ORIGINAL RESEARCH PAPER | ECONOMICS | Volume : 6 | Issue : 8 | August 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

Estimating Total Factor Productivity and its Components – Evidence from Manufacturing Sector of Tamilnadu, India

KEYWORDS: India; data envelopment analysis; productivity; efficiency; Tamilnadu; Malmquist.
JEL Classification: D24, L60, O47

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ABSTRACT *The study applied Data Envelopment Analysis (DEA) to estimate total factor productivity growth and to identify the sources of productivity growth in the manufacturing sector of Tamil Nadu. The study considered 12 major sectors and estimated productivity growth and the major sources of productivity growth during the period 1981-82 to 2007-08. The study found that the productivity growth in the industrial sector of Tamil Nadu at the aggregate level during the test period was almost nil. While it is the case at the aggregate level, there are mixed results at the sectoral level. During the pre-reform period, there was significantly higher productivity growth in almost all the sectors contributed mainly by the improvements in efficiency. On other hand, there was productivity deterioration in the post-reform period since almost all the sectors witnessed negative productivity growth despite a technical change in the post-reform period. The study based on the empirical findings suggests that there will be productivity growth only if any improvement in the technology is accompanied by the corresponding improvement in the efficiency with which the technology can be turned into productivity gains. A well developed and skilled labour force along with the improvements in the technological developments will lead to higher productivity growth in the manufacturing sector both at the aggregate and sectoral level.*

INTRODUCTION

The study on productivity becomes important in view of the limited availability of factors of production, particularly the capital. The proportion of the factors of production or the inputs will be different in the different industries depending on the nature of product. The works of Solow (1957) further emphasized the need for the study of productivity and utilization of factor inputs. The role of productivity in accelerating the pace of economic growth is well recognized in both theoretical and empirical literature on growth. Sharma (1999) stated that higher productivity growth in developed countries is attributed to a high level of human capital, reliable physical infrastructure and technical advancements while poor productivity growth in developing countries is mainly attributed to inward-oriented policy regime, poor physical infrastructure, shortage of human capital and a lower level of R&D. The role of productivity in economic growth and its measurement has been discussed and debated extensively in the literature – both in the context of India and other countries. In the case of India, a number of studies have examined the issue for different sectors at the all India and regional (state) levels (Ahluwalia, 1991; Dholakia and Dholakia, 1994; Krishna and Mitra, 1998; Trivedi and others (2000) Chand and Sen (2002), Goldar and Kumari (2003), Kalirajan and Bhide (2004), Parameswaran (2004), Madheswaran and others (2007), Bollard *et* al., (2013), Purna and Kailash (2016). It is in this view, the present study attempts to estimate the productivity growth in the industrial sector of Tamil Nadu.

INDUSTRIAL PROFILE OF TAMILNADU

Tamil Nadu is one of leading industrialized states of India. Tamil Nadu proves to be a safe haven for the investors owing to ideal business climate and healthy socioeconomic reforms. Logistical advantages due to presence of three major sea ports, an international airport and several domestic airports, quality of human resources, a peaceful industrial climate and a positive work culture have strengthened Tamil Nadu's standing in the industrial world. The State's business-friendly policies and proactive initiatives have played a key role in this resurgence. Tamil Nadu is one of the well-developed States in terms of development and has carved for itself a place of pride in the Industrial Map of India. In the post liberalization era, with gradual dismantling of license restrictions, Tamil Nadu has emerged as one of the front-runners by attracting large number of investments. The State is the third largest economy in India both in terms of investment and output (ASI 2009-10) and its current State Domestic Product is well over $19.6 Billion.

The State has a well-diversified manufacturing sector ranging from automobiles, textile, leather, petro-chemicals and information technology. Even before the liberalization wave hit Indian shores, Tamil Nadu had established itself on the industrial map of India as a hub for Automobile and Auto components, Textile, Leather, Cement, Sugar and Engineering industries. In the post-liberalization era, the State has witnessed growth of new knowledge-based industries such as Information Technology (IT), Information Technology Enabled Services (ITES), and Biotechnology. The State has emerged as one of the front-runners in attracting a large amount of domestic and foreign investments in all these areas.

