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EXTERNALITIES, INFRASTRUCTURE GROWTH AND INDUSTRIAL PERFORMANCE IN INDIA: AN APPLICATION OF MALMQUIST PRODUCTIVITY INDEX

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Abstract: *The present paper endeavors to find the impact of infrastructure development on productivity and efficiency of major manufacturing industries in India by using the data of eight major manufacturing industries for the period of 1991-2012. The study found that there exists significant long-run relation between the TFP growth and infrastructure development in India. The TFP growth of Indian Manufacturing is growing at 6 percent approximately per annum whereas, the technical progress is found to be 6.6 percent. It has been found that infrastructure development has been positively and significantly influencing the TFP growth and technical efficiency of all the major manufacturing industries. The capital intensity, availability of capital per unit of labour, has positive impact on textile, chemicals, food and beverages, metal and metal products and in machinery industries on total factor productivity growth.*

Keywords: *Manufacturing Industry, Malmquist Productivity Index, Infrastructure,Data Envelopment Analysis*

Jel Classification: *L6, H54, D24*

INTRODUCTION

The importance of infrastructure growth and its effect on industrial performance, which is one of the major indicators of economic growth has been felt intensely both, by the researchers and policy makers, as it is considered to be one of the prime productivity stimulators. The planning commission of India has recognized infrastructure development core to economic policy in general and to industrial policy in particular. The planned industrial development of the country has given the top priority to development of infrastructure sector because of its long-term spillovers on the other sectors of economy. The development of infrastructure along with the optimum amount of infrastructural capacity assumes great importance for developing economy to industrialize its comparatively backward areas. It is well known that development of infrastructural sectors like electricity, coal, steel, petroleum and refinery products, cement, railways, roads, ports and inland

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transport etc. are to precede growth of other economic activities and hence investment in infrastructure has to be made in anticipation of future demand rather than as a reaction to capacity deficiency. The basis for such a thesis is that once infrastructural capacity is created, it results in a number of external economies which lead to further reduction in the cost of production. This provides a great fillip for utilizing the unutilized and under-utilised resources which would have otherwise remained unutilized for want of infrastructural facilities. (Ganguly & Sharma, 1988).

Manufacturing is an important sector in the Indian economy, comprising about 31 percent of the non-agricultural GDP. (Natarajan and Duraisamy 2008) This sector has gained strength in many ways over the past more than twenty years, as a consequence of liberalization and a gradual integration with the world economy. Important industries, for instance automobile components, pharmaceuticals, chemicals, textiles have recorded exceptional growth in terms of overall output, as well as in exports since the reforms period (since 1991). Although, the sector has witnessed a moderate increase in the last two decades, but, the TFP growth of this sector declined to less than 2 percent in the 1990s, from above 5 percent in the 1980s (Goldar and Kumari 2003). The recent estimates found only a marginal improvement of TFP growth in the 2000s (Sharma and Sehgal 2010; Kathuria *et. al* 2010) and related research, as well as government institutions like Planning Commission has recognize the infrastructure deficit as the most critical short-term obstacle to growth of the manufacturing sector.

The slowdown in industrial production and exports indicates that Indian industry is being constrained both by capacity bottlenecks and by institutional obstacles. Capacity bottlenecks could arise from lacking core infrastructure. Ahluwalia *et al.* (1991) have identified infrastructure problems as a main factor threatening the sustainability of economic recovery. Such bottlenecks create significant impediments to the expansion of industrial output. They considerably weaken the supply-side response and the export capacity of the Indian industry. Moreover weak social infrastructure, leading to a lack of skilled labor may be another factor limiting growth and productivity for Indian manufacturing. Improving productivity in manufacturing is an important challenge in India because without an adequate level of productivity, the country could remain a supplier of cheap-labor goods in global markets. This would hamper advances in living standards and could slow down progress in poverty alleviation. Moreover an adequate level of manufacturing productivity is needed both to attract foreign direct investment and to increase domestic investment so that industry may be developed in more backward areas. This will ensure a more balanced growth pattern in the economy.

In the theoretical literature, public infrastructure is considered to be a crucial factor of productivity and efficiency enhancement through external economies (e.g. Romer 1986; Lucas 1988; Barro and Sala-i-Martin 1995; Anwar 1995). Empirical findings on this issue, however, are inconsistent and often contrary to each other. Over the last two decades a large number of studies have focused on this issue. Most have noted that public infrastructure positively and sizably affects economic performance (Aschauer 1989; Munnel 1990a and b). Some others, for example Evans and Karras (1994) and Holtz-Eakin (1994), challenged these findings on methodological ground and showed insignificant or minimal impact of public infrastructure on economic growth.

Nevertheless, infrastructure provision enhances the production and promotes overall economic growth through the process that affects the cost structure and productivity in economy, therefore, it is imperative to study the interrelationships and dynamics of production and infrastructure. In available literature there are some studies *i.e.* Munnel (1992), Holtz-Eakin (1994), Shah (1992), Canning and Fay (1993), Nadiri and Mamuneas (1994), Mitra *et al.* (2002), Hulten *et al.* (2006) and Sharma and Sehgal (2010) have tried to explore quantitative link between productivity and infrastructure in India, with special reference to industrial productivity.

The key objective of this paper is to analyze the inter-temporal and inter-industry variations in the total factor productivity (TFP) growth of major manufacturing industries using the non-parametric Malmquist productivity index (MPI) and to check whether infrastructure have any spillover on the TFP growth. The main thrust of the study is to decompose the TFP growth into i) efficiency change and ii) technical change. In addition, the measure of efficiency change (ECH) has further been decomposed into two mutually exclusive and exhaustive events i) pure-efficiency change (PECH) and ii) scale efficiency change (SECH). The earlier component indicates the change in management efficiency, whereas the later explains changes in scale of production.

PRODUCTIVITY INDEX: A METHODOLOGICAL FRAMEWORK

TFP growth is defined as the residual growth in outputs not explained by the growth in input use. Two approaches i.e. non-parametric and parametric are extensively applied in recent literature to measure the TFP growth. The prominent indices of TFP growth measurement are Laspeyres, Paasche, Fisher and Tornquist which measure the changes in the level of a set of variables between a base period and current period. However the measuring productivity change by the Laspeyres, Paasche, Fisher and Tornquist indices require quantity and price information as well as assumptions about the structure of technology and the behavior of producers. Alternatively, change can be measured using Malmquist Productivity Index (MPI) (Malmquist 1953). The index was introduced into DEA literature by Caves, Christensen and Diewert (1982) and is based on Malmquist's proposal to construct indices as a ratio of distance functions for the use in consumption analysis.

