manufacturing sector and due to the different methods used and different approaches of variable construction, results differ (Kathuria *et* al., 2103). The literature on the productivity measurement is reviewed by Goldar (2011b), Goldar and Mitra (2002) and Krishna (1987, 2006, 2007). To understand some of the studies based on Indian economy, they can be divided into three groups chronologically. The first group includes the studies from 1959-1979. Reddy and Rao (1962), Banerji (1975), Ahluwalia (1985) and Goldar (1986) conducted the study on productivity in Indian manufacturing sector for this time period and found out that TFP growth from 1959 to 1979 was either slow or negative. The second group consists of the studies undertook in 1990s and are majorly concerned about the use of value added function. Ahluwalia (1991) made the assertion that the TFP growth in manufacturing sector accelerated after 1980. She used the single deflation procedure while other studies like Balakrishnan and Pushpagandan (1994) relied on a more appropriate double deflation procedure and found out that there was a deceleration instead after 1980. Rao (1996) also supported the claim of Balakrishnan and Pushpagandan (1994) using the double deflation procedure and on the other hand Pradhan and Barik (1998) used the gross output function but still contradicted the results found out by Ahluwalia (1991). The third group studies are mostly dedicated to the impact of industrial and trade policies reforms and its impact on manufacturing sector’s productivity. Goldar (2004) found contrasting results to the finding of earlier studies, one by Unel (2003) and the other by Tata Services Limited (2003). According to both of these studies, the total factor productivity growth accelerated after the 1990 reforms. Goldar, (2004) used the value added function framework to estimate TFP on the basis of Translog index of TFP and showed that TFP growth decelerated in the post reform period and attributed it to the fall in the growth rate of agriculture sector and the decline in the capacity utilization in the industrial sector. Trivedi *et* al. (2011) supported his assertion too.

These studies mostly relied on ordinary least squares (OLS) method for the estimation; but it would assume that the input choices are determined exogenously. However, the firm's input choices can be endogenous too. For instance, the number of workers hired by a firm and the quantity of materials purchased may depend on unobserved productivity shocks. Therefore, if input choices and productivity are correlated, OLS estimation will yield biased parameter estimates (Kathuria *et* al., 2013). This problem is corrected in this paper using a methodology developed by Levinsohn and Petrin (2003) and it is explained in detail in the next section. Recently, researchers have started employing this methodology for the estimation of TFP growth. For instance, Kathuria *et* al. (2013) used Levinsohn and Petrin methodology along with the growth accounting and stochastic production frontier analysis approaches from 1994-1995 to 2005-2006 to see how sensitive results are to different estimation methods. It should be noted that it is one of the few studies which includes informal manufacturing sector as well.

Majumder and Mukherjee (2014) also estimated trends in factor productivity, technological progress and technological efficiency in the manufacturing sector using panel data of 19 Indian states using the Levinsohn and Petrin technique. It should be noted that the study is only concerned with the formal manufacturing sector. This study is focused on the balanced panel using unit level data for ten years to see whether pre-existing plants have experienced rapid productivity growth or not. It should be noted that this is one of the first attempts to compute TFP growth on a balanced unit level data set. However, Bollard *et. al.* (2011) also studied the similar exercise for estimating TFP growth and documented a substantial pickup in manufacturing TFP growth in India over 5 percent points per year for 1993–2007 vs. 1980–1992, but the estimates are not precise as the standard errors are quite high, depending on the correction for heteroscedasticity. Almost all of this speedup arises from changes in plant efficiency over time, as opposed to the reallocation of inputs across plants.

In the backdrop of the above literature survey we are now in a position to provide a rationale for conducting yet another study on the estimation of TFP growth for Indian manufacturing. First, the fundamental point to be emphasized is that the parameters of a production function – the total factor productivity is essentially a microeconomic phenomenon which can only legitimately be estimated at the level of a unit. Therefore, if we are interested to estimate these parameters then we must have to depend on the factory level data for estimating the production function. Secondly, except for the study by Bollard et al (2011), TFP has not been computed for the pre-existing factories over the time which means that the result would not be inflated by the increase in number of factories. Thirdly, the coverage of most of the studies ends by the 1990s. Our study covers the entire post liberalization period of the economy. Fourthly, our estimates are not affected by the biases of selection and simultaneity problem between input choices and unobservable productivity shocks. Thus, the chief motivation of our study was derived from the serious limitations of the existing studies on the estimation of production function for the Indian economy.

