IMPACT OF TRADE LIBERALIZATION ON PRODUCTIVITY GROWTH OF MANUFACTURING SECTOR: EVIDENCE FROM A NON-PARAMETRIC APPROACH WITH INDIAN DATA

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This paper explains the impacts of trade-liberalization and some technological-socio-economic variables on total-factor-productivity-growth of Indian Manufacturing. Productivity growth is measured by Malmquist-Productivity-Index, using non-parametric Data-Envelopment-Analysis. The study highlights intra-industrial differences in total-factor-productivity-growth exhibiting annual average of 3.90%. Decomposition of Malmquist-Index reveals that technical-change is the prime source of productivity increase. There is absence of unanimous relationship within industries. Lowering of tariff and relative adjustment of real effective exchange rate has contributed positively to productivity growth. Out of seventeen industries favorable effects of effective-protection, import-coverage-ratio, import-penetration-ratio and real effective exchange rate were felt on productivity growth of two, three, two and four industries respectively. Increase in productivity growth was also felt through increase in firm-size, real wage, increase in rate of real wage and lowering of the number of employees per worker. The need for undertaking industry-specific policies for promoting productivity growth is thus highlighted

Key Words: Trade Liberalization; Total Factor Productivity Growth; Manufacturing Sector; Non-parametric Approach

JEL Classification: F13; O49; L60; C14

I. INTRODUCTION

Industry has a major role to play in the economic development of underdeveloped countries. Industrial development process should be designed properly to achieve economic development. For any country, which wants to perform in their industrial sector, needs to enhance its cost competitiveness by fostering Total Factor Productivity Growth (TFPG). Naturally measurement of the rate of Total Factor Productivity (TFP) changes in manufacturing industries and identifying the factors, which account for productivity changes, are of great interest- both in academic and practical senses.

Manufacturing industries in developing countries rely heavily on imported intermediate inputs and sophisticated technology. Availability of both these factors also plays a crucial role in the variation in productivity of concerned industry. Since 1991, India has adopted the policies of trade liberalization and significant changes have been made in industrial policies through various reform programs. A related question may be what is the impact of trade liberalization on TFPG of Indian manufacturing sector? Answer to this question is also very important for framing appropriate policies for boosting up industrial growth of India (a developing country) in the context of changed scenario. In the early phases of industrialization, the productivity in Indian manufacturing sector was limited by the Government policies, such as, the reservation of production(a large amount of production items for small scale sector), high custom tariff - distorting resource allocation and prohibiting Indian industry's ability to compete in the international market, shutting down industries in response to normal competitive market forces and various types of distortions created by the structure of domestic trade taxes and excise duties. However, the situation is gradually changing since 1991 due to the introduction of trade and import liberalization policies by Government of India. Over the years several measures were undertaken by them for boosting up the industrial productivity. Tariff rates have considerably been brought down; quantitative restrictions on imported goods have been removed to a great extent. These were adopted along with changes in technology-import policy, foreign direct investment policy, to make Indian industrial sector more efficient and productive, technologically sounder and an able-competitor in front of world market.

Theoretically, favorable effects of import liberalization on TFPG of industrial productivity are supported. Positive effect of trade liberalization on TFPG of different manufacturing industries in India can be explained in several ways-(a) lowering of tariffs will provide to industrial firms cheaper availability of intermediate inputs, which will enable them to improve their productivity performance; (b) reduction in relative cost of imported capital goods will raise capital-labor ratio and embody sophisticated technology, thus enhancing TFPG; (c) openness to foreign competition may compel the industries to close their less-efficient firms and make existing firms technically more efficient; (d) increase in competitive pressure on industrial units under trade reforms policies will direct the industries to utilize the resources more efficiently; (e) right of entry to imported inputs and reform in real effective exchange rate along with different trade policies under liberalization help industrial sector to compete in export markets more effectively through increase in sales and gain in economies of scale which in turn resulted to growth in TFP.

As a result of changes in trade policies, Indian manufacturers find themselves threatened by both domestic and foreign competition. Under these circumstances, there emerges a need for measurement of TFP and identification of the factors that account for productivity changes. Specifically the appropriate relationship between trade-related factors (such as, import substitution, effective rate of protection, non-tariff barriers, effective exchange rate etc.) and factor productivity is very important in the context of recent policies of reforms.

The variation in TFPG across different industry groups will not only depend on trade-related factors but also on other characteristics of industry like firm size, degree of concentration, technological variables, knowledge intensity etc. Thus the analysis of impact of trade-related variables on TFPG requires the inclusion of all these factors to a possible extent. Estimation of TFPG of Indian manufacturing industries can be seen from Hasim and Dadi (1973), Banerji (1975), Ahluwalia (1991), Balakrishnan and Pushpangadan (1994), Dholakia and Dholakia (1994), Rao (1996), Ray (1997), Gangopadhyay and Wadhva (1998), Pradhan and Barik (1998), Mitra (1999), Srivastava (2000), Trivedi, Prakash and Sinate (2000), Soo (2008). Some recent studies, regarding the investigation of the relationship between TFPG and trade liberalization of Indian manufacturing industries are done by Krishna and Mitra (1998); Balakrishnan, Pushpangadan and Suresh Babu (2000) and Goldar and Anita Kumari (2003). All of them examined the effect of reforms on industrial productivity. Using firm-level data from Centre for Monitoring Indian Economy (CMIE) and applying similar kind of econometric models, Krishna and Mitra have found significant positive effect of reforms on industrial productivity whereas; Balakrishnan et al. have reported an adverse impact of reforms on industrial productivity. Study by Goldar and Anita Kumari (2003), using industry level data from Annual Survey of Industries (ASI) and incorporating some trade-related variables explicitly into the econometric analysis, concluded that tariff reforms have favorable and significant effects on TFPG whereas; the deceleration in productivity growth in the 90s is perhaps due to slower growth in agriculture and gestation lag in investment project.

Most of the above-mentioned studies commented on the effect of trade liberalization on productivity of aggregate industrial sector of India. Very few of them estimated productivity growth of industries at disaggregated level. Madheswaran et al (2007) estimated TFPG of Indian manufacturing industries at disaggregated level.[1]. The factor's effect at the sector-specific level, considering intra-industrial differences, is very important to find out since; the characteristics of Indian industries suggest that there exists high degree of intra-industrial disparity. Thus it is expected that the factors explaining variations in industrial productivity and also its responsiveness with respect to each factor will vary across different industries. This necessitates the analysis of productivity growth at sector-specific level. The present paper attempts to add the literature in this direction.

The purpose of the present paper is to estimate TFPG of seventeen 2-digit manufacturing industry groups of India, each of them taken at 3-digit disaggregated level,

[1] There are some studies on manufacturing industries at disaggregate level other that Indian manufacturing, like Elizabeth et al.(1994), Paternostro et al.(1999), Mahadevan (2000), Saal (2001).

using ASI data during 1980 to 2001 and also to explain the variations in TFPG of different industry groups separately.