Distance functions are representations of multi-output and multi-input technologies which require data only on input and output quantities (Fare *et al.* 1994). The selection of Malmquist productivity index over index number approaches is that former does not require any price information or technological and behaviourical assumptions (Coelli *et al*. 1998) Furthermore the MPI does not require the estimation of a representation of the production technology. This production technology may be a production frontier, or its dual, the cost frontier. However the choice depends on the problem to be analysed. A further advantage of MPI is that once production technology is estimated, one can decompose TFP change into its two mutually exclusive components i) technical change and ii) efficiency change. Moreover the MPI does not require a pre-specified optimizing criterion such as cost minimization or profit maximization.

Malmquist indices can be calculated using either parametric methods or linear-programming DEA- type methods. The methodology proposed by Fare *et al.* (1994) makes operational the principles of the Malmquist index with non-parametric methods. This method uses DEA to calculate the distance functions to produce the Malmquist TFP index and then decomposes this into technical change and efficiency change components.

The Malmquist index is defined using distance functions. Depending on the technology used as the reference, we can define a period *t*-based or a period *(t + 1)*-based Malmquist index. The period *t*-based Malmquist index is defined as

$$M_0^t = \frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} \tag{1}$$

Using the technology at *t + 1* as the reference, the period *(t + 1)* based Malmquist index is defined as:

$$M_0^{t+1} = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^t, y^t\right)} \tag{2}$$

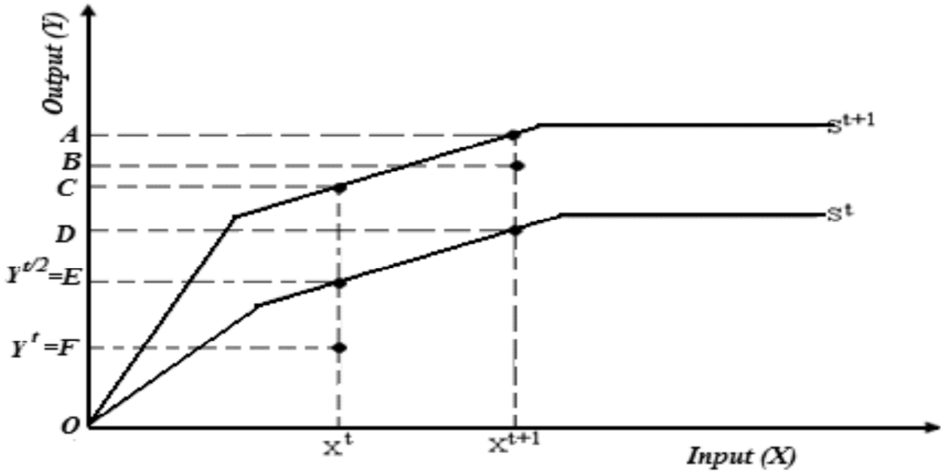
We can apply these definitions to measure productivity growth. An index greater than 1 as in our example means that productivity is growing and vice versa. For a frontier industry, productivity growth is equivalent to a shift in the frontier. A shift in the frontier upward and to the right can indicate technical progress, and this is captured by the Malmquist index with a value greater than 1 and vice versa. Similarly, improvements in any of the components of M_O are also associated with the values greater than unity of these components, and deterioration is associated with the values less than unity. It is pertinent to note that while the product of the 'technical efficiency change' and 'technological change' components is by definition equal M_O, those components may be moving in opposite directions. In other words, even if a sector experiences deterioration in efficiency, it could still end up with a positive growth in TFP, if the fall in its efficiency is smaller than the improvement in its technology.

This geometric mean of two Malmquist indices will be referred to here as the ''Fare index'' which is defined as:

$$M_0 = \sqrt{M_0^t * M_0^{t+1}} = \sqrt{\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} * \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^t, y^t\right)}} \tag{3}$$

Fare *et al*. (1994) showed that the Fare index could be decomposed into an efficiency change (catching up) component and a technical change component (frontier effect).

Figure 1: Separating TFPG in ECH and TECH



The catching-up effect measures how much close the industry is to the frontier by capturing the diffusion of technology or knowledge of technology use whereas the frontier effect measures the movement of the frontier between the two periods with regards to the rate of technology adoption. The efficiency change is defined as the ratio of output-oriented measure of Farrell technical efficiency between period *t* (given by OF/OE) and *t+1* (given by OB/OA) whereas the technical change or the shift in technology between the two periods, evaluated by taking the ratio of technology at time period t (given by OC/OE) and at time period *t+1* (given by OA/OD) in Figure 1.

Table 1 shows the decomposition for the three indices. The efficiency change component of the Malmquist indices measures the change in how far observed production is from maximum potential production between period *t* and *t + 1* and the technical change component captures the shift of technology between the two periods. It can be observed from the table that the efficiency change index is the same for all of the three Malmquist indices. The indices differ in the way they measure the shift in the frontier (technical change). The index M_0^t measures the shift in the frontier along a ray through the origin and the production point in *t + 1*. The index M_0^{t+1} measures the shift in the frontier through the production point in *t*. The technical change component of the Fare index is just the geometric mean of the technical change components in and . A value of the efficiency change component of the Malmquist index greater than 1 means that the production unit is closer to the frontier in period *t + 1* than it was in period *t* which indicates the production unit is catching up to the frontier. A value less than 1 indicates efficiency regress. The same range of values is valid for the technical change component of total productivity growth, meaning technical progress when the value is greater than 1 and technical regress when the index is less than 1.

Table 1
Decomposition of Malmquist Index

Index	*Efficiency Change*	*Technical Change*	*Characteristics*
Period 't' Based Malmquist	$\frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)}$	$\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}$	TECH measures the shift in the frontier along a ray through the production point in t+1.
Period t+1 Based Malmquist	$\frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)}$	$\frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}$	TECH measures the shift in the frontier along a ray through the production point in t.
Fare Index	$\frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)}$	$\sqrt{\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)} * \frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)}}$	TECH is the geometric mean of TECHCH in and M_0^{t+1}. EFCH is the same for the three indices.

Notes: i) Where Malmquist = EFCH*TECH; ii) EFCH measures the change in how far production is from maximum production; iii) TECH measures the shift in technology between the two periods evaluated at t+1, at t and at the geometric mean of t and t+1 (M_0).

