Total Factor Productivity of Indian Firms: A Malmquist Approach

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Abstract - The purpose of this paper is to measure the total factor productivity (TFP) growth of Indian firms listed in BSE- 500 index with reference to efficiency change and technological change. The study uses a balanced panel dataset of 49 companies over the period of 2001 to 2012. DEA based a non parametric Malmquist productivity index was used to compute total factor productivity and its components- technical efficiency change and technological change. The result shows that technological change has contributed more than efficiency change among Indian firms to the total factor productivity growth. It means TFP growth progress was obtained mainly due to innovations.

Keywords:* *Total Factor Productivity, Malmquist Index, Data Envelopment Analysis

I. INTRODUCTION

Productivity growth has been known as a key driver of economic growth. It is important not only to raise output but also to improve the competitiveness of an industry in domestic and global level. The growth of an economy is governed by two sources. These sources are input and productivity driven. The growth of input-driven is achieved by increase in factors of production which is subject to diminishing returns and is not sustainable in the long run [2, 10]. The productivity-driven growth is the growth in output that cannot be explained through growth in total inputs. The growth in productivity is also known as total factor productivity growth. Total factor productivity growth is the variation between actual growth of output and the growth due to combination of all factor inputs. Productivity is generally measured by single factor productivity and multi factor productivity. Multi factor productivity is also known as total factor productivity.

The TFP is an index of output divided by an index of input mix and suggest to the change in the productivity. Total factor productivity is a broadly used measure to compute productivity. Productivity and efficiency of Decision Making Units (DMU) is assessed by two approaches – parametric approach and non- parametric approach. The various parametric approaches are distribution free approach, thick frontier approach and econometric frontier approach. The specification of functional form of production function and cost function are required in these approaches. TFP is considered by various approaches such as - growth accounting approach, stochastic frontier analysis (SFA) and DEA based Malmquist productivity index. SFA and DEA based MPI have become more popular approaches for evaluation of TFP. Stochastic frontier analysis (SFA), is a parametric approach and Data envelopment analysis (DEA), is a non- parametric approach. DEA has significant advantages relatively to SFA such as; it does not need any functional form for the production function [17]. DEA based Malmquist productivity index has three main advantages relative to Tornqvist and Fischer indices and these were suggested by Grifell-Tatje Lovell (1996) [5] – (1) It does not need the assumption of cost minimization or profit maximization. (2) It does not want information regarding input and output prices. (3) If the researcher have panel data it allows the decomposition of productivity changes into two components the indices of total factor productivity change, technology change and efficiency change. DEA, the non – parametric approach to make a production frontier was first proposed by [1]. The DEA is highly popular tool with the researchers [12, 11, 8, 18].

In this study we use output – oriented analysis because most of firms have their objectives to maximize their output in the form of revenue or profit. It is also assumed that there is constant return to scale (CRS) technology to estimate the distance functions for calculating Malmquist TFP index and if technology exhibits constant return to scale, the input based and output based Malmquist TFP index provide the same measure of productivity change.

The present study is structured in such a way where section 2 presents the review of literature related with the present study. Section 3 deals with the objective and section 4 explains methodology, data and variables adopted for the study. Section 5 summarized the evaluation of results. And last section provides conclusion of the study.

II. REVIEW OF LITERATURE

Most of prior studies on productivity generally focused on input productivity such as labor or capital as a measure of input efficiency. An increase in the level of productivity shows an increase in the efficiency of inputs. Thus the same level of inputs can produce high level of output, which means that cost of production decrease. Further it shows an

 DOI : 10.18231/2454-9150.2019.0039

improvement in the quality of inputs. There are several factors affecting productivity such as level of technology and socio-demographic [4]. Other factors such as human resource management (HRM) and institutional reformation may also influence productivity. The following are some studies, which are used Malmquist productivity index to measure the productivity.

Arnade (1998) [3] used non-parametric Malmquist index approach to estimate agricultural productivity indices during the years 1961-1993 for 70 countries. In case of developing countries, he found that thirty six out of forty seven countries in the sample show negative technical change.

Isik and Hassan (2003) [6] examined efficiency change, technical change and productivity growth in Turkish commercial banks. They found that both private and public Turkish banks recorded significant productivity gains. These results were driven by more effective management of resources rather than technical progress.

Jeanneney *et al.* (2006) [19] measured the productivity growth of Chinese banking system and decomposing the productivity change into efficiency change and technological change. They found that the Chinese banking system had improved its total factor productivity and the growth in productivity was mainly achieved by due to technical progress rather than to development in efficiency.

Mittal and Dhingra (2007) [15] used Data envelopment analysis on selected 27 Indian commercial banks over the years 2003-04 and 2004-05. They found that private-sector banks were more efficient in terms of the productivity and profitability than other banks under public ownership.

In view of earlier studies, it has been recognized that large studies have been carried on productivity growth, but most of them are conducted in the area of agriculture, manufacturing and banking sector. This is the reason we want to measure the productivity growth of listed firms in India. The Malmquist productivity index decomposes the total factor productivity growth into "efficiency change" and "technical change". TFP can be improved by using its existing technology and factor inputs more efficiently which is termed as "efficiency change". The TFP of an industry may improve if the industry adopts technological improvements or innovations, which is termed as "technological change". Thus changes in TFP from one period to the next are the products of both efficiency change and technological change.