2.2 Determinants of Energy Intensity

India is a developing country and with a rapid increase in industrialization, where demand for energy resources and greenhouse gas emissions are rising tremendously. According to Government of India (2007) energy intensity in Indian industries is highest among the world and manufacturing sector being the largest consumer of commercial energy than any other Indian industries. However, it is observed that its usage is constantly falling since 1992 (Goldar, 2011). Energy is an important input in the process of production but due to its adverse effects on environment and limited resources it should be used very efficiently. To note, energy intensity is defined as the expenses on power, fuel etc. per unit sales and can be considered as a standard which shows how efficiently the energy is used in the economy/sector/plant level, and thus is used in this study.

The objective of this paper is also to find out the determinants of energy intensity that is based on two studies i.e. Sahu and Narayanan (2009) and Goldar (2011a). Sahu and Narayanan (2009) used multiple regression models to find out the determinants of energy intensity at firm level using data from the Center for Monitoring Indian Economy Prowess. They concluded that R and D intensive firms and foreign affiliated firms are considered as energy efficient. Further, there is an inverted-U relationship between the size of the firm and energy intensity. Industry dummies and firm dummies are also considered important in explaining energy intensity. Goldar (2011), on the other hand, used TFP as an explanatory variable along with others and found that technological advances can help using the energy efficiently. He used dynamic panel data model for the estimation and it is used in this study as well. Based on the earlier discussion use of a balance panel data at plant level and use of Levinsohn and Petrin approach may present a better result than compared to the earlier estimates and determinants. To incorporate the plant characteristics to an empirical model of energy intensity; we follow Doms and Dunne (1995) based on energy factor demand equation from a cost minimization model.

3. Data and Methodology

3.1 Data and Variables

The database used in this study is the unit-level panel data of the Annual Survey of Industries (ASI) brought out by Central Statistical Office (CSO) for the period 1998-99 to 2007-08. It may be mentioned here, that ASI covers industrial units registered as factories under the Factories Act. Thus, the analysis is confined to the organized sector of Indian manufacturing. As mentioned above, the estimation shall be carried out only for the pre-existing plants and therefore, a data set is created by identifying those factories which are present throughout in the period of ten years. The ASI has released plant-level data with plant identifiers for the years 1998–2007 and this is one of the reasons to choose this particular time period. After the process of data cleaning, 3,943 such factories could be identified i.e. 39,430 observations for a time period of 10 years. Table-1 shows the percentage of factories in the unbalanced as well as balanced panel data set as given by ASI.

Gross value added (calculated using formula given in tabulation program given by ASI) is used as a measure for output, productive capital stock (sum of book value of total fixed assets and total working capital-closing stock value) for capital input; the number for persons employed (average employment during the year) for labour input; materials consumed (calculated using formula given in tabulation program given by ASI) for the intermediate input-materials required; and sum of purchase value of four units namely (1) electricity purchased, (2) petrol-diesel-oil lubricants consumed, (3) coal consumed and (4) other fuel consumed, for the energy consumed as the other intermediate input, were defined from the balanced panel data. It should be pointed out that the value of fixed capital is the book value of fixed assets, i.e. the assets are at historical prices and the depreciated value of fixed assets is aggregated to form the net fixed capital stock in ASI. While replacement value of fixed assets would be a better measure, it has not been possible to make the required price correction.