The present study is significantly different from the earlier studies in many respects. First of all, the variations in TFPG of different manufacturing industries are estimated using non-parametric approach. Data Envelopment Analysis (DEA) is applied to measure the Malmquist Productivity Index (MPI) introduced by Caves, Christensen and Diewert (1982). Secondly, the use of distance function permits to directly incorporate changes in the level of technical efficiency as an important component of productivity changes between years. None of the earlier studies has employed DEA for measuring TFPG, except Ray (1997), who measured TFPG of different states and union territories of India at aggregate level. The measured MPI is decomposed to separate the contributions of technical change, efficiency change and scale efficiency change for each of the industries separately using the methodology suggested by Ray and Desli (1997). Finally, the second stage regression analysis is performed to explore the impact of trade liberalization on TFPG by taking into account some trade-related variables like, effective rate of protection, import coverage ratio, import penetration ratio, real effective exchange rate along with some other factors coming from industrial characteristics like, firm size, degree of concentration, level of technology and also economic-socio-political variable like movement of wage rates considering as determinants of TFPG. Relevantly, it can be mentioned here that the extensive Monte Carlo Simulation, done by Banker and Natarajan (2008), reveals the fact that if the contextual variables, affecting productivity, are independent of the input variables (although they may be correlated with each other), then a DEA-based procedure in the first stage followed by Ordinary Least Squares (OLS) analysis in the second stage yield consistent estimators of the impact of contextual variables. Additionally, two-stage DEA-based methods with OLS in the second stage significantly outperform the parametric methods.

The analysis of the present paper can also be considered as a study of intra-industrial variation in TFPG and will definitely be helpful for framing sector-specific policies for boosting up TFPG of different industry groups of India at disaggregate level.

The paper is organized as follows. Section II presents a brief account of TFPG and its decomposition into three components showing technical change, efficiency change and returns to scale effects respectively. A brief exposition of the non-parametric procedure for estimating MPI is presented thereafter. Section III describes the data set and reports the empirical findings. Section IV analyses the impact of trade liberalization on TFPG of manufacturing industries along with other determinants of TFPG. Section V draws conclusions of the study.

II. ESTIMATION AND DECOMPOSITION OF MULTI-FACTOR PRODUCTIVITY GROWTH (MFPG)

In the 1-output-1 input cases, the rate of productivity growth is measured by the difference in the growth rates of output and input quantities respectively. When multiple inputs are involved, the rate of MFPG can be measured by the difference in the growth rate of output and that of total input where growth rate of total input can be computed by the growth rates of individual inputs weighted by the partial output elasticity (according to Denney, Fuss and Waverman*,* 1981).

In parametric analysis, the specification of some explicit functional form of a production, cost or profit function is needed. In non-parametric analysis, the exact technological relationship is unspecified. The relevant assumptions are-

1. Both inputs and output are freely disposable and the production possibility set is convex.

2. All input-output combinations, which are actually observed, are by definition feasible.

3. Variable Returns to Scale (VRS) is assumed throughout the analysis.

A. *Methodology*

Consider, for simplicity, a single input-single output industry. Let x_k^t and y_k^t represent the input and output quantities of industry *k* at time *t*. The average productivity of this industry at time *t* is

$$AP_k^t = \frac{y_k^t}{x_k^t} \qquad (1)$$

Thus, a productivity index for this industry at time *t +1,* with period *t* treated as the base, will be

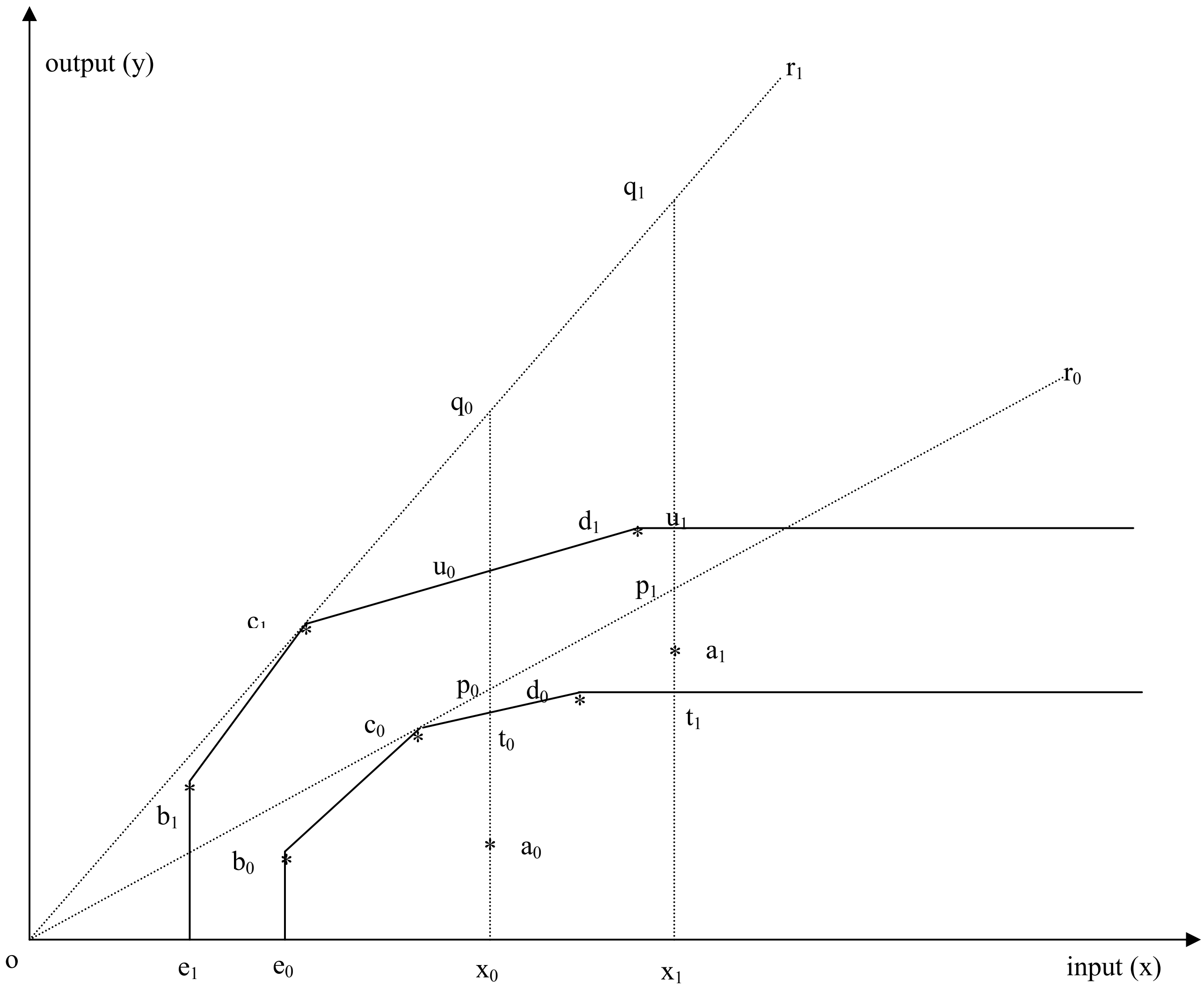
$$\Pi_{k(t+1)} = \frac{AP_k^{t+1}}{AP_k^t} = \frac{y_k^{t+1}/x_k^{t+1}}{y_k^t/x_k^t} \qquad (2)$$

which does not in any way depend on the assumptions about returns to scale.

In order to identify the sources of productivity change, however, a bench- mark technology is needed, where returns to scale assumption becomes important.

According to Varian (1984), the free disposal convex hull of the observed input-output vectors provides an inner approximation to the true underlying production possibility set if the above mentioned first two assumptions hold good.

Now construct a benchmark technology to evaluate the importance of returns to scale:



Consider four industries: a, b, c and d. Points a_0, b_0, c_0 and d_0 in the figure show the observed input-output levels of the respective industries in period *0*.

Similarly, points a_1 through d_1 show their input-output levels in period *1*.