III. OBJECTIVES OF THE STUDY

The main objective of this study is to calculate total factor productivity and its components - technical change and technical efficiency change of Indian firms listed on BSE – 500 index over the period 2001 – 2012 by Data envelopment analysis based Malmquist productivity index. This study attempts to find answer this question – What are the sources of TFP growth of firms?

IV. DATA AND METHODOLOGY

Data

The firm level data have been collected from "Prowess" a database of Indian companies, maintained by the Centre for Monitoring the Indian Economy (CMIE). Our sample does not include banks, financial institutions, merged companies and Satyam computer services Ltd. The final sample set consist 49 companies of BSE- 500 index after remove outliers and deleting companies with incomplete data over a period of 2001-2012.

Variables

The variables we use consist of inputs in the form of capital, labor and outputs. In this study we use one output and two inputs variables.

Output Variable - In terms of output we use net sale.

Input Variables -In terms of capital we use gross fixed assets of a firm that includes both tangible assets such as land, building, plant and machinery and intangible assets such as goodwill, software etc. Labor, which is a freely moving variable in the estimation of the production function, is measured by compensation to employees that include all cash and payments in kind made by a company to its employees.

In this study we use output – oriented analysis because most of firms and industries have their objective to maximize their output in the form of revenue or profit. It is also assumed that there is constant return to scale (CRS) technology to estimate the distance functions for calculating Malmquist TFP index and if technology exhibits constant return to scale, the input based and output based Malmquist TFP index provide the same measure of productivity change. The Malmquist productivity index is an index of geometric mean of TFP index from period (t) to (t+1). The Malmquist TFP index measures the TFP change between two data points by calculating the ratio of the distances of each data points relative to a common technology.

In order to keep away from choosing the MPI of an arbitrary period Färe *et al.* (1994) [13] denote the output-oriented Malmquist productivity change index as:

Output- oriented Mamquist Productivity index as: (Model 1)

$$M_o(X^{t+1}, Y^{t+1}, X^t, Y^t) = \sqrt{\frac{D_o^t(X^{t+1}, Y^{t+1})}{D_o^t(X^t, Y^t)} \frac{D_o^{t+1}(X^{t+1}, Y^{t+1})}{D_o^{t+1}(X^t, Y^t)}} \quad (1)$$

Färe *et al.* (1994) further states that the MPI formula in equation (1) can be equivalently rewritten as:

 DOI : 10.18231/2454-9150.2019.0039

$M_o(X^{t+1}, Y^{t+1}, X^t, Y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \sqrt{\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \cdot \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}}$ (2)

The first ratio on the right hand side of equation (2) measures the changes in technical efficiency (EFFCH) between period *t* and *t+1* as a catching-up to the frontier effect. The second term measures (TECHCH) the change in production technology generally referred to as a shift in production frontier.

Technical Efficiency Change = EC = $\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}$ (3)

Technological Change = TC = $\sqrt{\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \cdot \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}}$ (4)

The Malmquist Productivity Index (MPI) of total factor productivity change (TFPCH) is the product of technical efficiency change (EFFCH) and technological change (TECHCH).

TFPCH = EFFCH x TECHCH (5)

The Malmquist productivity change index hence can be written as:

$M_o(X^{t+1}, Y^{t+1}, X^t, Y^t)$ = EFFCH x TECHCH (6)

Technical efficiency (TE) change measures the change in efficiency between current *(t)* and next *(t+1)* periods, while the technological change (Frontier effect) 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.

The Malmquist productivity index is an index of geometric mean of TFP index from period (t) to (t+1) .When the value of MPI is greater than one it shows improvement in productivity and a value less than one shows a decline in productivity and when equal to one it means no change in productivity.

To estimate TFP growth rate, one is deducted from TFP index and then value is multiplied by 100 to express it in percentage. This process has been applied to calculate the growth rates of related indices of MPI also.

Growth rate = (TFP index – 1)* 100

V. RESULTS

Descriptive Statistics of DEA

This section provides brief description of variables used in the study. The dataset consist of 49 firm's data for the period of 2001 to 2012. Table 1 represents the variables.

Table 1: Descriptive statistics of input and output variables

(in millions)

Variable	**Range**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Net Sale	540000	314.8	541614.2	44700	80006.18
Compensation to Employees	86385..3	44.6	86429.9	4097.74	9735.01
Gross Fixed Assets	417086	196	417282	30884.49	53840
N = 637					

Net sale is used as output range between 314.8 and 541614.2 with standard deviation 80006.18. Compensation to employees is used as input in terms of labor has standard deviation 9735.01. And gross fixed assets are also used as input in terms of capital has range between 196 and 417282 with standard deviation 53840. The larger figure of standard deviation shows that the data dispersion in the series is quite large.