Table 1: Number of Factories in the Selected Balance Sample

2-Digit NIC 2008	Industry Sub-Groups	Balanced Sample		Unbalanced Sample	
		NoF	percent	NoF	percent
15	Food products and beverages	8690	23.4	62460	18.4
16	Tobacco products	726	2	7389	2.2
17	Textiles	5896	15.8	36235	10.7
18	Wearing apparel	815	2.2	11799	3.5
19	Tanning and dessing of leather manufacture of luggage, handbags, saddlery, harness and footwear	568	1.5	6483	1.9
20	Wood and of products of wood and cork except furniture; Articles of straw and plating materials	692	1.9	7454	2.2
21	Paper and paper products	780	2.1	9234	2.7
22	Publishing, printing and reproduction of recorded media	705	1.9	8597	2.5
23	Coke, refined petroleum products and nuclear fuel	477	1.3	3342	1
24	Chemicals and chemical products	3702	9.9	31028	9.1
25	Rubber and plastic products	812	2.2	15519	4.6
26	Other non-metallic mineral products	2733	7.3	31046	9.1
27	Basic metals	1661	4.5	19209	5.7
28	Fabricated metal products, except machinery and equipments	956	2.6	18786	5.5
29	Machinery and equipments	2206	5.9	24721	7.3
30	Office, accounting and computing machinery	89	0.2	899	0.3
31	Electrical machinery	1192	3.2	12573	3.7
32	Radio, television and communication equipment and apparatus	573	1.5	4284	1.3
33	Medical, precision and optical instruments; watches and clocks	596	1.6	4482	1.3
34	Motor vehicles, trailers and semi-trailers	1141	3.1	9198	2.7
35	Other transport equipment	1177	3.2	6541	1.9
36	Furniture	836	2.2	8433	2.5

Note: NoF- Number of Factories, Source: Author’s estimates using ASI data.

3.2 Methodology

The traditional methodology of estimating productivity is ordinary least squares (Kathuria *et* al., 2013). This technique involves estimating output as a function of the inputs and then subtracting estimated output from the actual output to capture productivity as a residual term but concerns have been raised that this process may suffer from the simultaneity and selection bias. Levinsohn and Petrin (2003), henceforth LP, devised an approach to tackle this problem in 1999. This approach is a modified version of the method used by Olley and Pakes in 1992.

Olley and Pakes method requires the investment variable to be non-zero and non-missing which is generally not possible for developing countries. Hence, LP method is preferred in this study. Levinsohn and Petrin, (2003) hypothesize that while producers observe information about their firm's productivity, this information is unavailable. This causes the problem of simultaneity because a firm's knowledge of its productivity, that is unknown, will affect its hiring and investment decision especially when it is observed by the firm early enough to allow the firm to change the factor input decision. This information asymmetry introduces a simultaneity bias.

Thus least square estimation of a production function may lead to estimates of the coefficients of variable inputs that are biased upwards. The second problem facing econometricians using least square estimation techniques is selection bias. Producers make decisions regarding whether or not to stay in the market based on productivity information coupled with their level of capital stock. Levinsohn and Petrin (2003) explain that if there is a correlation between exit of a firm from the sample and quantity of input used by the firm, then this will cause the input coefficient estimate to carry a bias. Sometimes, firm-level data sets contain missing values due to plants dropping out of the sample. If these firms are selected in a non-random manner, then the sample may become biased. Specifically, if firms with low TFP tend to exit the sample and the quantity of capital used by exiting firms is less than other inputs, then, the selection bias in the least square estimation will make the capital coefficient larger than it ought to be in the firms remaining in the market.

Levinsohn and Petrin (2003) suggest that instead of using investment as the proxy variable (as Olley and Pakes suggested), intermediate inputs be used to control for simultaneity because intermediate input consumption is a superior proxy for change in productivity. The primary advantage of this approach is that even firms with zero investment can be retained in the dataset. Levinsohn and Petrin highlight another theoretical benefit of this approach: adjusting intermediate input consumption is relatively less expensive than adjusting investment, in response to changes in productivity levels. Levinsohn and Petrin assume that the production technology is represented by a production function like equation (1).