Industry *a* uses input ox_0 to produce output a_0x_0 in period *0* and input ox_1 to produce output a_1x_1 in period *1*.

Thus, the productivity index for industry *A* in period *1* is

$$\Pi_{a1} = \frac{a_1x_1 / ox_1}{a_0x_0 / ox_0} \qquad (3)$$

By convexity, all points in the convex hull of the points a_0, b_0, c_0 and d_0 (i.e., the convex combinations of these points) represent feasible input-output combinations in period *0*. The free disposal convex hull is the set of points bounded by the horizontal axis and the broken line $e_0b_0c_0d_0$ – extension. Under Variable Returns to Scale (VRS), all points in this region represent feasible input-output combinations in period 0, although under Constant Returns to Scale (CRS) all radial expansion and (non-negative) contraction of feasible input-output bundles are also feasible, thus the CRS production possibility set in period 0 is the cone formed by the horizontal axis and the ray or_0 through the point c_0. The VRS frontier in period 1 is the broken line $e_1b_1c_1d_1$- extension and the CRS frontier is the ray or_1 through the point c_1.

Define the production possibility set as

$$S^t = \{(x, y) : y \text{ can be produced from } x \in \text{ period } t\} \tag{4}$$

The output distance function[2] is

$$D^t(x, y) = \min \theta : \left(x, \frac{1}{\theta} y \right) \in S^t \tag{5}$$

In period *0*, the maximum producible output from input ox_0 is t_0x_0 under the VRS assumption. Thus the distance functions are

$$D_V^0(x_0, y_0) = \frac{a_0x_0}{t_0x_0} \quad \text{and}$$

$$D_V^o(x_1, y_1) = \frac{a_1x_1}{t_1x_1} \text{ , in period } 0$$

The productivity index for industry A is

$$\Pi_{a0} = \frac{a_1x_1 / ox_1}{a_0x_0 / ox_0} = \frac{a_1x_1 / p_1x_1 \,.\, p_1x_1 / ox_1}{a_0x_0 / p_0x_0 \,.\, p_0x_0 / ox_0} = \frac{D_c^0(x_1, y_1)}{D_c^0(x_0, y_0)} \tag{6}$$

Analogously,

$$\Pi_{a1} = \frac{a_1x_1 / ox_1}{a_0x_0 / ox_0} = \frac{D_c^1(x_1, y_1)}{D_c^1(x_0, y_0)} \tag{7}$$

According to Färe, Grosskopf, Norris and Zhang (FGNZ, 1994) for any reference technology; the distance functions can be calculated. The productivity index is given by the ratio of the CRS distance functions even if the technology was not characterized by CRS.

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[2] Let the production possibility set: *T= {(x, y): x* can produce *y}. Let* (x, y) be any input-output bundle, (not necessarily feasible), then the output- oriented distance function is $D(x, y) = \min \theta : \left(x, \frac{1}{\theta} y \right) \in T$. Thus, $(x, y) \in T$ implies $D(x, y) \leq 1$.

With explicit assumption of VRS, comparing CRS and VRS frontiers in period *0*, we get both t_0 and t_1 are points on the production frontier, (both are technically efficient), and the average productivity at t_0 is higher than that of t_1. The point of highest average productivity along the VRS frontier in period *0* is c_0, where as along the CRS frontier, that remains constant. The point of highest average productivity along the VRS frontier is called the Most Productive Scale Size (MPSS), according to Bankar, Charnes and Cooper (1984).

At the MPSS, the CRS and VRS frontiers coincide. Notably, the average productivity at the MPSS of the VRS frontier (point c_0) is equal to the constant average productivity at any point on the CRS frontier (say, p_0 or p_1). The scale efficiency at any point on the frontier is measured by the ratio of the average productivity at that point to the average productivity at the MPSS.

Thus,

$$SE^0(x_0, y_0) = \frac{AP(t_0)}{AP(c_0)} = \frac{t_0 x_0}{p_0 x_0} = \frac{D_c^0(x_0, y_0)}{D_v^0(x_0, y_0)} \tag{8}$$

Also,

$$SE^0(x_1, y_1) = \frac{AP(t_1)}{AP(c_0)} = \frac{D_c^0(x_1, y_1)}{D_v^0(x_1, y_1)} \tag{9}$$

Now eq. (6) can be written as

$$\Pi_{a0} = \frac{D_v^0(x_1, y_1) \cdot \dfrac{D_c^0(x_1, y_1)}{D_v^0(x_1, y_1)}}{D_v^0(x_0, y_0) \cdot \dfrac{D_c^0(x_0, y_0)}{D_v^0(x_0, y_0)}} = \frac{D_v^0(x_1, y_1)}{D_v^0(x_0, y_0)} \cdot \frac{SE^0(x_1, y_1)}{SE^0(x_0, y_0)} \tag{10}$$

In a perfectly analogous manner,

$$\Pi_{a1} = \frac{D_v^1(x_1, y_1)}{D_v^1(x_0, y_0)} \cdot \frac{SE^1(x_1, y_1)}{SE^1(x_0, y_0)} \tag{11}$$

Now, the MPI can be decomposed, as done by Ray and Desli (1997), in the following manner.

The expression is,

$$\Pi a = (\Pi_{a0} \cdot \Pi_{a1})^{\frac{1}{2}}$$

$$= \left[\frac{D_v^0(x_1, y_1)}{D_v^0(x_0, y_0)} \cdot \frac{SE^0(x_1, y_1)}{SE^0(x_0, y_0)} \times \frac{D_v^1(x_1, y_1)}{D_v^1(x_0, y_0)} \cdot \frac{SE^1(x_1, y_1)}{SE^1(x_0, y_0)} \right]^{\frac{1}{2}}$$

$$=\left[\frac{D_v^0(x_1,y_1)}{D_v^0(x_0,y_0)}\cdot\frac{D_v^1(x_1,y_1)}{D_v^1(x_0,y_0)}\right]^{\frac{1}{2}}\times\left[\frac{SE^0(x_1,y_1)}{SE^0(x_0,y_0)}\cdot\frac{SE^1(x_1,y_1)}{SE^1(x_0,y_0)}\right]^{\frac{1}{2}}$$

$$=\frac{D_v^1(x_1,y_1)}{D_v^0(x_0,y_0)}\times\left[\frac{D_v^0(x_0,y_0)}{D_v^1(x_0,y_0)}\cdot\frac{D_v^0(x_1,y_1)}{D_v^1(x_1,y_1)}\right]^{\frac{1}{2}}\times\left[\frac{SE^0(x_1,y_1)}{SE^0(x_0,y_0)}\cdot\frac{SE^1(x_1,y_1)}{SE^1(x_0,y_0)}\right]^{\frac{1}{2}} \tag{12}$$

= peffch . techch . sch

where

peffch = $\dfrac{D_v^1(x_1,y_1)}{D_v^0(x_0,y_0)}$ measures pure technical efficiency change,

sch = $\left[\dfrac{SE^0(x_1,y_1)}{SE^0(x_0,y_0)}\cdot\dfrac{SE^1(x_1,y_1)}{SE^1(x_0,y_0)}\right]^{\frac{1}{2}}$ measures change in scale efficiency, and

techch = $\left[\dfrac{D_v^0(x_0,y_0)}{D_v^1(x_0,y_0)}\cdot\dfrac{D_v^0(x_1,y_1)}{D_v^1(x_1,y_1)}\right]^{\frac{1}{2}}$ measures technical change[3], which is the geometric mean of the shift in the production function at x_0 and x_1.