Analysis of Malmquist Productivity Index and its Components

We calculate the TFP growth and its components for 49 firms of India over the period 2001 -2012 using data from Prowess. The variables we use in the form of inputs are labor and capital. In terms of output we use net sale. In terms of input we use gross fixed assets as capital input and compensation to employees as labor input. We use output based Malmquist productivity index with constant returns to scale (CRS) to measure total factor productivity and its components such as technical change and technical efficiency change. Table 2 shows productivity change, technical change and efficiency change in each period under the CRS. TFPCH progress is considered when its value is greater than one. TFPCH regress is considered when its value is less than one. No change in TFPCH is considered when its value is equal to one.

Table 2: Annual growth rates of TFP and its components - 2001 to 2012

YEAR	**EFFCH**	**G.R**	**TECHCH**	**G.R**	**TFPCH**	**G.R**
2001	1.043	4.3	0.938	-6.2	0.978	-2.2
2002	0.955	-4.5	1.001	0.1	0.955	-4.5
2003	1.086	8.6	0.935	-6.5	1.016	1.6

 DOI : 10.18231/2454-9150.2019.0039

ISSN : 2454-9150 Vol-04, Issue-11, Feb 2019

2004	0.777	-22.3	1.331	33.1	1.034	3.4
2005	1.076	7.6	1.037	3.7	1.116	11.6
2006	1.189	18.9	0.918	-8.2	1.091	9.1
2007	1.148	14.8	0.881	-11.9	1.011	1.1
2008	0.955	-4.5	1.057	5.7	1.01	1
2009	0.605	-39.5	1.628	62.8	0.985	-1.5
2010	1.482	48.2	0.656	-34.4	0.972	-2.8
2011	0.869	-13.1	1.155	15.5	1.003	0.3
2012	0.964	-3.6	1.068	6.8	1.03	3
Mean	0.99	-1	1.026	2.6	1.016	1.6

Source: Calculated by use of *DEAP, version 2.1.*

EFFCH- Efficiency change, TECHCH-Technological change, TFPCH- Total factor productivity change, G.R-Growth rate

Table 2 shows that Indian firms have registered TFPCH growth at the rate of 1.6 percent per annum during 2001-2012. During the period, TFPCH achieved the growth rate on account of (-1) percent growth rate of technical efficiency and 2.6 percent growth rate of technological change. It shows that technological change has contributed more than efficiency change among Indian firms to the total factor productivity. The table shows eight out of twelve years, Indian firms have experienced productivity gain. The positive growth rates have been observed during the years 2003-2008, 2011 and 2012 ranging from 0.3 (2011) to 11.6 (2005) percent. However, the productivity losses have been observed in the remaining four years. The negative growth rates have been noticed during the period 2001-2002 and 2009- 2010 ranging from -1.5 (2009) to -4.5 (2002) percent. The Indian firms have captured TFPCH at an exciting rate of 11.6 percent per annum in the year 2005 followed by 9.1 percent in the year 2006.

As for EFFCH index, Indians firms experienced efficiency increase in six years and efficiency decrease in remaining six years of the study period. The efficiency increase has been observed during the years 2001, 2003, 2005-2007 and 2010 ranging from 4.3 (2001) percent to 48.2 (2010) percent. The efficiency decrease has been observed during the years 2002, 2004, 2008- 2009 and 2011- 2012 ranging from -3.6 (2012) to -39.5 (2009) percent. The sample firms have captured EFFCH at the rate of 48.2 percent per annum in the year of 2010, followed by 18.9 percent in the year 2006. The EFFCH growth rate observed during the entire study period is -1 percent.

Indian firms reported growth rate in terms of TECH change index in the years 2009 and 2004 at the rate of 62.8 percent and 33.1 percent respectively. The sample firms have observed technological progress during seven years 2002, 2004-2005, 2008-2009 and 2011-2012 ranging from 0.1 (2002) percent to 62.8 (2009) percent. And technological regress have been observed in the remaining five years 2001, 2003, 2006-2007 and 2010 ranging from -6.2 (2001) percent to -34.4 (2010) percent. The TECH change growth rate observed during the entire study period is 2.6 percent.

The sample firms have realized that TFPCH growth is either due to technological progress or improvement in technical efficiency during the study period. But both technical efficiency and technological progress affected positively TFP growth of firms in year 2005 only.

VI. CONCLUSION

This study used the DEA based output oriented Malmquist productivity index to analyze the total factor productivity growth and its components technical change and efficiency change of Indian firms over the period 2001-2012. A value greater than one will indicate a positive TFP growth while, a value lesser than one will indicate a decrease in TFP growth. The finding shows that on average, Indian firms have TFP growth at the rate of 1.6 percent per annum during 2001-2012. During the period, TFPCH achieved the growth rate on account of (-1) percent regress rate of technical efficiency and 2.6 percent growth rate of technological change. It shows that technological change has contributed more than efficiency change among Indian firms to the total factor productivity. It means TFP growth was mainly obtained through innovations. These results are similar with the [13, 7]. The results are not consistent with [9, 16].

Future study could examine other features that are not included in this study such as industry wise classification of firms and use stochastic frontier analysis and other productivity index like Tornqvist productivity index etc.

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ISSN : 2454-9150 Vol-04, Issue-11, Feb 2019

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