Tamil Nadu Government is keen on improving the State's competitiveness not only in the new growth sectors but the State Government is also determined to ensure the revival of the traditional industrial sectors with a declared vision to make Tamil Nadu a regional gateway to Asia and a major exporter of manufactured goods. In order to achieve this objective, the state government has resolved to rejuvenate the traditional industries. The focus of the State policy has been to facilitate and incentivize large industrial house to locate these factories within Tamil Nadu. This has led to the operation of a multiplier effect in terms of larger

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employment generation and investments in ancillary units and the related services sector. Industrial Infrastructure, such as roads, water supply, railways, industrial parks, etc., has also received adequate attention of the State. The State now focuses on stimulating further industrial development, attracting investment, facilitating new manufacturing capacity and enabling global manufacturing competence and competitiveness of the local industry. A Special Task Force on Industrial Development has been constituted by Government with the Chief Minister as Chairman and with senior industry representatives as members to speed up the industrial development in the State. The Government has announced new Industrial Policy during November 2007 with the aim "to give an impetus to the factors leading to industrial growth such as methodology of financing, development of technical skills, identification of the needs of industry by encouraging university-industry interaction and efficient government administration". Tamil Nadu Industrial Policy 2006-07, focused on stimulating further industrial development. It aims to attract investment, facilitate manufacturing capacity and enable global manufacturing competence and competitiveness of local industry. Tamil Nadu is well ahead in the industrial activities through dispersing industrialization. The State attracts foreign direct investment to strengthen the capital in the industrial sector. To promote the industrial activities in dynamic, the State is creating a favourable industrial climate in the State by announcing Industrial Policies, IT Policies from time to time and provides industrial assistances to the entrepreneurs.

Productivity growth is an important source through which output can be further increased. There are large numbers of studies on productivity growth but they were carried out for aggregate of manufacturing sector. Recently researchers made their contribution at the sectoral / firm level studies in order to explain the differences in the efficiencies of the sectors or the firms. Even in these studies, the manufacturing sector of a region/state has been considered in an aggregated manner. Further, they adopted relatively old methodologies of estimating productivity growth which is a great drawback of these studies. In other words, these studies are lacking in explaining the sources of such productivity growth. Hence there is a need to look into the studies on productivity growth in two ways: the first is the disaggregated study and secondly the application of relatively advanced methodology to estimate and to explain the sources of productivity growth. Large number of studies has been carried out in the recent past which stressed on the impact of economic reforms on the productivity growth in the Indian manufacturing. Again there was a common drawback in all these studies that they did not consider sufficiently longer period in their studies. Hence there is a need arises to include longer time period in the analysis to estimate the impact of economic reforms on the productivity growth in the Indian industrial sector. In the same way, there is a need to look into the impact of economic reforms at the regional level. India constitutes 28 states and 7 union territories. It is assumed that the economic reforms being implemented at the national level will have similar impact at the state level also. This has become an issue to be examined empirically. It is in this view; the present study makes an attempt to estimate the productivity growth of the industrial sector of Tamil Nadu. Further, the study proposes to apply the Data Envelop Analysis (DEA) to measure the productivity growth and the sources of such productivity growth from 1981-82 onwards to estimate the impact of economic reforms on the industrial productivity of Tamil Nadu.

DATA AND METHODOLOGY

Data

The study is based on the secondary data collected from Annual Survey of Industries (ASI) compiled and published by the Ministry of Statistics and Programme Implementation (MOSPI), Government of India. The data base consists of data on various aspects of Indian manufacturing both at the national and state level and is compiled from the annual reports submitted by the firms. The industrial sector of Tamil Nadu has been subdivided into 12 major sectors which contribute about 96 percent of the gross value added of the aggregate industrial sector of Tamil Nadu. The required data were collected for a period of 27 years from 1981-82 to 2007-08, the latest year for which the complete set of data available (ASI 2009-10).