Färe, Grosskopf, Norris and Zhang (FGNZ, 1994) showed a similar decomposition. However, as pointed out by Ray and Desli (1997), there exists some inconsistency in their method of analysis. The technical change factor, according to FGNZ (1994), is the geometric mean of the shift in the pseudo production function[4] and not of actual production function.

B. *Non-parametric Methodology*

The decomposition of the MPI into technical change, technical efficiency change and scale efficiency change can be applied in practical sense if the reference technology set is constructed from sample data in the following way -

Let, y_j^t and x_j^t represent the output and input vectors respectively of firm *j* (*j*=1, 2, 3 ...N) in period *t*. Following Varian (1984), an inner approximation to the underlying production possibility set in period *t* will be

$$S^t=\left[(x,y):\sum_{j=1}^{N}\lambda_j x_j^t\le x;\sum_{j=1}^{N}\lambda_j y_j^t\ge y;\sum\lambda_j=1;\lambda_j\ge 0\big(j=1,2,3....,N\big)\right]$$

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[3] The terminologies peffch, techch and sch are borrowed from FGNZ (1994).

[4] Let 1-input 1-output technology be represented by the production function $y=f(x)$. Average productivity of $x=\dfrac{f(x)}{x}$. Let it be maximized at $x=x^*$ where, $f'(x)=\dfrac{f(x)}{x}$. Taking $f'(x^*)=w$, the pseudo production function be defined as *R(x) =wx* which exhibits CRS and is a ray through the origin.

It is to be noted here that, by assumption, any observed input bundle $\left(x_t^j, y_t^j\right)$ is feasible in period *t*.

By the convexity assumption, any input-output pair $(\bar{x}, \bar{y})$ satisfying

$\bar{x} = \sum_{j=1}^{N} \lambda_j x_j^t, \bar{y} = \sum_{j=1}^{N} \lambda_j y_j^t, \sum_{j=1}^{N} \lambda_j = 1, \lambda_j \geq 0, \left(j = 1,2,3.....,N\right)$ is also feasible, and by the free disposability assumption, any $x \geq \bar{x}$ corresponds $\bar{y}$.

Hence, x can also produce y if $y \leq \bar{y}$.

Therefore, the output oriented distance function under VRS is obtained as

$$D_v^t\left(x_k^i, y_k^i\right) = \frac{1}{\Phi^*} \quad , \quad \text{where } \Phi^* = \max \Phi$$

subject to

$$\sum_{j=1}^{N} \lambda_j y_t^j \geq \Phi y_k^t \; ; \sum_{j=1}^{N} \lambda_j x_t^j \leq x_k^t \; ; \quad \sum_{j=1}^{N} \lambda_j = 1; \quad \lambda_j \geq 0, \left(j = 1,2,3.....N\right)$$

The own-period distance functions can be found for t=k, while t $\neq k$ will define the cross-period distance functions.

III. DATA SOURCES AND EMPIRICAL ANALYSIS

A. *Data Sources*

To determine MPI, the study visualizes a single-output four-input production technology for different manufacturing industries of India. Output is measured by the gross value of production. The inputs are capital, labor, fuels and materials.

The basic yearly input-output data for different 2-digit and corresponding 3-digit manufacturing industries are obtained from the Annual Survey of Industries (ASI) – summary results for the factory sector. Except labor input (which are measured by number of workers), all other inputs and output data are reported in the ASI in value terms (in Rs. Lakhs). All nominal values are deflated by appropriate wholesale price indexes to obtain real values.

- Gross value of output is deflated by the price index of different manufacturing products.
- Perpetual Inventory Accumulation Method (PIAM) determines the capital stock. Here, doubling the value of fixed capital and deflating the series by appropriate wholesale price indexes for machinery and equipment, initial value of gross capital stock in real terms is constructed. Then adding them with current year's gross investment, current year's capital stock is formulated.
- Fuel consumption is deflated by the price index for fuel, power and lubricants and
- Expenditure on materials is deflated by the price index of industrial raw materials.

The period of analysis for the present study is taken from 1980-81 to 2001-02.

The computer program DEAP (developed by Tim Coelli) is used to calculate the MPI.

B. *Empirical Analysis*

Table 1 represents the list of industry groups with their abbreviations as well as the sample averages of the MPI (all MPI averages are geometric means) for individual industry group. Because the productivity index in any one year treats the year immediately preceding as the base, the difference between the value of the MPI and unity shows the productivity growth rate over the previous year. The sample averages of such annual growth rates[5] are also reported in Table I.

The disaggregated analysis reveals widespread variation in productivity changes. Out of 17 industry groups 16 show productivity increase except the industry group BMA that captures productivity decline at a rate of 4.05% per annum. Average TFPG, taking all the industry groups together, is reported as 3.90%. Among all the industry groups, 7 exhibit productivity growth rates above the average value and rest of the groups show the rate below the average. The TFPG figure varies from the highest value of 11% for W&P industry to the lowest value that signifying negative growth of 4.05% for BMA industry, among all the industries.

- The industry group P&P experience 8.243% growth annually in total factor productivity.
- TP industry shows a moderate rate of 7.81%, similar to that of WSSF industry (7.147%).
- The rate of productivity increase varies from 5% to 7% annually for 2 industry groups namely, (i) JVF, (ii) OFP.
- The industry groups experiencing productivity growth rate more that 2% but less than 4% per annum are (i)CT, (ii)NMP, (iii)NEM, (iv)EM, (v) TE&P and (vi) BC&P.
- Remaining four industry groups- FP, BTRP, L&P and MP&P show very low rate of growth in productivity, either less than 1% or slightly over to unity.

[5] For any industry group, the average is the simple mean of the growth rates from those years for which the Malmquist Productivity Index could be computed.

TABLE I

Malmquist Productivity Index and Productivity Growth Rate-by Industry (Annual Averages)

Manufacturing Industry Groups	Malmquist Index	Productivity Growth Rate
Food Products (FP)	0.993	0.047%
Other Food Products (OFP)	0.988	5.58%
Beverages, Tobacco & Related Products (BTRP)	0.972	0.038%
Cotton Textiles (CT)	0.985	3.931%
Wool, Silk & Synthetic Fibre Textiles (WSSF)	1.011	7.147%
Jute & Vegetable Fibre (except Cotton) (JVF)	0.936	6.044%
Textile Products (including Wearing Apparel) (TP)	1.039	7.81%
Wood & Wood Products (W&P)	0.963	11.00%
Paper, Paper Products (P&P)	0.984	8.243%
Leather & Products of Leather (L&P)	0.990	1.084%
Basic Chemical & Chemical Products (BC&P)	0.989	2.841%
Non-metallic Mineral Products (NMP)	0.990	3.851%
Basic Metal & Alloys Industries (BMA)	0.954	-4.05%
Metal Products & Parts, except Machinery and Equipment (MP&P)	0.993	1.175%
Non-electrical Machinery & Equipments (NEM)	1.010	3.277%
Electrical Machinery & Equipment (EM)	1.009	2.942%
Transport Equipments & Parts (TE&P)	1.003	2.842%

Average value of TFPG, considering all the industry groups: 3.90%

One of the significant factors behind the overall progress or decline in productivity, found in different industry groups, can be the (average) rate of technical change (i.e. progress or regress).[6]

[6] With the advancement in science and technology, technical progress is possible. With this, the production frontier is expected to shift outward by producing increasing quantities of output from any specific input-bundle in the passage of time. On the other hand, when the same input-bundle produces less and less output over time causing an inward shift of the production function, technical regress is noticed.