Source: (See: A. Nin *et al.* (2003))

In order to calculate the M_0 for industry between *t* and *t+1* for a constant returns-to-scale (CRS) technology, the four different distance functions that make up the index, that is, $D_o^t\left(x^{k',t}, y^{k',t}\right)$, $D_o^{t+1}\left(x^{k',t+1}, y^{k',t+1}\right)$, $D_o^t\left(x^{k',t+1}, y^{k',t+1}\right)$, and $D_o^{t+1}\left(x^{k',t}, y^{k',t}\right)$ are required to be calculated using linear programming approach. For calculating output-oriented distance functions for the industry k', four different linear programming problems can be stated as:

$$\left.\begin{aligned}
&D_o^{t+j}(x^{k',t+j}, y^{k',t+j})^{-1} = \max\ \theta^{k'} \\
&\text{subject to} \\
&\theta^{k'} y_m^{k',t+j} \le \sum_{k=1}^{K} z^{k,t+i} y_m^{k,t+i}\ , && m = 1,\ldots,M; \\
&\sum_{k=1}^{K} z^{k,t+i} x_n^{k,t+i} \le x_n^{k',t+j}\ , && n = 1,\ldots,N; \\
&z^{k,t+i} \ge 0\ , && k = 1,\ldots,K.
\end{aligned}\right\} \tag{4}$$

where (i,j)=(0,0) for solving for $(D_o^t(x^{k',t}, y^{k',t}))^{-1}$;

(i,j)=(1,1) for solving for $(D_o^{t+1}(x^{k',t+1}, y^{k',t+1}))^{-1}$;

(i,j)=(0,1) for solving for $(D_o^t(x^{k',t+1}, y^{k',t+1}))^{-1}$; and

(i,j)=(1,0) for solving for $(D_o^{t+1}(x^{k',t}, y^{k',t}))^{-1}$.

In the above linear programming problems, $z^{k,t}$ is an intensity variable indicating the intensity at which a particular industry is employed in constructing the frontier of the technology set. The technology specified here is non-parametric but assumes constant *returns-to-scale* and strong disposability of inputs and outputs. In above formulation θ is the efficiency score and takes value between 0 and 1. Following Afrait (1972), one may allow for variable returns to scale (increasing, constant or decreasing) by having $\Sigma Z_k = 1$ as a restriction in all of the linear programs. Thus, by estimating the distance functions defined by model (8.10) along with the restriction $\Sigma Z_k = 1$, we can decompose the *EFCH* into pure efficiency change (PEFCH) and scale efficiency change (SEFCH) as follows.

$$EFCH = PEFCH * SEFCH \tag{5}$$

Where

$$EFCH = \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)};\ PEFCH = \frac{D_V^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_V^t\left(x^t, y^t\right)};\ \text{and}$$

$$SEFCH = \frac{D_C^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_V^{t}\left(x^{t+1}, y^{t+1}\right)} * \frac{D_C^{t}\left(x^{t}, y^{t}\right)}{D_V^{t}\left(x^{t}, y^{t}\right)}$$

Further, to investigate the impact of presence of infrastructure externalities on Indian manufacturing industries in long-run, the technique of panel data co-integration has been applied. Therefore, in the first step there is need to check for the statistical impurities generally arising from the non-stationary time series. In order to, avoid the spurious regression we need to check the order of the integration for the given time series variables. The order of integration is defined as the order of differencing at which a non-stationary variable becomes stationary. For the same generally the Augmented Dickey Fuller (ADF) and Phillip Peron (PP) statistics has been applied (Asteriou and Hall, 2007). However, when dealing with panel data, the estimation procedure is more complex than the ordinary time series. The crucial factor in panel data estimation appears to be the degree of heterogeneity as all the individuals in a panel may not have the same properties. So if we carry out a panel unit root test where some of the panel have unit root and some do not and the situation becomes more complex (Asteriou and Hall, 2007).

Testing for Unit-Root in Panel Data

In order to check for the presence of unit root, different panel data tests like, Levin, Lin and Chu (2002), Maddala and Wu (1999), and Im, Persaran and Shin (2003), have been suggested. However, Levin and Chu (LC), and Im, Persaran and Shin (IPS) test statistics are most widely used statistics to check the presence of unit root in panel data. In the present chapter, we apply the IPS test to check for the order of integration for our panel data variables included into the model The IPS overcomes the major drawback of the LL test which restricts the ρ to be homogeneous across all the cross-sectional units. The IPS test provides separate estimation for each *i* section, allowing different specifications of parametric values, the residual variance and lag length. Their model is given as:

$$\Delta Y_{it} = a_i + \rho_i Y_{i,t-1} + \sum_{k=1}^{n} \phi_k \Delta Y_{i,t-k} + \delta_i t + u_{it} \tag{6}$$

While now the null of $\rho_i = 0$ for all *i* against the alternative of $\rho_i < 0$ for at least one *i* has been formulated. Im, Persaran and Shin (1997) formulated their model under the restrictive assumption that *T* should be the same for all cross-sections, requiring a balanced panel to compute the $\bar{t}$ test statistics. Their $\bar{t}$ statistics is nothing else than the average of the individual ADF t-statistics for testing $\rho_i = 0$ for all *i* (denoted by t_{pi}):

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_{pi} \tag{7}$$

IPS (1997) also showed that under specific assumptions t_{pi} converges to a statistics denoted as t_{iT} which they assume finite mean and variance. They then computed values for the mean $(E[t_{iT} / \rho_i = 1])$ and for the variance $(Var[t_{iT} / \rho_i = 1])$ of the t_{iT} statistic for different values of N and lags included in the augmentation term in equation:

$$\Delta Y_{it} = a_i + \rho_i Y_{i,t-1} + \sum_{k=1}^{n} \phi_k \Delta Y_{i,t-k} + \delta_i t + \theta_t + u_{it} \tag{8}$$

Based on those values, they then constructed the IPS statistics for testing unit roots in panel data given by:

$$t_{IPS} = \frac{\sqrt{N}\left(\bar{t} - {}^{1}\!/_{N} \sum_{i=1}^{N} E[t_{it} / \rho_i = 0]\right)}{\sqrt{Var[t_{it} / \rho_i = 0]}} \tag{9}$$

which they have proved follows the standard normal distribution as $T \to \infty$ followed by $N \to \infty$ sequentially. Finally, they also suggested a group mean Lagrange multiplier test for testing panel unit root. The Monte Carlo simulations proved that both their LM and *t* statistics possess better finite sample properties than the LL test.

Testing for Co-integration in Panel Data

Further, if data is not stationary at their levels then one way of solving the problem of non-stationarity is to difference the time series data until stationarity is not achieved. However, this solution is not ideal. If we difference the variables then the model can no longer give a unique long-run solution (Asteriou and Hall, 2007). This problem can be resolved by applying Co-integration. Non-Stationary variables at levels are said are said to be co-integrated if any linear combination of these non-stationary variables provides us a series which is stationary at levels. This type of relationship is known as long-run relationship between these variables. Granger (1981) introduced a remarkable link between non-stationary processes and the concept of long-run equilibrium; this link is the concept of co-integration. Engle and Granger (1987) further formalized this concept by introducing a very simple test for the existence of co-integrating (i.e. long- run equilibrium) relationships. In such a case, after testing for the existence of co-integration, if it exist, it is necessary to form the model in the equivalent ECM (Error Correction Model) to get casual relationship between time series variables.