$$Y_{it} = F\left(L_{it}, M_{it}, E_{it}, K_{it}, \Omega_{it}\right) \quad (1)$$

Where, Y_{it} is a measure of output for firm i at time t; L_{it}, M_{it}, E_{it} are the freely variable inputs of labor, material, and energy that can adjust instantly; K_{it}, Ω_{it} are capital inputs and the productivity shock respectively which are regarded as state variables which require time to be adjusted. Transforming the above production function in to logs allows linear estimation, so that the small letters represent log-values of the above mentioned variables, yielding:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \beta_k k_{it} + u_{it} \tag{2}$$

Here, u_{it} can be split into two elements: Ω_{it} and η_{it}. The former is the productivity shock, a state variable that is observed early enough to influence the firm's decisions regarding future production. This in turn influences the input consumption decision of the firm, which brings about the correlation between input levels and productivity that causes the OLS estimates to be biased. The latter is the true error term that may contain both unobserved shocks and measurement errors that have no impact on the plant's decisions.

Thus, we have,

$$u_{it} = \Omega_{it} + \eta_{it} \tag{3}$$

Substituting (3) in (2) yields:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \beta_k k_{it} + \Omega_{it} + \eta_{it} \tag{4}$$

A material demand function is then introduced to tackle the problem of simultaneity, which can also be defined as the correlation between the error term (the productivity) and the inputs. Therefore, Levinsohn and Petrin define an unknown function for the optimal material demand that is dependent on the two state variables:

$$m_{it} = m_t\left(\Omega_{it}, K_{it}\right) \tag{5}$$

This equation is assumed to be strictly increasing in Ω_{it} implying that productivity is positively related to the current material demand, so firms that experience large positive productivity shock in this period will demand more materials in the next period. The monotonicity assumption also allows to estimate the unobserved productivity function semiparametrically, by inverting the material demand function. This yields an estimate for the unobserved productivity that is contingent upon observable material and capital inputs:

$$\Omega_{it} = m_t^{-1}\left(m_{it}, K_{it}\right) = \Omega_t\left(m_{it}, K_{it}\right) \tag{6}$$

Now, if we substitute (6) in (4), we have:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \beta_e e_{it} + \beta_k k_{it} + \Omega_t\left(m_{it}, K_{it}\right) + \eta_{it} \tag{7}$$

We define the function:

$$\phi_{it}\left(m_{it}, k_{it}\right) = \beta_0 + \beta_m m_{it} + \beta_k k_{it} + \Omega_t\left(m_{it}, K_{it}\right) \tag{8}$$

Where, $\phi_{it}\left(m_{it}, k_{it}\right)$ is estimated as a second order polynomial in log materials and log capital. Hence, using (8) in (7), we have our first estimating equation:

$$y_{it} = \beta_l l_{it} + \beta_e e_{it} + \phi_{it}\left(m_{it}, k_{it}\right) + \eta_{it} \tag{9}$$

In (9), we have a third order polynomial expansion in capital and materials to approximate ϕ_{it}. This polynomial is allowed to vary over time and the time index accounts for changes in the market structure experienced by the firm over time. Now, OLS estimation of this equation yields coefficients on all variable inputs, and also the coefficient ϕ_{it}. This brings the first stage of estimation to a close. In the second stage Levinsohn and Petrin assume, as outlined in Olley and Pakes, that expectation of future productivity follows a first-order Markov process as follows:

$$\Omega_{it} = E\left[\Omega_{it} \mid \Omega_{it-1}\right] + \xi_{it} \tag{10}$$

Where, future productivity is contingent upon current productivity, and unanticipated innovations in productivity represented by ξ_{it}. They also use two moment conditions to identify the coefficients β_m and β_k. The first moment is arrived at by assuming that capital will not be adjusted in the same period for changes or innovation in productivity:

$$E\left[\eta_t + \xi_y \mid k_t\right] = 0 \tag{11}$$

The second moment is arrived at due to the fact that current productivity growth and the previous period's material demand are not correlated:

$$E\left[\eta_t + \xi_t \mid m_{t-1}\right] = 0 \qquad (12)$$

Using assumptions (10), (11) and (12), Levinsohn and Petrin arrive at the following expectation to estimate the coefficients on capital and material:

$$E\left[y_{it+1} - \beta_l l_{it+1} - \beta_e e_{it+1} \mid k_{it+1}\right] = \beta_0 + \beta_k k_{it+1} + \beta_m m_{it+1} + E\left[\Omega_{it+1} \mid \Omega_{it}\right] \qquad (13)$$