Methodology

The primary objective of the study is the estimation of total factor productivity growth and sources of such productivity growth. Among the different measures of productivity, the study applied Data Envelopment Analysis (DEA), a non-parametric method, is used to estimate the malmquist index. The DEA has some advantages over the stochastic frontier approach, which calculates both technical efficiency and technical change components of TFP growth (Pradeep and Chen, 2012). The stringent assumptions on the product market structure and weak price information could be avoided by using the Malmquist index. The Malmquist Productivity Index (MPI) is considered to be superior in many aspects particularly in the estimation of the source of productivity growth in terms of efficiency change and technical change. To estimate and decompose the productivity growth, the study applied the computer programme DEAP 2.1 developed by Tim Coelli in 1996.

The study applied two input frame work to estimate the productivity. The study used value added as output and labour and capital as factor inputs. The gross value added was deflated by the whole price index (WPI) of respective sectors and thus the real value added was used in the analysis. Similarly, the total number of persons engaged was considered as the labour and gross fixed capital was used as capital input which was deflated by the WPI of machines and machine tools. Both output and capital was deflated with 1993-94 as base year.

Measurement and Decomposition of Total Factor Productivity Growth

Charnes et al. (1978) proposed the data envelopment analysis approach to construct a best practice frontier without specifying production technology. The Data Envelopment Analysis (DEA) is a special mathematical linear programming model and test to assess efficiency and productivity. It allows use of panel data to estimate changes in total factor productivity and breaking it down into two components namely, technological change (techch) and technical efficiency change (effch). TFP growth measures how much productivity grows or declines over time. When there are more outputs relative to the quantity of given inputs, then TFP has grown or increased. TFP can grow when adopting innovations such as electronics, improved design, or which we call "technological change" (techch). TFP can also grow when the industry uses their existing technology and economic inputs more efficiently; they can produce more while using the same capital, labor and technology, or more generally by increases in "technical efficiency" (effch). TFP change from one year to the next is therefore comprised of technological change and changes in technical efficiency.

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This study uses the output-oriented model of DEA-Malmquist to put much weight on the expansion of output quantity out of a given amount of inputs. Therefore, TFP index is a ratio of the weighted aggregate outputs to weighted aggregate inputs, using multiple outputs and inputs. Input and output quantities of industries are sets of data used to construct a piece-wise frontier over the data points. Efficiency measures are then calculated relative to this frontier that represents an efficient technology. The best-practice industry determines the production frontier, that is, those that have the highest level of production given a level of economic inputs. Points that lie below the piece-wise frontier are considered inefficient while points that lie on or above the frontier are efficient. Since many inputs are used, and shared outputs may be produced, the Malmquist approach was developed to combine inputs and outputs and then measure changes.

The Malmquist index measures the total factor productivity change (TFPCH), between two data points over time, by calculating the ratio of distances of each data points relative to a common technology. As per Malmquist Productivity Index (MPI) approach, total factor productivity can increase not only due to technical progress (shifting of frontier) but also due to improvement in technical efficiency (catch-up). This approach has become quite popular because: it does not require price data, therefore suitable when price data are not available or price data are distorted, (ii) it rests on much weaker behavioural assumptions, since it does not assume cost minimizing or revenue maximizing behaviour, (iii) it uses time serious data and provides a decomposition of productivity change into two components – technical change and technical efficiency change. The significance of the decomposition is that it provides information on the source of overall productivity change (Singh and Agarwal, 2006).

A Malmquist Total Factor Productivity (TFP) index measures productivity change, and decompose this productivity change into technical change and technical efficiency change. The distance functions of Malmquist approach is most commonly used for output comparisons (Price and Jones, 1996; Abbott, 2006; and Ramesh and others 2007). An output-orientated approach of computing TFP growth has been considered in this study.

Fare et al (1994) specifies an output-based Malmquist productivity change index as:

$$m_o\left(y^{t+1}, x^{t+1}, y^t, x^t\right) = \left[\frac{d_o^t\left(x^{t+1}, y^{t+1}\right)}{d_o^t\left(x^t, y^t\right)} \mathrm{X} \frac{d_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{d_o^{t+1}\left(x^t, y^t\right)}\right]^{1/2}$$

… (1)

The subscript "o" has been introduced to remind us that these are output-oriented measures

This represents the productivity of the production point (x^{t+1}, y^{t+1}) relative to the production point (x^t, y^t). **A value greater than one will indicate positive TFP growth from period t to period t+1.** This index is, in fact, is the geometric mean of output-based Malmquist TFP indices.