According to this approach, if the time series variables are integrated of same order, then the next step is to estimate the long-run equilibrium relationship via estimating the following equation and obtain the series of estimated residuals $(\hat{u}_t)$:

$$Y_t = \beta_1 + \beta_2 X_t + u_t \tag{10}$$

After, this check for the order of integration of the residuals by performing Dickey Fuller (DF) test on the residual series. The form of the DF test to check for stationarity of the residuals without any constant or time trend is given as in following equation:

$$\Delta u_t = a_1 \hat{u}_{t-1} + \sum_{i=1}^{n} \delta \Delta \hat{u}_{t-i} + v_t \tag{11}$$

If $\hat{u}_t$ is stationary at levels, i.e., $u_t \sim I(0)$, then we can reject the null hypothesis that the variables X_t and Y_t are not co-integrated. Thus, the Engle-Granger (1987) co-integration test is based on an examination of the residuals of a spurious regression performed using *I(1)* variables. If the variables are co-integrated then the residuals should be *I(0)*. On the other hand if the variables are not co-integrated then the residuals will be *I(1)*.

Pedroni (1999, 2004) and Kao (1999) extend the Engle-Granger concept of co-integration to time series involving panel data by proposing several tests that allow for heterogeneous intercepts and trend coefficients across cross-sections. Consider the following regression:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1it} + \beta_{2i} x_{2it} + \ldots + \beta_{Mi} x_{Mit} + e_{it} \tag{12}$$

for $t = 1, \ldots, T$; $i = 1, \ldots, N$; $m = 1, \ldots, M$; where y and x are assumed to be integrated of order one i.e., *I(1)*. The parameters α_i and δ_i are individual and trend effects which may be set to zero if desired. Under the null hypothesis of no co-integration, the residuals e_{it} will be *I(1)*. The general approach is to obtain residuals from Equation (12) and then to test whether residuals are *I(1)* for each cross-section. Pedroni describes various methods of constructing statistics for testing for null hypothesis of no co-integration $\rho_i = 1$. There are two alternative hypotheses: the homogenous alternative, $(\rho_i = \rho) = 1$ for all i (which Pedroni terms the within-dimension test or panel statistics test), and the heterogeneous alternative, $\rho_i < 1$ for all i (also referred to as the between-dimension or group statistics test).

Technical Efficiency and TFP growth in Indian Manufacturing Sector: Empirical Results

As the Malmquist Productivity Index is related to measure of Technical Efficiency, therefore, using the abovementioned data set, the value of technical efficiency has been worked out. Table 2 provides the Geometric Mean of the components of overall technical efficiency for major eight infrastructure industries which worked out to be 0.892 which shows nearly 11 percent technical inefficiency exists among major manufacturing industries in India. Alternatively, the input employed in manufacturing industries could have been contracted by 12 percent (1-1/TE*100). The average output loss due to scale inefficiency was 8.92 percent for the entire study period which implies by improving the scale of industries the output could be improved by nearly 9 percent.

The inter-industry analysis of overall technical efficiency depicts that the food and beverage industries has been observed to be the best practice industry with an average overall technical efficiency score 0.931. In comparison to food and beverage industry the Metal and Metal Products industry is the worst performer among major eight manufacturing industries with an Overall Technical Efficiency score 0.858 which implies that there exists 14.2 percent output loss in Metal and Metal Products due to technical inefficiency. However, OTE for food and beverages, chemicals and Textiles industry is more than 90 percent whereas non-metal, metal and metal products, machinery and transport industries have inefficiency more than 10 percent in entire study period. It is worth mentioning that the efficiency level in beginning of the study period among food and beverage, chemical, miscellaneous, Metal and Metal products was high as compared to other industries which implies that the pro-market reforms have helped in increasing the Technical Efficiency of these manufacturing industries.

Table 2
Inter-Industry Variations in Technical Efficiency in Major Infrastructure Industries in India

		Overall Technical Efficiency	*Pure Technical Efficiency*	*Scale Efficiency*
1	Food & Bevg.	0.931	0.981	0.913
2	Textiles	0.926	0.978	0.929
3	Chemicals	0.913	0.961	0.914
4	Non-Metallic	0.882	0.935	0.912
5	M&M Products	0.858	0.925	0.900
6	Machinery	0.878	0.943	0.913
7	Transport	0.887	0.955	0.896
8	Miscellaneous	0.882	0.965	0.910

Notes: i) M&M represents Metal and Metal Products Industry; ii) Entire period averages are Geometric Means of i^{th} industry for period of 1990-91 to 2011-12.

Source: Author's Calculations

According to technical efficiency estimates Indian manufacturing industries can be grouped into three types with high technical efficiency score on top i.e. greater than 0.9, the middle technical efficiency group between 0.85 to 0.9 and, finally low technical efficiency group with less than 0.85 score.

Table 3
Performance and Distribution of Indian Manufacturing Industries

High Performing Industries (1≤Tech. Efficiency<0.9)	*Moderate Industries (0.9≤Tech. Efficiency<0.85)*	*Low Performing Industries (0.85≤Tech.Efficiency<0)*
i) Food and Bevg. (0.931) ii) Textiles (0.926) iii) Chemicals (0.913)	i) Non Metallic (0.882) ii) M&M Products (0.858) iii) Machinery (0.878) iv) Transport (0.887) v) Miscellaneous (0.882)	Nil

Source: Author's Calculations

There is a considerable gap in technical efficiency between high efficiency group and low efficiency group, suggesting unbalanced growth between different manufacturing industries in India. As the Indian manufacturing industries consist of small number of mega sized firms equipped with advance technologies, skilled manpower and access to foreign capital and large number of small and medium enterprises, even though, the large firms are utilizing frontier production technology, the number of firms is very small as compared to those which are operating far below the production frontier. Thus overall technical efficiency not only reflects the composition of Indian manufacturing sector but also the wide technical gap between frontier large firms and lagging small firms.

Sources of OTE in Major Indian manufacturing Industries

It has been theoretically observed that OTE can further be decomposed into pure technical efficiency and scale efficiency. The pure technical efficiency or managerial efficiency is a measure of managerial performance whereas scale reflects the choice of optimum scale of production. Therefore, pure technical efficiency is a devoid of scale effect and can be measured subject to the assumption of varying returns to scale.

The visualization of Table 2 reveals that approximately 5 percentage point of 9 percent of OTE has been contributed by scale factors and the remaining inefficiency caused by managerial sub-performance. Hence it is evident from these facts that the scale inefficiency is major source of overall technical inefficiency in major Indian manufacturing industries. It suggests that there is need to increase or decrease the size of scale in order to reap the economies of scale and operate on efficiency frontier. inter-industry analysis of pure technical efficiency reveals that all the major infrastructure industries have managerial efficiency more than 90 percent with food and beverages industry on top with score of 0.981 and succeeded by textile and chemical industries with score of 0.978 and 0.961 respectively. Whereas on the other side the highest level of managerial inefficiency found in Metal and Metal products industry tunes to approximately 8 percent whereas transport, miscellaneous industry, chemical and non-metallic industries have shown the intermediate performance in managerial efficiency with the score ranging between 0.94 to 0.96.