Denoting $\left(\Omega_{it}\right) = \beta_0 + E\left[\Omega_{it+1} \mid \Omega_{it}\right]$ equation (13) can be rewritten as:

$$y_{it+1} - \beta_l l_{it+1} - \beta_e e_{it+1} = \beta_k k_{it+1} + \beta_m m_{it+1} + g\left(\phi_{it} - \beta_k k_{it} - \beta_m m_{it}\right) + \xi_{it} + \eta_{it} \qquad (14)$$

Equation (14) can be estimated using previously obtained values of β_l, β_e, ϕ while the unknown functional form of g is approximated using a third order polynomial expansion of $\left(\phi_{it} - \beta_k k_{it} - \beta_m m_{it}\right)$. This estimation will yield consistent coefficients for material and capital inputs: β_m, β_k. Once all coefficients have been obtained, total factor productivity of each firm is calculated as the difference between the actual and predicted value of output for each firm:

$$TFP_{it} = y_{it} - \hat{\beta}_l\, l_{it} - \hat{\beta}_e\, e_{it} - \hat{\beta}_k\, k_{it} - \hat{\beta}_m\, m_{it} \qquad (15)$$

As a second objective of the study, determinants of energy intensity are also estimated. Fixed effects model and Random Effects model are used. The TFP growth computed from equation (15) is used as an one of the explanatory variables other than the plant level variables. Thus, the following equation is estimated following the approaches of Sahu and Narayanan (2009) and Goldar (2011).

$$\ln(EI) = \beta_1 + \beta_2 TFP_{it} + \beta_3 \ln Output_{it} + \beta_4 OECDD_{it} + \beta_5 RUC_{it} + \beta_6 OD + \beta_7 Location_{it} + u_{it}$$

(16)

In determining the factors of energy intensity at plant level, we have used the natural log of energy intensity as the dependent variable where energy intensity is defined as the fuel consumed per unit gross output. For explanatory variables; TFP for each plants, plant output (natural Log of Output; *Output*), OECD dummies for technology (*OECDD*), rural urban code given in ASI data (*RUC*), ownership type (*OD*) and plants in the same state (*Location*) were used for the estimation.

4. Empirical Estimates

4.1 Estimation of TFP and TFP Growth

The estimated production function using Levinsohn and Petrin approach shows, except a few industries, the elasticity of output i.e. value added with respect to labour and capital are significantly different from zero. The results are presented in table-2. This estimation includes all those factories that existed from 1998-1999 to 2007-2008. In 13 out of 22 industries, the elasticity of labour is relatively higher than the elasticity of capital. Most of the capital intensive industries have the value of elasticity of capital higher than that for labour including coke, refined petroleum products and nuclear fuel, non-metallic mineral products and basic metals. Evidently, both of the elasticities are insignificant for the office accounting and computing machinery implying none of the input mode is really important for these two industries. Coke, refined petroleum products and nuclear fuel is the only industry with a negative value of the elasticity of labour and a low positive value for the elasticity of capital implying the industry heavily relies on inputs other than labour and capital.