The Malmquist index of total factor productivity change (tfpch) is the product of technical efficiency change (effch) and technological change (techch) as,

tfpch = effch x techch (2)

The Malmquist productivity change index, therefore, can be written as:

M_0 (yt+1, xt+1, yt, xt) = effch x techch (3)

Technical efficiency change (catch-up) measures the change in efficiency between current (*t)* and next (*t+1)* periods, while the technological change (innovation) captures the shift in frontier technology. Technological change (techch) is the development of new products or the development of new technologies that allows methods of production to improve and results in the shifting upwards of the production frontier. More specifically, technological change includes new production processes, called process innovation and the discovery of new products called product innovation. With process innovation, firms figure out more efficient ways of making existing products allowing output to grow at a faster rate than economic inputs are growing. The cost of production declines over time with process innovations - new ways of making things.

Technical efficiency change, on the other hand, can make use of existing labor, capital, and other economic inputs to produce more of same product. An example is increase in skill or learning by doing. As producers gain experience at producing something they become more and more efficient at it. Labor find new ways of doing things so that relatively minor modifications to plant and procedures can contribute to higher levels of productivity.

RESULTS AND DISCUSSION

Annual Means of TFPG

DEA (Data Envelopment Analysis) methodology was applied to decompose the total factor productivity growth (TFPG) in Tamil Nadu Industries and its sectors for pre and post reform period 1982-83 to 1991-92 and 1992-93 to 2007-08.

Table 1 reports the estimates of TFPG and its components namely efficiency change (effch) and technical change (techch). It should be remembered that the Malmquist Productivity Index (MPI) greater than one (MPI>1) indicates productivity improvement and less than one (MPI<1) refers productivity deterioration. Similarly total factor productivity change (tfpch) is the product of efficiency change and technical change (tfpch = effch x techch).

It is evident from the table 1 that during the pre-reform period there was an increase in the total factor productivity growth by three percent for the aggregate manufacturing sector in Tamil Nadu mainly contributed by technical change by the same extent along with a marginal improvement in the efficiency change (0.1 percent)

Table 1
Annual Means of TFPG and its Components

Year	Effch	Techch	Tfpch
1982-83	1.035	1.009	1.044
1983-84	1.066	0.928	0.99
1984-85	0.93	1.277	1.187
1985-86	0.992	0.88	0.873
1986-87	1.007	1.099	1.108
1987-88	1.019	0.904	0.921
1988-89	0.952	1.161	1.106
1989-90	0.932	1.114	1.039
1990-91	1.084	0.962	1.043
1991-92	1.081	0.947	1.024
1992-93	0.813	1.005	0.817
1993-94	1.079	1.126	1.216
1994-95	0.85	1.037	0.881

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1995-96	0.936	0.996	0.932
1996-97	1.112	0.888	0.987
1997-98	1.001	1.001	1.002
1998-99	0.86	1.207	1.038
1999-00	1.286	0.736	0.946
2000-01	0.985	1.095	1.078
2001-02	1.05	0.943	0.991
2002-03	0.969	0.898	0.87
2003-04	0.839	1.386	1.163
2004-05	0.924	1.022	0.944
2005-06	1.061	1.081	1.147
2006-07	0.909	1.167	1.061
2007-08	0.829	1.141	0.945
Mean-Pre-Reform	1.001	1.030	1.030
Mean-Post-Reform	0.978	1.023	1.000
Overall Mean	0.986	1.026	1.011

Out of 10 years considered in the pre-reform period, there were productivity improvements in seven years. It ranged from 18.7 percent in 1984-85 to -12.7 per cent in 1985-86. The highest positive growth of 18.7 per cent in TFPG was contributed mainly by the technical change by 27.7 per cent while the contribution of efficiency change was negative at seven percent. As against this, the significant decline in both technical change (-12 %) and efficiency change (-0.08 %) pulled down the TFPG to -12.7 per cent in 1985-96.