As shown in Table II, 16 industries exhibit technical progress over the sample period with varying degrees except BMA industry, which exhibits technical regress of 7.13% annually leading to fall in productivity.

- The group OFP exhibits tremendous technical progress of 23.77%, the highest among all the industry groups.
- The industry groups experiencing technical progress around 7% per annum are JVF, TP and P&P.
- 7 industry groups exhibit technical progress at a rate ranging from 2% to 6% per annum and they are (i)WSSF, (ii)CT, (iii)NMP, (iv) BC&P, (v)NEM, (vi)EM, (vii)TE&P.
- FP, BTRP, L&P industries experience very slow technical progress of less than 1% annually while just above 1% technical progress is grasped by MP&P and W&P industries.

Table II

Levels of Technical Change (Progress or Regress) and Rate of Technical Change -by Industry (Annual Averages)

Manufacturing Industry Groups	MPI of Technical Change	Rate of Technical Change
Food Products (FP)	0.996	0.08%
Other Food Products (OFP)	0.987	23.77%
Beverages, Tobacco & Related Products (BTRP)	0.971	0.148%
Cotton Textiles (CT)	0.983	4.73%
Wool, Silk & Synthetic Fibre Textiles (WSSF)	1.009	5.73%
Jute & Vegetable Fibre (except Cotton) (JVF)	0.934	7.63%
Textile Products (including Wearing Apparel) (TP)	1.037	6.65%
Wood & Wood Products (W&P)	0.966	1.44%
Paper, Paper Products (P&P)	0.984	6.88%
Leather & Products of Leather (L&P)	0.991	0.968%
Basic Chemical & Chemical Products (BC&P)	0.989	2.92%
Non-metallic Mineral Products (NMP)	0.991	4.08%
Basic Metal & Alloys Industries (BMA)	0.953	-7.13%
Metal Products & Parts,		
except Machinery and Equipment (MP&P)	0.993	1.03%
Non-electrical Machinery & Equipments (NEM)	1.010	2.80%
Electrical Machinery & Equipment (EM)	1.008	2.26%
Transport Equipments & Parts (TP)	1.005	2.55%

Note: The Malmquist Productivity Index (MPI) averages are Geometric Means.

The study on technical efficiency and scale efficiency for different industry groups in India is presented in Table III. A positive value of scale efficiency implies that an industry has moved closer to its most productive scale size whereas a negative value implies movement further away from the highest ray average productivity.

The fourth column of Table III exhibits the scale efficiency change of various industry groups. It should be noted that out of 17 industry groups 16 move to the most productive scale size since all of them show positive value of scale efficiency change.

Table III

Rate of Change in Pure and Scale Efficiency- by Industry (Annual Averages)

Manufacturing Industry Groups	MPI of Technical Efficiency	Technical Efficiency Change	Scale Efficiency Change
Food Products (FP)	0.999	0.079%	-0.14%
Other Food Products (OFP)	1.000	0.604%	6.18%
Beverages, Tobacco & Related Products (BTRP)	1.000	0.484%	1.025%
Cotton Textiles (CT)	1.000	1.067%	0.375%
Wool, Silk & Synthetic Fibre Textiles (WSSF)	1.001	1.003%	1.19%
Jute & Vegetable Fibre (except Cotton) (JVF)	1.000	-0.175%	1.181%
Textile Products (including Wearing Apparel) (TP)	1.000	0.77%	1.753%
Wood & Wood Products (W&P)	1.000	0.074%	0.092%
Paper, Paper Products (P&P)	1.001	-0.041%	0.147%
Leather & Products of Leather (L&P)	1.000	-0.014%	0.052%
Basic Chemical & Chemical Products (BC&P)	1.000	0.048%	0.186%
Non-metallic Mineral Products (NMP)	1.000	- 0.49%	1.342%
Basic Metal & Alloys Industries (BMA)	1.000	0.054%	0.245%
Metal Products & Parts, except			
Machinery and Equipment (MP&P)	1.000	0.037%	0.155%
Non-electrical Machinery & Equipments (NEM)	0.999	- 0.053%	0.538%
Electrical Machinery & Equipment (EM)	1.001	0.256%	2.33%
Transport Equipments & Parts (TE&P)	1.001	0.317%	0.093%

Note: The Malmquist Productivity Index (MPI) averages are Geometric Means.

The third column of the following table reveals that most industries improved in technical efficiency and moved closer to the frontier over the years. The average level of technical efficiency is very high and almost equal to 100% considering all the industry groups. In general, it can be said that different manufacturing industries in India are producing outputs close the optimal output levels (i.e., the output level that can be produced optimally using respective input bundles available in different industries).

- (i) JVF, (ii)P&P, (iii)L&P, (iv)NMP, (v) NEM- these industry groups already moved to the cent percent efficiency level and there is almost no scope for further improvement in their efficiency level.
- Industry groups which have little scope for improvement in technical efficiency, since their efficiency levels are already close to 100%, are (i)FP, (ii)W&P, (iii)BC&P, (iv)MP&P, (v)TP. Some level of improvement in technical efficiency is possible for (i)CT, (ii)WSSF, (iii)OFP, (iv)BTRP, (v)EM and (vi)TE&P industries.
- Interestingly, for BMA industry a very low level of technical efficiency change is apparently suggesting little scope for improvement, it does not represent the true situation, because for this industry group, technical regress is reported over the years indicating lowering down of the production frontier.

To analyze wide variation in productivity growth of different manufacturing industry groups as seen in Table I, the regression analysis is performed in order to find out the factors responsible for it. In this context one of the purpose of this empirical study is to investigate the impacts that trade liberalization has on TFPG considering different manufacturing industries of India, keeping in mind that the effect of trade liberalization on a specific industry will jointly depend on changes in trade-related variables and industrial characteristics of that particular industry. The average annual productivity growth rate is taken as dependent variable and as explanatory variables for this exercise some policy variables, depicting the instances of trade liberalization and some other variables representing the structure of the industry are considered.

IV. FACTORS BEHIND PRODUCTIVITY GROWTH – APPLICATION OF REGRESSION ANALYSIS

This section presents the results of regression analysis applied to analyze the variation in TFPG of different industry groups.

Productivity Growth Rates (PGR) are computed for seventeen industry groups during 1980-81 to 2001-02 and treated as dependent variable. The regression equations contain the following variables-

$$PGR_{it} = F(Y/N_{it}, CR_{it}, K/L_{it}, NP_{it}, W_{it}, LNW_{it}, DELW_{it}, ERP_{it}, ICR_{it}, IPR_{it}\ REER_{it}, u_{it})$$

where i denotes the ith firm of an industry and t = time period. Total number of Indian industries = 17.

Here, output per factory (Y/N) is taken as a measure of firm size, giving an idea of scale of operations also. Theoretically there are two broad ways by which firm size affects industrial performance. With capacity diversification, a larger firm can be able to exploit economies of scale and generate higher TFPG relative to smaller firms. Alternatively, since size is correlated with market power (Shepherd (1986)) and market power helps to develop X-inefficiencies, it can lead to relatively inferior performance (Leibenstein (1966)).Therefore, theory does not show any bias toward larger firm or smaller firm to enhance TFPG rate. The perusal of the empirical literature on this issue [Mukherjee (1963), Randy (1990), Ahluwalia (1991), Majumder (1997), Urata and Kawai (2002), Biesebroeck (2005), Stierward and Yong (2005), Castany et al (2007), Yadav (2007)] suggests that these studies vary both with respect to choice of the indicators specifying firm size[7] and the conclusions arrived at regarding the positive, negative or no impact of firm size on TFPG.