The analysis regarding scale efficiency reflects that the scale inefficiency varies from 11 percent in transport sector to 9 percent in chemical industry. Among the major eight infrastructure industries, it is of worth mentioning here that except transport, all other have inefficiency level less than 10 percent. Moreover, the scale efficiency is found to decline in machinery, transport, Metal and Metal Products and miscellaneous industries, whereas it has improved in food and beverage, textiles and chemical industries. It has been theoretically said that such an improvement in food and beverages industry may be attributed to existence of large number of small and medium enterprises and their catching up towards foreign technology in post liberalised regime. On the other side the size of scale efficiency has improved because of enhanced investment in capital goods leading to increase in productivity of labour owing to more capital per unit of labour, greater capacity utilization in food and beverage industry (Ali, 2009).

However, the decline of scale efficiency among the above mentioned industries raised the question, "Why efficiency decline despite the market reforms, huge investment inflows etc."? The failure of Indian manufacturing industries to achieve catch-up will lead to increase in inefficiency in post-reform period. As, increase in investment in India does not lead to export penetration and was instead, oriented mainly towards domestic markets and at the same time penetration of foreign manufacturing firms in Indian market coupled with grater inflows of FDI particularly in post liberalised regime added great competitive pressures to the domestic firms and at the same time forced the domestic firms to squeeze their market shares (Geng. N., 2011).

Total Factor Productivity growth among Indian Manufacturing Industries

The calculation of Malmquist Productivity Index (Table 4 &5) reveals that the productivity in Indian Manufacturing has been observed increasing at 6 percent approximately per annum. The inter-industry analysis of TFP growth shows that the Metal and Metal Products industries have registered growth at 9.6 percent and 8.9 percent respectively, whereas transport sector registered 6 percent growth. The TFP growth was slowest in food and beverages industry to the tune of 1.9 percent followed by the textile sector and non-metallic industries with 4.6 percent and 5.9 percent respectively. In other industries the range of TFP growth lies in between 5 to 8 percent per annum. The increase in TFP growth has been found in almost all the major manufacturing industries.

The increase was led by machinery followed by Metal and Metal Products, transport and miscellaneous industries, thus forms the top tier industry group with the fast growing TFP, while the second tier industry consists of non-metallic, chemical and textile industries with the food and beverages industry in tier third because of sluggish TFP growth. It may be noted that the TFP growth has shown negative trend in early 1990's may be due to the immediate adverse effect of investment on productivity due to gestation lag. Further, based on the analysis of productivity for various industry groups it has been observed that the TFP has shown downward trend after 1995 *i.e.* post WTO period particularly in food beverage, chemical and non-metal minerals industries. The opening of world markets with the slow catching-up with new technology given the less expenditure on R&D may be attributed to such fall in productivity of these industries. However, in case of textile industry the evidence is mixed one.

Table 4
Inter-Industry Variations in TFP Growth and Technical Change in Major Infrastructure Industries in India

		TFP Growth	*Technical Change*
1	Food & Bevg.	1.019	1.017
2	Textiles	1.046	1.054
3	Chemicals	1.047	1.044
4	Non-Metallic	1.059	1.068
5	M&M Products	1.089	1.082
6	Machinery	1.096	1.114
7	Transport	1.061	1.079
8	Miscellaneous	1.064	1.073
9	All Industries	1.059	1.066

Notes: i) M&M represents Metal and Metal Products Industry; ii) Entire period averages are Geometric Means of i^{th} industry for period of 1990-91 to 2011-12.
Source: Author's Calculations

The decomposition of TFP growth into technical progress and efficiency change reveals that the manufacturing industries have a 6.6 percent technical progress from1991-92 to 20011-12. The inter-industry analysis reveals that machinery industry has shown the highly technical progress about 11 percent in the entire study period. The metal and metal products have technical progress to the tune of 8.2 percent followed by transport industry with score of 7.9 percent whereas, the food and beverage industry remain at back with a small and significant score of 1.7 percent.

The efficiency change (Table 6) in major infrastructure industries in India reveals that machinery, transport are the front runner industries in catching up while metal and metal products industry followed by non-metallic industry and miscellaneous industry have shown significant progress in catching up. The decomposition of efficiency change into pure efficiency change and scale efficiency, reveals that all the major infrastructure industries have pure efficiency score either 1 or near to one. The direct connotation of this result is that entire catching up is reflected by scale efficiency change or alternatively the entire change in efficiency change is contributed by scale efficiency change. Therefore, the major manufacturing industries have tendency to realize there impurities by 'learning-by-doing' process and thus, they may downsize or increase the scale of production accordingly in the next period.

The inter-industry and inter-temporal analysis of efficiency change explains that the transport, machinery industries have shown maximum catching up whereas food and beverages industry, chemical, textile industry have shown little progress in catching up to the technology. The miscellaneous metal and metal product industries have shown intermediate progress in the entire study period. The inter-industry analysis of decomposition of efficiency change into managerial efficiency change and scale efficiency change reveals that almost all the industries have score equal to one in the entire study period. This explains the 100 percent catching up in managerial efficiency change. The scale efficiency change varies between different industries ranging between 12 percent in transport to -8 percent in chemical industries. As pure efficiency change is equal to one or nearly one among all the infrastructure industries thus 100 percent catching up in overall efficiency change is mainly contributed by scale efficiency change. The transport and machinery industries have shown maximum catching up in scale efficiency change whereas food and beverage, chemical and textile industries have shown little progress in catching up. As the miscellaneous industry have scale efficiency change and pure efficiency change are equal to unity, thus, the entire total factor productivity growth is contributed by technical progress.