The level estimates of log value of TFP are computed at the unit level, using Levinsohn and Petrin methodology. We observed that at the two digit level food and beverages and office, accounting and machinery industries, have productivity at the highest level, while coke, refines products and nuclear fuel and basic metals at the lowest. The productivity for each and every sector has increased from 1998-1999 to 2007-2008, implying that TFP level estimates are of not much importance. Therefore, TFP growth (TFPG) estimates are computed at the unit level by subtracting the one lag observations from the TFP level estimates. TFP growth estimates for the pre-existing factories are given in table-3. It can be seen that all the industries has positive TFP growth from 2000-2008 except radio and television communication. Majumdar and Mukherjee has computed similar TFP growth estimates using Levinsohn and Petrin methodology for the period 2000-2010 for 16 industries. Our estimates are higher than the estimates computed by them in almost all the industries substantially except in basic chemicals and non-mineral products. However, only marginal difference is there and the sign remains the same. In the ASI data of 2008-2009, NIC classification updated and therefore, our study is limited till 2007-2008. Majumdar and Mukherjee merged some of the industries at various levels in order to compare the results from previous classification. However, the similar exercise is not performed in our study to keep the study free from any complications. By looking at the sub-periods, we can see that five industries recorded negative TFPG in 2000-2004 while only three in 2004-2008. Except office and accounting industry, all other negative values are of small order.

Thus, with very high positive TFPG in almost every sector in the time period concerned, we conclude that the productivity dispersion did not fall over time as one can expect from diminishing returns combined with input reallocation. The pre-existing factories achieved a very high pick up in TFPG from 2000 to 2008 and this is only attributed to the within plant efficiency over time and not to the reallocation of inputs from the low end to high end units. For example, food and beverages industry shows a tremendous jump in this sector in 2005-2008 as compared to 2000-2004. A closer inspection reveals that this can due to the Food Safety and Standard Act which came in existence in 2006. According to the report on Food Processing Sector in India (2015) by Corporate Catalyst Pvt. Ltd., 13 laws were applicable on food and food processing sector till 2005 leading to the various standards of food additives, contaminants, food colours etc. In order to regulate the food industry by one standard reference point, the Ministry of Food and Processing enacted “Food Safety and Standard Act” in 2006. This can be a very strong reason for the high jump in productivity of food and beverages sector. Apart from this, paper industry is another priority sector in the list with a very high TFPG.

This is one of the sectors which are in the priority list of RBI for the 100 percent foreign collaboration and foreign equity participation approval. Government de-licensed this sector completely in 1997, and since then only it is continuously achieving a high growth every year. In sum, Indian manufacturing sector’s growth is the sole result of within plant efficiency and not due to the reallocation of inputs from low to high units like in China. Moreover, some of the high jumps in the sector can be explained through the enactment of various laws and policies in that time period.

Table 2: Elasticity of Value Added With Respect to Labour and Capital

2-Digit NIC-2008	Industry Sub-Groups	Coefficient of Labour	Coefficient of Capital
15	Food products and beverages	0.25** (0.037)	0.137** (0.005)
16	Tobacco products	0.197** (0.009)	0.081** (0.016)
17	Textiles	0.091* (0.012)	0.157** (0.008)
18	Wearing apparel	0.179* (0.067)	0.239** (0.018)
19	Tanning and dessing of leather manufacture of luggage, handbags etc.	0.19** (0.03)	0.151* (0.056)
20	Wood and of products of wood and cork except furniture; Articles of saw	0.121** (0.024)	0.182** (0.006)
21	Paper and paper products	0.2410** (0.032)	0.094** (0.048)
22	Publishing, printing and reproduction of recorded media	0.305** (0.03)	0.121** (0.025)
23	Coke, refined petroleum products and nuclear fuel	-0.06** (0.035)	0.061** (0.01)
24	Chemicals and chemical products	0.218** (0.041)	0.155** (0.03)
25	Rubber and plastic products	0.124* (0.057)	0.451 (0.17)
26	Other non-metallic mineral products	0.109** (0.018)	0.206** (0.038)
27	Basic metals	0.097** (0.012)	0.245 (0.132)
28	Fabricated metal products, except machinery and equipments	0.266*** (0.001)	0.187** (0.047)
29	Machinery and equipments	0.231* (0.068)	0.179** (0.026)
30	Office, accounting and computing machinery	0.182 (0.719)	0.260 (0.135)
31	Electrical machinery	0.299** (0.016)	0.185** (0.033)
32	Radio, television and communication equipment and apparatus	0.224** (0.003)	0.256*** (0.001)
33	Medical, precision and optical instruments; watches and clocks	0.227** (0.031)	0.197 (0.203)
34	Motor vehicles, trailers and semi-trailers	0.231* (0.055)	0.128** (0.043)
35	Other transport equipment	0.329 (0.123)	0.168 (0.261)
36	Furniture	0.308** (0.03)	0.175** (0.011)

Source: Author’s estimates using ASI data.