During the post-reform period there was no productivity growth. There was an improvement in technical change by 2.3 percent but the efficiency change declined by 2.2 percent. It could be observed that there were productivity improvements in seven out of 16 years ranging from 0.2 per cent in 1997-98 and 21.6 per cent in 1993-94. The higher TFPG was contributed together by technical change (12.6 per cent) and efficiency change (7.9 per cent). There were productivity deterioration in 9 years out of 16 years ranged from -0.9 percent in 2001-02 caused by a negative technical efficiency by 5.7 per cent and –18.3 percent in 1992-93 primarily due to a greater fall in the efficiency change of 18.7 per cent despite a marginal technical efficiency of 0.5 per cent.

During the entire period of study, 1981-82 to 2007-08, the average improvement in productivity was estimated at 1.1 percent at the aggregate level. The marginal growth in TFP was contributed mainly in technical change to the extent of 2.6 percent despite a negative efficiency change of 1.4 percent. It could be observed that the efficiency change found positive for 12 years out of 26 years (effch greater than 1) while technical change was found positive for 16 years out of 26 years (techch greater than 1). On an average, the total factor productivity change was found positive for 14 years (MPI >1) and negative for 12 years (MPI <1) out of 26 years considered in the study.

Sectoral Means of TFPG

Table 2 Sectoral Means of TFPG and its Components

Sectors	effch	techch	tfpch
Food and Food Products	0.971	1.01	0.981
Tobacco Products	0.999	1.009	1.008
Textile Products	0.983	1.021	1.004
Wood and Wood Products	0.964	1.004	0.968
Paper and Paper Products	0.947	1.055	0.999
Leather and Fur Products	0.997	1.005	1.002
Basic Chemicals and Chemical Products	0.949	1.045	0.992
Rubber, Plastic, Petroleum and Coal Products	1	1.065	1.065
Non Metallic Minerals Products	0.986	1.043	1.029
Basic Metals and Alloy Industries	0.984	1.051	1.034
Machinery and Equipments	1	1.036	1.036
Transport Equipments and Parts	0.984	1.035	1.019

Table 2 presents mean Malmquist productivity index at the sectoral level. Out of 12 industries, eight sectors recorded productivity improvement while four sectors recorded productivity deterioration during study period 1981-82 to 2007-08. The industries which recorded productivity growth during the study period include Tobacco industries (0.8 percent contributed by technical change by 0.9 percent despite a negative efficiency change of -0.1 percent), Textile industries (0.4 percent contributed by technical change by 2.1 percent in spite of a negative efficiency change of -1.71 percent), Leather & Fur industries (0.2 percent contributed by the technical change of 0.5 percent in spite of a negative efficiency change of -0.3 per cent), Rubber and Plastic industries (6.5 percent contributed by technical change 6.5 percent with nil contribution of efficiency change), Non-metallic industries (2.9 percent contributed by technical change 4.3 percent in spite of a negative efficiency change of -1.4 percent), Basic metals & mineral industries (3.4 percent mostly contributed by technical change 5.1 percent in spite of a negative efficiency change of -1.6 percent), Machinery industries (3.6 percent contributed by technical change 3.6 percent with zero contribution of efficiency) and Transport industries witnessed a productivity gain of 1.9 percent contributed by technical change 3.5 percent despite a negative efficiency change of -1.6 percent.

Out of 13 industries, productivity decline was recorded by four sectors which include Food & Beverages industries (-1.9 percent due to the greater decline in efficiency change at -2.9 despite of a positive technical change of one percent), Wood and wood products (-3.2 percent due to the greater fall in the efficiency change at -3.6 percent despite of a positive technical change of 0.4 percent), Paper & paper products (-0.1 percent due to the decline in efficiency change at -5.3 percent but a higher technical change was increased at of 5.5 percent), Chemical industry(-0.8 percent due to the greater fall in the efficiency change at -5.1 percent despite of a positive technical change of 4.5 percent).

It could be observed that all the above eight sectors gained the productivity growth mainly due to higher technical change rather than efficiency change. In the same way productivity decline witnessed by four sectors was primarily due to efficiency deterioration. This shows that the workers were inefficient for the modern technologies implemented in the industries in recent years which led to productivity decline in these sectors.