Concentration ratio (CR) of a particular industry group captures the effect of market structure on TFPG. A negative influence of CR is expected by some researchers because competition may lead to cost consciousness and drive for technological advancement. Others may point out the advantages of big size, secured market and expect a positive association between CR and TFPG. The conclusion from the empirical literature also varies and does not provide us a single answer [Kendrick (1973), Katz (1969)]. To compute industrial CR the present paper uses Gini-Hirschman coefficient of industrial concentration, captured by the formula:

$$GH = \sqrt{\sum_{i=1}^{n} Y_{it}^{2}} , \qquad \text{where } Y_{it} = \text{market share of ith firm in period t.}$$

Capital-labor ratio (K/L) serves as technological variable. The conventional capital-labor ratio gives an idea about the relative degree of mechanization. Normally, it is expected that there exists positive relationship between K/L and TFPG.

(Non-production) employee per production worker (NP) is also a technological variable and is related to the composition of work force. A higher number of employees per worker generally signify a higher degree of bureaucratic control within the firm that can hinder productivity. Besides, recruitment of non-production employees is quite often a response to the political pressure by the party in power to provide employment of its party cadres. These political employees are more likely to hinder productivity. Such a line of reasoning postulated a negative relation between NP and TFPG[8]. On the other hand, a positive relation between NP and TFPG indicates that the combination of work force is just right to operate efficiently and to promote growth in TFP of different industries.

Real wage (W) and change in real wage rate (LNW or DELW) both are considered as determinants of TFPG. If W is sufficiently high for any industry group then skilled workers can be attracted towards that industry and considering skill as a positive determinants of TFPG, it can be argued that as W increases through the involvement of skilled workers in the production process productivity can increase. It may also be possible that TFPG is associated with changes in real wage rate. This justifies the inclusion of LNW or DELW in the regression process.

[7] Alternative measures of firm size, used by the researchers, are- number of workers, log value of sales, assets of the firm, amount of intermediate inputs, capital stock per factory etc.

[8] Ray (1997) observed preponderance of non-production workers hinder productivity increases of different Indian States and Union Territories.

The variables which are included to grab the effect of trade liberalization on performance of industrial productivity are Effective Rate of Protection (ERP), Import Coverage Ratio (ICR), Import Penetration Ratio (IPR) and Real Effective Exchange Rate (REER). The data for ERP, ICR and IPR is taken from Das (2003). ERP measures the distortion due to tariff on input and final output prices and thus measures the protection to domestic factors of production. The concept of ERP is discussed by Meade (1951) and extensively defined by Johnson (1960) and Corden (1966).

According to Corden, ERP is the percentage excess of domestic value added, vis-à-vis world value added (considering tariff and other barriers).

Therefore, $ERP_j = \left(VA_j^* - VA_j\right) / VA_j$

Where ERP_j = Effective Rate of Protection of the jth product

VA_j^* = Value added of the final product j at free trade prices

VA_j = Value added of the final product j at tariff distorted prices

The expected relationship between ERP and TFPG is negative implying that with reduction in ERP productivity growth enhances through increased competitive pressure on domestic industry.

ICR quantifies the change in non-tariff barriers over time by industries. In tune with Das (2003), ICR is defined as

$$C_j = \frac{\sum D_i M_i}{\sum M_i}$$

Where D_i (dummy variable) = 1 if product is listed under banned/restricted, limited permissible, canalized i.e., affected by non-tariff barriers

= 0 if product is listed under OGL or free i.e., not affected by non-tariff barriers

j stands for a particular industry group and i represents a product line within that particular industry group.

M_i = the value of imports of the ith product which is subject to non-tariff barriers.

IPR captures the effect of both tariff and non-tariff barriers and also the effect of shifting of products from restricted list into free product's category. IPR is expressed as the ratio of industry imports (M_j) to domestic availability (D_j) for industry j. Domestic availability is defined as production (P_j) plus imports (M_j) minus exports (X_j)

i.e, $IPR_j = \dfrac{M_j}{D_j} = \dfrac{M_j}{P_j + M_j - X_j}$

A priori expectation would be to expect a negative relation between ICR (and IPR) with TFPG. Negative and significant coefficient of ICR signifies that with lowering of non-tariff barriers, there emerges a boosting up effect on imports and through more capitalistic and sophisticated technology; the industry group may acquire TFPG over the years. On the other hand, negative and significant coefficient of IPR can be justified as follows. The combined effect of both - lowering of tariff and shifting of products from restricted list to OGL or free category products in turn increases imports so that imported goods become cheaper to producers. As a result, there is reduction in production cost due to adoption of imported technology and capital goods (both are qualitatively better). The whole process leads to the enhancement of TFPG of concerned industry group.

Finally, REER has been taken from the publication of Reserve Bank of India (*Hand Book of Statistics on Indian Economy)*. The index of REER is thirty-six country bilateral trade-based weights with 1985 = 100 as base[9]. REER is included as an explanatory variable because of the following reason. With the lowering of tariff and non-tariff barriers, domestic market became very much exposed to import competition. Since there is a negative relation between ERP and TFPG, a positive relation should be expected between REER and TFPG implying that appropriate adjustment in REER may be helpful to reduce relative cost of imported capital goods that supports technological progress. The openness to foreign competition forces the existing firms within the industry group to improve their technical efficiency. All these, in turn, initiate TFPG of the particular industry group.

On the other hand, a depreciation of REER may counter-effect the reduced import barriers. In reality, after the economic reform the favorable effect of reduction in ERP appears to be counterbalanced partially due to the depreciation in REER in the post-reform period. So to capture the effects of trade reforms on productivity, REER should be taken as one of the determinants of TFPG and the coefficient of REER is expected to be positive to promote TFPG of different manufacturing.

Note that, regressions of PGR on all the explanatory variables taken together; can face a possibility of multicollinearity since there is clear possibility of either K/L and NP or ICR, IPR, REER to be correlated among them.

So various regressions have been tries out considering different combinations of explanatory variables. None of the regressions includes K/L and NP simultaneously or ICR, IPR and REER together at a time.

Analysis of Regression Results

Figures presented in Table IV yield the following observations.

The coefficient of firm size (Y/N) is positive and statistically significant at 5%, 10% level for L&P, EM industries respectively and at 10% (one tail) level for BMA and P&P industries, implying that increase in firm size may foster TFPG of these industry groups. The industry BTRP shows negative coefficient of Y/N but not statistically significant.

[9] For detail methodology, refer Reserve Bank of India Bulletin, July 1993, pp. 967-969.

The coefficient of Concentration ratio (CR) is positive and statistically significant at 10% level for MP&P and 10% (one tail) level for FP, W&P, P&P industry groups, signifying the advantages of big size, clustering of firms and market security over the years, lead to enhance the growth process of TFP, whereas, CR has no significant impact on TFPG of BC&P and TE&P industries although the first shows positive and the second shows negative coefficients of CR.

The coefficient of capital-labor ratio (K/L) is positive for the group P&P at 1% level of significance and for TP and W&P industries with very low level of significance such as 18% and 15% respectively. It may be argued that with reduction in non-tariff barriers and effective rate of protection, there is a decrease in relative cost of imported capital goods; as a result, there is a rise in capital-labor ratio supporting the technological progress and which in turn, facilitates TPFG of respective industry groups.