Table 3: TFPG Trends across Industries at Two-Digit Level

2-Digit NIC-2008	Industry Sub-Groups	2000-04	2005-08	2000-08
15	Food products and beverages	0.55	5.31	2.40
16	Tobacco products	4.89	0.35	1.24
17	Textiles	0.57	1.34	1.10
18	Wearing apparel	-1.42	4.56	0.72
19	Tanning and dessing of leather manufacture of luggage, handbags, saddlery, harness and footwear	0.16	2.63	1.24
20	Wood and of products of wood and cork except furniture; Articles of straw and plating materials	-0.68	1.67	2.62
21	Paper and paper products	3.43	2.69	3.80
22	Publishing, printing and reproduction of recorded media	1.98	2.03	2.52
23	Coke, refined petroleum products and nuclear fuel	4.22	4.54	4.61
24	Chemicals and chemical products	-0.22	1.21	1.21
25	Rubber and plastic products	-0.11	4.22	1.82
26	Other non-metallic mineral products	0.73	2.66	1.70
27	Basic metals	-0.14	2.35	2.30
28	Fabricated metal products, except machinery and equipments	0.94	3.42	3.33
29	Machinery and equipments	0.69	4.03	2.57
30	Office, accounting and computing machinery	1.28	-4.22	1.77
31	Electrical machinery	2.18	6.32	3.26
32	Radio, television and communication equipment and apparatus	2.45	-3.76	-0.73
33	Medical, precision and optical instruments; watches and clocks	2.94	1.02	1.20
34	Motor vehicles, trailers and semi-trailers	4.02	1.98	3.45
35	Other transport equipment	0.37	2.53	1.50
36	Furniture	2.52	-0.06	1.73

Source: Author’s estimates using ASI data.

4.2 Determinants of Energy Intensity

To get started with finding the relationship between TFP computed above and energy intensity, we have calculated the spearman’s rank correlation coefficient between them using the ranks at two digit industry level (table 4). The estimation of the spearman’s rank correlation coefficient is -0.135 implying a weak but a negative relationship. This would mean that the plants which have higher TFP are using less energy and therefore, can be termed as energy efficient.

Table 4: TFP Growth and Energy Intensity

2-Digit NIC-2008	Industry Sub-Groups	TFPG 2000-08	Rank of TFPG	Energy intensity	Rank of Energy Efficiency
15	Food products and beverages	2.40	9	0.225	5
16	Tobacco products	1.24	16.5	0.026	21
17	Textiles	1.10	20	0.907	1
18	Wearing apparel	0.72	21	0.047	17
19	Tanning and dressing of leather manufacture of luggage, handbags, saddlery, harness and footwear	1.24	16.5	0.053	13
20	Wood and of products of wood and cork except furniture; Articles of straw and plating materials	2.62	6	0.119	9
21	Paper and paper products	3.80	2	0.171	7
22	Publishing, printing and reproduction of recorded media	2.52	8	0.041	19
23	Coke, refined petroleum products and nuclear fuel	4.61	1	0.037	20
24	Chemicals and chemical products	1.21	18	0.228	4
25	Rubber and plastic products	1.82	11	0.099	10
26	Other non-metallic mineral products	1.70	14	0.279	3
27	Basic metals	2.30	10	0.878	2
28	Fabricated metal products, except machinery and equipments	3.33	4	0.188	6
29	Machinery and equipments	2.57	7	0.047	17
30	Office, accounting and computing machinery	1.77	12	0.025	22
31	Electrical machinery	3.26	5	0.047	17
32	Radio, television and communication equipment and apparatus	-0.73	22	0.054	12
33	Medical, precision and optical instruments; watches and clocks	1.20	19	0.067	11
34	Motor vehicles, trailers and semi-trailers	3.45	3	0.050	14
35	Other transport equipment	1.50	15	0.161	8
36	Furniture	1.73	13	0.048	15

Source: Author's estimates using ASI data, Spearman's Rank Correlation Coefficient = -0.135.