The next section attempts to analyse the spillover effects of infrastructure across Indian manufacturing industries. The presence of externalities of infrastructure enable the domestic firm to use new channels of technology and the effect is present in the form of enhanced efficiency and total factor productivity growth. For the same Pedroni (2000) heterogeneous group mean panel co-integration statistics test has been utilized to estimate a long run relationship between endogenous variables and infrastructure index pertaining to infrastructure spillover across Indian manufacturing industries. A preliminary step in this is to test the stationarity of series therefore, in order to examine the long run relationship between infrastructure, externalities and Total Factor Productivity growth. The presence of unit root in aforementioned variables has been tested using IM, Pesaran and Shin (IPS) panel unit root test. The testing of presence of unit root is essential because of *i)* to get exact order of integration so as to get rid of problem of spurious regression; *ii)* to check the existence of co-integrating relationship (*i.e.* long run) between infrastructure development and TFP growth of major manufacturing industries of India; and *iii)* to identify the relevant policy variables for augmenting TFP growth and technical efficiency of Indian manufacturing industries. Further, the presentation of results pertaining to IPS panel unit root test (Table 7) reveals that

Table 5

Inter-Industry Variations in Total Factor Productivity Growth and Technical Change In Major Infrastructure Industries in India

Years	*Industries*															
	Food & Bevg.		*Textiles*		*Chemicals*		*Non-Metallic*		*M&M Products*		*Machinery*		*Transport*		*Miscellaneous*	
	TFP	*TC*	*TFP*	*TC*	*TFP*	*TC*	*TFP*	*TC*	*TFP*	*TC*	*TFP*	*TC*	*TFP*	*TC*	*TFP*	*TC*
1991/92	0.838	0.834	0.839	0.850	0.894	0.854	0.909	0.909	1.005	0.941	0.983	0.988	1.064	1.008	1.014	1.014
1992/93	1.029	1.003	0.993	0.993	0.989	0.981	1.201	1.201	1.141	1.149	1.129	1.123	1.124	1.139	1.056	1.056
1993/94	1.028	1.028	1.007	0.994	0.953	1.058	0.838	0.899	0.873	0.932	0.998	1.165	1.008	1.187	1.021	1.184
1994/95	0.987	0.987	0.902	1.129	0.919	0.919	1.018	1.174	1.004	1.343	0.992	1.273	1.229	1.169	1.137	1.233
1995/96	1.002	1.002	1.152	0.939	1.172	1.056	1.315	1.063	1.338	0.954	1.445	1.011	0.95	0.888	0.989	0.974
1996/97	0.915	0.922	1.109	1.252	1.074	1.006	0.958	1.186	0.948	1.099	0.902	1.038	0.985	1.297	0.998	0.906
1997/98	0.986	1.308	1.184	1.262	1.009	1.328	1.026	1.185	1.433	1.625	1.268	1.215	1.039	0.765	1.244	1.477
1998/99	1.016	0.937	1.022	1.063	0.982	1.113	1.039	1.015	0.974	0.808	0.916	0.825	0.948	0.921	1.184	0.887
1999/00	1.124	0.912	1.056	0.878	1.193	1.030	1.069	1.073	1.269	1.127	1.037	1.037	0.981	1.100	1.038	1.311
2000/01	0.895	1.025	1.019	1.086	0.903	1.118	0.96	1.095	1.078	1.583	1.048	1.343	0.995	1.105	1.013	1.026
2001/02	1.034	1.009	0.937	0.941	1.078	1.081	1.152	0.978	1.035	0.789	1.242	1.068	1.167	1.091	1.058	1.075
2002/03	1.042	0.933	1.128	1.042	1.046	0.855	0.997	1.014	0.943	1.001	1.053	1.066	1.028	1.020	1.045	0.897
2003/04	1.089	1.207	1.126	1.222	1.244	1.458	1.156	1.249	1.264	1.351	1.292	1.267	1.204	1.156	1.171	1.319
2004/05	1.025	1.161	1.158	1.150	1.009	1.148	1.079	1.228	1.083	1.083	1.208	1.280	1.249	1.241	1.037	1.029
2005/06	1.157	0.921	1.058	0.954	1.049	0.827	1.029	0.866	1.086	1.129	1.079	1.229	1.106	1.255	1.017	1.121
2006/07	1.039	1.250	1.008	1.169	1.041	1.076	1.102	1.051	1.173	0.944	1.136	0.892	1.095	0.956	1.073	1.006
2007/08	1.129	1.054	1.102	1.073	1.134	1.129	1.058	1.112	1.092	1.243	1.086	1.256	0.948	0.997	0.919	0.952
2008/09	1.056	0.940	1.066	0.959	1.064	0.952	1.037	1.038	1.027	1.025	1.006	1.148	1.035	1.204	1.065	1.075
2009/10	1.048	1.171	1.148	1.054	1.078	1.097	1.031	1.054	1.145	1.101	1.074	0.973	1.023	1.076	1.072	1.009
2010/11	1.127	1.128	1.045	1.037	1.045	1.034	1.078	1.073	1.099	1.094	1.062	1.107	1.089	1.002	1.024	1.112
2011/12	1.098	1.007	1.102	1.102	1.038	1.084	1.056	1.002	1.108	1.075	1.104	1.142	1.073	1.092	1.036	1.092
Entire Period#	1.019	1.017	1.046	1.053	1.047	1.044	1.059	1.068	1.089	1.082	1.096	1.114	1.061	1.079	1.064	1.073

Notes: i) The above values of TFP growth are calculated by using index $M_0 = \sqrt{M_0^t * M_0^{t+1}} = \sqrt{\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)} * \frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^t, y^t\right)}}$ where, the distance functions of this index are calculated by using DEAP software; ii) M& M represents Metal and Metal Products Industry; iii) Entire period averages are Geometric Means of i^{th} industry for period of 1990-91 to 2011-12.

Source: Author's Calculations

Table 6
Inter-Industry Variations in Efficiency Change in Major Infrastructure Industries in India

	Industries											
Years	*Food & Bevg.*			*Textiles*			*Chemicals*			*Non-Metallic*		
	OTECH	*PECH*	*SECH*	*OTECH*	*PECH*	*SECH*	*OTECH*	*PECH*	*SECH*	*OTECH*	*PECH*	*SECH*
1991/92	1.005	1.025	0.981	0.987	0.992	0.995	1.046	1.022	0.983	1.000	0.993	0.979
1992/93	1.026	1.000	1.026	1.000	1.008	0.992	1.008	1.006	0.980	1.000	1.109	1.021
1993/94	1.000	0.981	0.896	1.013	0.949	0.932	0.901	0.959	1.004	0.932	0.878	0.953
1994/95	1.000	0.956	1.051	0.815	0.993	0.940	1.000	0.948	1.075	0.867	0.953	1.013
1995/96	1.000	0.951	1.062	1.227	0.976	1.124	1.110	1.020	0.906	1.238	1.087	0.924
1996/97	0.992	0.978	0.918	0.886	0.945	0.984	0.998	1.022	1.068	0.808	1.049	0.948
1997/98	0.754	1.147	0.815	0.938	1.152	0.869	0.963	1.056	0.908	1.063	0.906	1.174
1998/99	1.084	1.000	1.084	0.961	1.000	0.961	0.882	0.877	1.123	1.023	1.156	0.885
1999/00	1.233	1.000	1.233	1.203	1.000	1.203	1.158	1.140	1.016	0.997	1.000	0.997
2000/01	0.873	1.000	0.873	0.939	1.000	0.939	0.808	0.899	0.898	0.877	0.873	1.005
2001/02	1.025	1.000	1.025	0.996	1.000	0.996	0.997	1.026	0.973	1.178	1.124	1.049
2002/03	1.117	1.000	1.117	1.082	1.000	1.082	1.224	1.085	1.128	0.983	1.016	0.967
2003/04	0.902	1.000	0.904	0.922	0.998	0.924	0.853	1.000	0.853	0.926	1.003	0.923
2004/05	0.882	1.000	0.881	1.007	1.002	1.004	0.879	1.000	0.879	0.879	0.948	0.927
2005/06	1.256	0.992	1.173	1.109	1.000	1.109	1.269	0.923	1.375	1.188	0.953	1.246
2006/07	0.831	1.008	0.890	0.862	1.000	0.862	0.967	1.054	0.918	1.049	1.107	0.937
2007/08	1.071	1.000	1.071	1.044	0.925	1.129	1.004	0.996	1.009	0.951	0.869	1.107
2008/09	1.124	1.000	1.124	1.111	1.081	1.028	1.117	1.032	1.082	0.999	1.117	0.895
2009/10	1.000	1.000	1.042	1.000	1.076	1.032	1.212	1.025	1.068	0.955	1.012	0.935
2010/11	1.087	1.000	1.112	1.026	1.025	1.000	1.022	1.212	1.076	0.963	1.118	0.839
2011/12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.076	1.043	1.088	1.002	0.933