Mean TFPG during Pre and Post-Reform Period

Table 3 reports mean productivity growth of the selected industries during pre and post-reform period. This analysis is helpful to understand the real impact of ongoing reforms in the industries sector. It is evident from the table that out of 12 sectors, ten sectors recorded positive productivity growth during pre-reform period the highest being Rubber, Plastic, Petroleum and coal products industry at 10 per cent and the least positive TFPG was recorded by Basic chemical and chemical products at 1.1 per cent. The sectors which recorded negative productivity growth include Wood and wood products (-4.1 per cent) and Transport equipment industry (-0.7 per cent). A common observation for the productivity gains during the pre-reform period would be an improvement in efficiency rather

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than technology excepting in Paper and paper products industry and Basic chemical and chemical products industry in which the technical change was the source of productivity growth.

Table 3
Sources of Productivity Growth during Pre and Post Reform Period

Sector	Pre-Reform			Post-Reform		
	effch	techch	tfpch	effch	techch	Tfpch
Food and Food Products	1.039	0.985	1.024	0.931	1.026	0.955
Tobacco Products	1.032	0.998	1.030	0.979	1.015	0.994
Textile Products	1.036	1.002	1.037	0.952	1.034	0.984
Wood and Wood Products	1.000	0.959	0.959	0.942	1.033	0.973
Paper and Paper Products	0.990	1.055	1.045	0.920	1.055	0.971
Leather and Fur Products	1.077	1.006	1.084	0.961	1.013	0.974
Basic Chemicals and Chemical Products	0.978	1.034	1.011	0.932	1.052	0.981
Rubber, Plastic, Petroleum and Coal Products	1.000	1.100	1.100	1.000	1.044	1.044
Non Metallic Minerals Products	1.004	1.049	1.053	0.975	1.040	1.014
Basic Metals and Alloy Industries	1.011	1.060	1.072	0.968	1.045	1.011
Machinery and Equipments	1.001	1.026	1.027	1.000	1.042	1.042
Transport Equipments and Parts	0.969	1.025	0.993	0.994	1.042	1.036

As against this, during the post-reform period, the situation was quite contradictory that all the sectors which experienced productivity growth in pre-reform period were found to record a steep fall in productivity growth and turned even negative except in Machinery and equipments industry (from 2.7 per cent to 4.2 per cent) and Transport equipments and parts industry (from -0.7 per cent to 3.6 per cent). The productivity deterioration in majority of sectors is a clear indication that economic reforms have not benefited the manufacturing sectors in the state. It cannot be ignored that there is a positive contribution of reform process in terms of technical efficiency as almost all the sectors experienced technological development but the improvements in technology could not be converted into productivity gains due to significant decline in efficiency. It is the quality and skill of the man power which make effective use of technology to produce higher output. In the absence of these, any improvement in technology will not yield desirable change in the productivity growth in any sector.

CONCLUSION

The study applied DEA to estimate total factor productivity growth and to identify the sources of productivity growth in the manufacturing sector of Tamil Nadu. The study found that the productivity growth in the industrial sector of Tamil Nadu at the aggregate level during the test period was almost nil. While it is the case at the aggregate level, there are mixed results at the sectoral level. A comparison of productivity growth in the pre and post-reform period indicate significant differences in the estimates of TFPG and its sources. During the pre-reform period, there was significantly higher productivity growth in almost all the sectors contributed mainly by the improvements in efficiency. On other hand, there was productivity deterioration in the post-reform period since almost all the sectors witnessed negative productivity growth despite a technical change in the post-reform period. Further, the obtained estimates reveal that during the post-reform period, there was significant improvement in the technical efficiency caused generally by the increased inflow of capital and technological advancements. But, there was no corresponding improvement in the efficiency change. There will be productivity growth only if any improvement in the technology is accompanied by the corresponding improvement in the efficiency with which the technology can be turned into productivity gains. Therefore, it may be suggested that the government should concentrate on the efficiency improvements by way of education and training to adept at the available technology. A well developed and skilled labour force along with the improvements in the technological developments will lead to higher productivity growth in the manufacturing sector both at the aggregate and sectoral level.

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