We have a balanced panel data of plants and therefore fixed effects and random effect models can be used for the estimation instead of an ordinary least square method. From the estimates of both the models based on equation (16), fixed effects model is selected over the random effect model based on the result of the Hausman test statistic. The estimates of the fixed effects model, is presented in table 5. The coefficient of TFP is negative and significant and thus confirming the relationship between TFP and energy intensity. Meaning, plants with higher TFP are energy efficient compared to the others. However, the plant output is statistically significant and positive. Meaning plants with higher output are energy intensive.

This joint effect of TFP and Output relation to energy intensity can be described as the productivity dilemma hypothesis as described in Tang et al (2015). The empirical results suggest that, in general, plant productivity has negative impact on energy intensity however; output has positive relationship with energy intensity. At the same time, we can also observe that the OECD dummies are also statistically significant and negative.

Table 5: Determinants of Energy intensity-Fixed effects model

Independent Variables	Coef.	Robust Std. Err.	t
Total Factor Productivity	-4.5063	2.309	-1.95**
Plant Output	2.356	1.091	2.159***
Dummy for medium low technology industries	-1.3379	0.695	-1.92**
Dummy for medium high technology industries	-0.3162	0.215	-1.47
Dummy for high technology industries	-0.9727	0.560	-1.74*
Rural-Urban code	0.4011	0.209	1.92**
Ownership Dummy	0.0148	0.010	1.42
Units located in same state	-0.0005	0.000	-1.86*
Constant	11.546	5.810	1.99
sigma_u	1.282		
sigma_e	1.680		
Rho	0.368		
R-sq: within	0.107		
Between	0.016		
Overall	0.035		
corr(u_i, Xb)	-0.656		
F(9,3861)	21.610***		
Number of obs	39430		
Number of groups	3943		

Note: Standard error adjusted for 3943 clusters in factory code, ** and * refers to statistically significant at 5 and 10 percent respectively.
Source: Authors calculation from ASI data.

This would mean that medium low tech and the high tech plants are energy efficient where as the low tech plants and medium high tech plants are energy intensive. Further, plants that are located in the rural areas are also found to be energy intensive compared to the plants located on the urban areas. One of the explanations may relate to the cost and availability of energy. For the plants, located in the urban set up may not have the problems with the availability and energy sources but the rural plants may have to incur an additional cost of transport for the energy related intermediate inputs. Therefore, the plants located in the rural areas are energy intensive. It should be noted that the estimation is carried on the adjusted standard error of the factory code. From the result is can also be observed that if the units are located in the same state that increases energy efficiency.

5. Conclusion

The analysis presented above clearly shows high and positive estimates of TFP growth of pre-existing factories implying that Indian manufacturing sector's growth is attributed to the within plant efficiency and not to the reallocation of resources from the low to high units. In the sub-periods from 2005-2008, industries have higher productivity growth than 2004-2008. For instance, food and beverages industry was growing at 5.31 in 2005-2008 which can be explained through the enactment of Food Safety and Standard Act in 2006. The estimates of elasticity of output with respect to labour and capital are also significant for most of the industries. In the second part of the study, it could be understood that energy consumption is very high in Indian manufacturing sector and its reduction is considered as a measure of economic growth. Units or industries can be coined as energy efficient if their energy requirement is low. TFP can be considered as a standard for technology and came out to be a very strong factor in determining energy intensity of the units. It is concluded that the units which have high TFP are energy efficient. Other variables such as industry wise OECD dummies for technology were also significant and negative. Our findings should be taken with caution due to the following limitations. Firstly, we are analyzing large formal manufacturing plants and not taking into account the informal manufacturing sector. Secondly, we could not take some of the important variables which are included in previous studies as they are not incorporated in ASI data.

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