	M&M Products			*Machinery*			*Transport*			*Miscellaneous*		
	OTECH	*PECH*	*SECH*	*OTECH*	*PECH*	*SECH*	*OTECH*	*PECH*	*SECH*	*OTECH*	*PECH*	*SECH*
1991/92	1.068	1.019	1.005	0.995	0.970	0.923	1.056	0.972	1.007	1.000	0.996	1.004
1992/93	0.993	1.120	0.916	1.005	1.041	1.074	0.987	1.019	1.050	1.000	1.004	0.996
1993/94	0.937	0.914	1.018	0.857	0.941	0.911	0.849	0.858	1.102	0.862	0.870	0.991
1994/95	0.748	0.964	0.996	0.779	0.962	0.932	1.051	1.055	0.996	0.922	1.025	0.899
1995/96	1.402	1.012	1.085	1.430	0.954	1.167	1.070	0.902	0.977	1.015	1.035	0.981
1996/97	0.863	1.054	0.913	0.869	1.038	0.934	0.759	1.094	0.844	1.102	0.950	1.160
1997/98	0.882	0.933	0.945	1.043	0.987	1.058	1.358	1.131	1.200	0.843	1.008	0.835
1998/99	1.205	1.025	1.176	1.110	1.131	0.911	1.029	1.000	1.029	1.335	1.131	1.181
1999/00	1.126	1.112	1.012	1.000	0.950	1.015	0.892	0.985	0.906	0.792	0.995	0.796
2000/01	0.681	0.897	0.759	0.780	0.898	0.970	0.900	0.963	0.934	1.101	1.005	1.095
2001/02	1.311	1.088	1.206	1.163	1.166	0.997	1.070	1.054	1.015	0.984	1.000	0.984
2002/03	0.942	0.992	0.950	0.987	0.990	0.998	1.008	0.992	1.016	1.166	1.000	1.166
2003/04	0.936	1.033	0.906	1.020	1.015	1.005	1.042	1.008	1.033	0.888	1.000	0.888
2004/05	1.000	0.925	1.081	1.000	1.000	1.000	1.007	1.000	1.007	1.008	1.000	1.008
2005/06	0.962	0.950	1.012	0.878	0.895	0.981	0.881	0.923	0.955	0.907	1.000	0.907
2006/07	1.243	1.138	1.093	1.274	1.117	1.141	1.145	1.083	1.057	1.067	0.990	1.078
2007/08	0.879	0.829	1.061	0.865	0.884	0.978	0.951	0.984	0.966	0.965	0.991	0.974
2008/09	1.002	1.154	0.868	0.876	1.059	0.828	0.860	0.967	0.889	0.990	0.961	1.031
2009/10	1,000	1.107	0.953	0.895	1.073	0.974	0.933	0.953	0.937	0.963	1.000	1.007
2010/11	1.053	1.093	0.992	0.967	1.067	0.953	0.975	0.993	0.997	0.942	1.000	1.027
2011/12	1.048	1.127	0.936	0.925	1.088	0.927	0.984	0.937	0.974	0.952	1.000	1.083

Source: Author's Calculations

for all the individual series the hypothesis of unit root cannot be rejected at level or alternatively the variables are found to be non-stationary at the levels. However all the variables attain stationarity after the first level differencing.

Table 7
IM, Pesaran and Shin (IPS) Panel Unit Root Test

Variables	*Without Trend*		*With Trend*		*Order of Integration*
	At Level	*1st Difference*	*At Level*	*1st Difference*	
LNTFP	0.112	-4.35*	0.171	-4.37*	I(1)
LNTE	1.473	-3.27*	-1.532	-4.63*	I(1)
LNINFRA	1.047	-5.24*	1.203	-4.23*	I(1)
LNKL	1.224	-2.55*	1.262	-3.05*	I(1)
LNRDIN	1.063	-3.10*	-1.421	-5.43*	I(1)

Notes: i) The critical values for the panel unit root test at the 1 percent and 5 percent levels of significance are -2.326 and -1.645, respectively; and ii) * denotes significant at 5 percent level.
Source: Author's Calculations

Table 8 provides the long run dynamics i.e. co-integration analysis to ascertain the existence of long run relationship between infrastructure index and TFP growth of Indian manufacturing industry. For the same Pedroni (1999) heterogeneous group mean panel co-integration statistics test has been used to explore the existence of long run relationship between TFP growth and major policy variables. It has been observed that out of four alternative statistics, three statistics reveal the existence of co-integration. In the other model two statistics support the existence of co-integration between the above mentioned variables.

After the, confirmation of a linear combination between the variables in the long run, the individual long run estimates for equations $Ln(TFP) = \alpha + \beta Ln(INFRA) + \delta_{it} + e_{it}$ and $Ln(TE) = \alpha + \beta Ln(INFRA) + \delta_{it} + e_{it}$ has been estimated. Considering the fact that OLS estimators are biased and inconsistent when applied to co-integrated panels therefore, we utilize the 'group mean' panel Fully Modified OLS (FMOLS) estimators developed by Pedroni (2001).