But there are some industry groups such as, CT, BMA, NEM and EM industries; which exhibit negative and statistically significant impact of K/L on respective TFPG. For these four industry groups, the visual inspection of data on K/L reveals that K/L remains more or less stagnant over the time thus failing to have any positive significant impact on TFPG of respective industries.

The coefficient of (non-production) employees per production worker (NP) is negative and statistically significant at 1% for MP&P industry and 10% for BC&P, 10% (one tail) for TE&P industries. It can be argued that reduction of internal bureaucracy by lowering the number of (non-production) employees can be resulted to increase in TFPG. On the other hand, the sole industry group-OFP captures positive impact of NP on TFPG with statistical significance of 10 %(one tail). Here NP helps to increase in TFPG of the industry group because the combination of non-production employees and production worker is effective to foster TFPG. P&P industry exhibits negative coefficient of NP, but the significance level is very low at about 18%.

Increase in real wage (W) may have a favorable effect on TFPG of P&P and FP industries, because the coefficient of W is positive and statistically significant at 1% and 10% level respectively. The coefficient of W is negative and statistically significant at 10% (one tail) for solely TE&P signifying a negative association between W and TFPG. OFP exhibit negative but insignificant effect of W on TFPG.

The coefficient of change in real wage rate (LNW or DELW) is positive and statistically significant at 1% level for P&P; 5% level for NEM; 10% level for BTRP; and 10% (one tail) for CT industry groups, implying that these industry groups were paying lower wages to the workers compared to the others, when the concerned industries started production. Then they increased the wage rate gradually and skilled workers are hired by them thus enhancing the TFPG through the passage of time. On the other hand, the coefficient of LNW or DELW is negative and significant at 1% level for TP, W&P, and 10% level for EM and L&P, 10% (one tail) for BMA and BC&P industries. Therefore, for TP, W&P, EM L&P and BC&P industries it can not be claimed that growth in TFP has been due to increase or change in real wage rate.

TABLE IV

DETERMINANTS OF PRODUCTIVITY GROWTH
(Dependent Variable: Productivity Growth Rate (PGR))

Manufacturing Industry Groups	Y/N	CR	K/L	NP	W	LNW	DELW	ERP	ICR	IPR	REER	R^2
Food Products (FP)		3.778	-34.957		2.820						0.0086	0.325
		(1.997) ****	(-1.489) ********		(2.502) **						(2.502) **	
Other Food Products (OFP)	4.150			17.988	-8.580							0.193
	(0.999)			(1.898) ****	(-1.013)							
Beverages, Tobacco	-0.021		-3.516				2.269					0.209
& Related Products (BTPR)	(-0.134)		(-0.347)				(2.042) ***					
Beverages, Tobacco		-2.606	-22.847				2.939					0.264
& Related Products (BTRP)		(-0.972)	(-1.108)				(2.293) ***					
Cotton Textiles (CT)			-74.720			1.625		-0.293		-3303.080		0.288
			(-2.320) ***			(1.967) ****		(-0.892)		(-1.801) ****		
Textile Products (TP)			16.061				-2.582	-0.068	0.197			0.510
(including Wearing Apparel			(1.401) **********				(-3.704) *	(-0.137)	(0.254)			
Wood & Wood Products (W&P)		2.771	46.774				-2.917				0.008	0.455
		(1.664) ****	(1.497) *******				(-3.477) *				(1.427) *********	

Notes: § Each estimated equations include a constant term.

¶ Y/N=output per factory; CR= concentration ratio; K/L= capital-labor ratio; NP= non-production) employees to production workers; W= real wage; LNW, DELW= change in real wage; ERP= effective rate of protection; ICR= import coverage ratio; IPR= import penetration ratio; REER= real effective exchange rate.

‡ Figures in parentheses are t-ratios. *- Significant at 1%, **- Significant at 5%, ***- Significant at 10%, ****- Significant at 10% (one tail), *****- Significant at 12%, ******- Significant at 14%, *******-Significant at 15%, ********- Significant at 16%, *********- Significant 17%, **********- Significant at 18%.

TABLE IV (Contd.)

DETERMINANTS OF PRODUCTIVITY GROWTH
(Dependent Variable: Productivity Growth Rate (PGR))

Manufacturing Industry Groups	Y/N	CR	K/L	NP	W	LNW	DELW	ERP	ICR	IPR	REER	R^2
Paper, Paper Products (P&P)		3.836	40.597				1.799				0.008	0.870
		(1.720) ****	(4.073) *				(9.129) *				(2.180) ***	
Paper, Paper Products (P&P)		5.344		-9.651	1.849						0.121	0.781
		(1.905) ****		(-1.414) **********	(4.874) *						(2.145) ***	
Leather & Products of leather (L&P)	2.663		-25.621			-0.908		0.324	-2.502			0.377
	(2.591) ***		(-0.786)			(-2.082) ****		(0.939)	(-1.493) ********			
Leather & Products of Leather (L&P)	2.672		-34.209			-0.998			-1.350			0.338
	(2.610) **		(-1.098)			(-2.356) ***			(-1.187)			
Basic Chemical & Chemical Products (BC&P)		3.759		-11.316		-0.736		-0.222		-158.990		0.382
		(0.976)		(-2.575) ***		(-1.745) ****		(-0.997)		(-2.575) ***		

Notes: §Each estimated equations include a constant term.

¶ Y/N=output per factory; CR= concentration ratio; K/L= capital-labor ratio; NP= non-production) employees to production workers; W= real wage; LNW, DELW= change in real wage; ERP= effective rate of protection; ICR= import coverage ratio; IPR= import penetration ratio; REER= real effective exchange rate.

‡ Figures in parentheses are t-ratios. *- Significant at 1%, **- Significant at 5%, ***- Significant at 10%, ****- Significant at 10% (one tail), *****- Significant at 12%, ******- Significant at 14%, *******-Significant at 15%, ********- Significant at 16%, *********- Significant 17%, **********- Significant at 18%.

TABLE IV (Contd.)

DETERMINANTS OF PRODUCTIVITY GROWTH
(Dependent Variable: Productivity Growth Rate (PGR))

Manufacturing Industry Groups	Y/N	CR	K/L	NP	W	LNW	DELW	ERP	ICR	IPR	REER	R^2
Basic Metal & Alloys (BMA)	0.299		-7.476				-2.535	-0.320	0.140			0.510
	(1.856) ****		(-3.026) *				(-1.909) ****	(-1.563) ******	(0.877)			
Metal Products & Parts (MP&P)		4.598		-33.940				-0.263		-418.782		0.485
		(2.409) ***		(-3.329) *				(-3.593) *		(-2.135) ***		
Non-electrical Machinery			-58.319			0.990		-0.354			0.008	0.569
& Equipments (NEM)			(-4.180) *			(2.786) **		(-1.643) *****			(2.060) ****	
Electrical Machinery	0.881		-24.038				-2.041	-0.102		-557.724		0.466
& Equipment (EM)	(2.274) ***		(-1.831) ****				(-2.067) ***	(-0.606)		(-1.482) *******		
Transport Equipments		-0.430		-13.354	-0.585			-0.851				0.322
& Parts (TE&P)		(-0.960)		(-1.724) ****	(-1.890) ****			(-1.815) ****				

Notes: §Each estimated equations include a constant term.

¶ Y/N=output per factory; CR= concentration ratio; K/L= capital-labor ratio; NP= non-production) employees to production workers; W= real wage; LNW, DELW= change in real wage; ERP= effective rate of protection; ICR= import coverage ratio; IPR= import penetration ratio; REER= real effective exchange rate.