Table 8
Pedroni Test of Co-integration

Statistics	*Ln(TFP), Ln(INFRA), Ln(K/L), Ln(RDIN)*	*Ln(TE), Ln(INFRA), Ln(K/L), Ln(RDIN)*
Panel v-Statistic	-2.732	1.732
Panel rho-Statistic	-5.824*	-7.824*
Panel PP-Statistic	-9.353*	-6.353*
Panel ADF-Statistic	-11.783*	-2.783

Notes: i) * denotes significance at 5 percent level
Source: Author's Calculations

The FMOLS method is able to accommodate considerable heterogeneity across individual members of the panel. Indeed, one important advantage of working with a cointegrated panel approach of this type is that it allows pooling the long run information contained in the panel while permitting the short run dynamics and fixed effects to be heterogeneous among different members of the panel. An important convenience of the fully modified approach is that it produces unbiased estimators and nuisance parameter free standard normal distributions.

The impact of infrastructure, capital intensity and research and development intensity on total factor productivity growth has been tested on eight major infrastructure industries and results have been interpreted accordingly. It has been estimated that the infrastructure development index has positive and significant impact on all the major manufacturing industries. Out of them transport, miscellaneous manufacturing, metal and metal products are front runners in terms of relationship between infrastructure development index and TFP growth whereas the capital intensity which could be defined as the ratio of total capital stock to labour expenses has positive impact on all major infrastructure industries except chemical industry. This means the availability of capital per unit of labour leads to enhancement of efficiency and thereby factor productivity in these industries. Thus, it advocates the policy of increase in capital stock upto the point where diminishing returns to scale starts. Further, the variable research and development intensity defined as a percentage expenditure on R&D of net turnover, has positive impact on non-metallic minerals industry and metal and metal products industry. Most of the industries donot incur much expenditure on R&D, hence it has no significant impact on TFP in food and beverage, transport equipment and Non metal mineral industries. It is pertinent to note that low expenditure on R&D may lead to late adoption of new channels of technology by the Indian industries particularly in chemical, machinery and metal and metal product industries, which may ultimately reduce the spillover of infrastructure on Indian industries.

Therefore, a serious attention must be diverted towards the promotion of R&D among Indian industries. Moreover, the analysis pertaining to the impact of infrastructure on technical efficiency depicts that development of infrastructure has positive and significant impact on efficiency of all major infrastructure industries. The development of infrastructure in terms of roads, railways, airways, ports, power generation, etc. lead to greater mobilization of resources in the economy which in turn have positive impact on resource use in manufacturing industries. The addition of infrastructure stock in the economy enables the industries to explore the untapped markets and thereby expand their scale of production. Therefore, the policy of development of infrastructure may be supported along with its effective utilization to augment the total factor productivity growth among manufacturing industries in India.

Table 9
FMOLS Estimation for the Impact of Infrastructure on TFP and TE

S.No	*Industry*	*Infrastructure Index*	*Capital Intensity (K/L)*	*R&D Intensity*
Dependent Variable: Total Factor Productivity (Ln (TFP))				
1	Food and Beverage	0.142**	3.764**	0.043
		(4.363)	(3.526)	(1.249)
2	Chemical	0.0523**	(-) 2.13	0.275**
		(2.635)	((-) 1.613)	(3.943)
3	Machinery	0.172**	2.171**	0.305**
		(3.265)	(2.389)	(3.483)
4	Metal and Metal Products	0.232**	1.755*	0.654
		(4.326)	(2.192)	(0.873)
5	Non Metallic Mineral Products	0.182**	1.083**	0.054
		(3.229)	(3.298)	(1.547)
6	Textile	0.257**	0.784	0.037**
		(8.762)	(1.653)	(2.726)
7	Transport Equipments	0.356**	1.064**	(-) 0.534
		(7.388)	(2.937)	(0.738)
8	Miscellaneous Manufacturing	0.325*	0.875**	0.076
		(2.256)	(4.926)	(1.493)
Dependent Variable: Technical efficiency (Ln (TE))				
1	Food and Beverage	0.093**	1.893**	0.728*
		(3.531)	(5.273)	(2.142)
2	Chemical	0.1109**	(-) 1.432*	0.231**
		(3.631)	((-) 2.133)	(4.243)
3	Machinery	0.214**	2.321**	0.409**
		(3.993)	(4.382)	(4.833)
4	Metal and Metal Products	0.363**	1.359	0.879
		(5.304)	(1.269)	(1.277)
5	Non Metallic Mineral Products	0.247**	0.093**	0.149
		(2.349)	(2.946)	(1.263)
6	Textile	0.389**	0.382**	0.084*
		(4.743)	(2.695)	(1.723)
7	Transport Equipments	0.538	0.082*	0.467
		(1.388)	(1.962)	(1.268)
8	Miscellaneous Manufacturing	0.425**	0.983**	0.104*
		(3.018)	(5.438)	(2.013)

Note: * and **represents the value is significant at 5 percent and 1 percent level of significance respectively.

Source: Author's Calculations

CONCLUSION

India being a fast growing economy of the world has much interest in improving productivity and efficiency because of immense global competition for her industries therefore, putting more efforts towards infrastructure development in recent times. The present paper has endeavored to find the impact of infrastructure development on productivity and efficiency of major manufacturing industries in India. The study reveals that there exists a significant long-run nexus between the total factor productivity growth of manufacturing industries and infrastructure development in India. The analysis pertaining to TFP growth explains that the productivity in Indian Manufacturing has growing at 6 percent approximately per annum. The inter-industry analysis of TFP growth shows that the Metal and Metal Products industries have registered highest growth at 9.6 percent whereas slowest one is in food and beverages industry to the tune of 1.9 percent. The search for important components of TFP growth depicts that the manufacturing industries are achieving technical progress to the tune of 6.6 percent per annum. The efficiency change in major infrastructure industries in India reveals that machinery, transport are the front runner industries in catching up while metal and metal products industry followed by non-metallic industry and miscellaneous industry have shown significant progress in catching up. The decomposition of efficiency change into pure efficiency change and scale efficiency, reveals that all the major infrastructure industries have pure efficiency score either 1 or near to one. Thus, the entire change in efficiency change is contributed by scale efficiency change. In other words the major manufacturing industries have tendency to realize there impurities by 'learning-by-doing' process and thus, they may downsize or increase the scale of production accordingly in the next period.

Further, infrastructure development has been positively and significantly influencing the TFP growth and technical efficiency of all the major manufacturing industries. The capital intensity, availability of capital per unit of labour, has positive impact on textile, chemicals, food and beverages, metal and metal products and in machinery industries on total factor productivity growth. The R&D intensity is not significantly affecting the TFP in food and beverage, transport equipment and Non-metal mineral industries. As it is proxy of technology adoption the less focus on it ultimately reduces the spillover of infrastructure on other Indian industries. Therefore, a serious attention must be paid towards the promotion of R&D among Indian industries. Moreover, the analysis pertaining to the impact of infrastructure on technical efficiency expresses the positive impact of development of infrastructure on technical efficiency of all major manufacturing industries. Therefore, the policy of development of infrastructure may be supported along with its effective utilization to augment the total factor productivity growth among manufacturing industries in India.

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