‡ Figures in parentheses are t-ratios. *- Significant at 1%, **- Significant at 5%, ***- Significant at 10%, ****- Significant at 10% (one tail), *****- Significant at 12%, ******- Significant at 14%, *******-Significant at 15%, ********- Significant at 16%, *********- Significant 17%, **********- Significant at 18%.

Coming to the trade-related variables it can be said that the variable representing import liberalization is Effective Rate of Protection (ERP) and the coefficient of ERP is consistently negative for the industry groups for which it appeared in the regression specification. The coefficient is statistically significant at 1% level for MP&P and 10% (one tail) for TE&P and 12% for NEM industries implying that with reduction in ERP productivity growth enhances through increased competitive pressure on domestic industry.

Other variables capturing trade policy reforms are Import Coverage Ratio (ICR) and Import Penetration Ratio (IPR). EM and L&P industries show negative coefficient of ICR but the significance level is as low as 16% for each of them. The coefficient of ICR is positive but statistically insignificant for TP and BMA industries. The coefficient of IPR is negative and statistically significant at 10% (one tail) for CT; 10% level for BC&P and MP&P industries. Negative and significant coefficient of ICR and IPR signifies TFPG of the concerned industries over the years. EM industry experiences negative and statistically insignificant coefficient of IPR.

The coefficient of Real Effective Exchange Rate (REER) is statistically significant at 10% for FP and P&P industries and 10% (one tail) for NEM industry. For W&P the coefficient of REER is positive and the significance level is as low as 17%. To realize the effect of reduction in ERP on TFPG, the coefficient of REER is expected to be positive and it is rightly so for the above industry groups. Actually, depreciation in REER will offset the effects of tariff reduction.

To sum up, the results of the regressions is very much industry specific, which in turn, places the need for formulating industry-specific policies for enhancing TFPG of Indian manufacturing industries, keeping in mind that the variables explaining TFPG, as well as the responsiveness of TFPG to those particular significant factors vary across different industry groups. Impact of trade-related variables on TFPG does not indicate any significant adverse effect of import liberalization on productivity growth of different industries. Rather there are indications that a lowering of tariff and realistic adjustment of real effective exchange rate may have contributed positively to Total Factor Productivity Growth of different manufacturing industries.

V. CONCLUSION

The present paper tries to explain the intra-industrial differences in TFPG, considering some trade-related variables along with other determinants of TFPG, bearing in mind that the effect of trade liberalization on a specific industry group will jointly depend on movement of trade related variables and industrial characteristics of that particular industry group. Further most of the earlier studies, related to the analysis of TFPG, commented on the effect of any explanatory variable considering aggregate industrial sector. But given the fact that there exists high degree of intra-industrial disparity, it is expected that no single explanation for variation in TFPG of each industry group at disaggregated level will hold true. Rather, factors explaining the variation in TFPG and also its responsiveness regarding each factor will vary across different industries. The present paper add the literature in this direction by explaining the variation in TFPG at disaggregated level of manufacturing industries of India in view of the differences in inter-industrial structure and highlighting the role of trade-related factors. The use of non-parametric approach of DEA to measure TFPG has certain advantages over the parametric approach in the sense that no assumption is required regarding functional relationship between input and output, but this non-parametric approach remained largely unexploited till date. To measure the TFPG of different manufacturing industry groups, a two-stage DEA-based procedure is applied, where OLS estimation is used in second stage to explain the variation in TFPG of concerned industry group. According to Banker and Natarajan (2008), such a method yields consistent estimates of the impact of contextual variable and also significantly outperforms the parametric method. From 1980-81 to 2001-2002, considering 17 industry groups, the average TFPG is reported as 3.90% per annum. Decomposition of MPI into technical change, technical efficiency change and scale efficiency change reveals that technical change is the prime driving-force of productivity increase. Highest productivity growth is achieved by Manufacture of Wood and Wood Products, which is basically due to technical progress. The sole industry group- Basic Metal and Alloys Industry experiences technical regress. Out of 17 industry groups 16 show positive value of scale efficiency change (only one group exhibits negative value) implying movement towards the most productive scale size.

Considering the variables, defining industrial characteristics, the present paper reopens the old debate between firm size and productivity growth at disaggregate level with evidence from Indian manufacturing industries in a set up where the variables capturing industrial structure and also trade liberalization are included to explain the variation in TFPG and the productivity is measured by DEA. The results of the analysis exhibit that firm size has positive and significant impact on TFPG of Leather Industry; Electrical Machinery Industry; Basic Metal & Alloys Industry. Clustering of firms over the years may lead to TFPG of Food Industry; Wood, Wood Products Industry; Paper, Paper Products Industry and Metal Products Industry, whereas, big size, secured market lead to TFPG of Beverages and Tobacco Industry. The two technological variables considered here are capital-labor ratio and (non-production) employees per production worker. The coefficient of capital-labor ratio is expected to be positive and the effect is vividly captured by Paper, Paper Products Industry and the effect is significant at a very low level for Textile Products; Wood, Wood Products Industry Groups. A reduction of internal bureaucracy due to lower number of non-production employees per production worker can be resulted to increase in TFPG of Metal Products; Basic Chemical and Transport Equipment Industry Groups. On the other hand, the right combination of work-force is operating in Other Food Products Industry thus helping TFPG.

Increase in real wage can enhance the growth process of TFP of Paper, Paper Products Industry and Food Industry. Positive change in real wage rate has favorable, significant effect on TFPG of Paper, Paper Products Industry; Beverages, Tobacco Industry; Non-electrical Machinery Industry; Cotton Textile Industry.

Regarding the effect of trade liberalization on TFPG of different industries, the impacts of trade-related factors like ERP, ICR, IPR and REER on TFPG are very much industry specific.

Effective Rate of Protection (ERP) represents a proxy measure of import liberalization and negative coefficient of ERP implies lowering of ERP has favorable effect on TFPG as shown by two industry groups - Metal Products Industry and Transport Industry. Reduction in ICR and fall in IPR signify that imported goods become cheaper leading to greater access on more capitalistic and sophisticated technology, cost of production may fall and industry groups may enhance their TFPG over the years. Negative and significant coefficient of Import Coverage Ratio (ICR) is exhibited by Electrical Machinery Industry whereas; three industry groups namely, Cotton Textile, Basic Chemical and Metal Products Industries experience negative and significant coefficient of Import Penetration Ratio (IPR). The coefficient of Real Effective Exchange Rate (REER) is expected to be positive throughout the regressions and it happens so for four industries - Food Products Industry; Paper, Paper Products Industry; Non-electrical Machinery Industry whereas; the significance level is low for Wood, Wood Products Industry. Notably, with change in each of these variables the magnitude and responsiveness of TFPG vary across industries.

Analysis regarding the relationship between trade-related variables and TFPG broadly reports that lowering of tariff, non-tariff barriers, shifting of products from restricted list to OGL category and realistic adjustment of real effective exchange rate may have contributed positively to Total Factor Productivity Growth of different manufacturing industries. So it can be said that the effects of trade-related variables on TFPG of different industries are definitely felt and the impact of trade liberalization do not indicate any significant adverse effect on productivity growth of Indian manufacturing industries.

The whole analysis reveals that there is great heterogeneity in TFP performance across industry groups and there exists intra-industrial differences in the determinants of TFPG also. The relationship is different not only with respect to sign condition but also to the extent to which the factors can influence TFPG. All the observations, in turn, place the need for formulating industry-specific policies for enhancing Total Factor Productivity Growth of Indian manufacturing sector.

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