A DEA Malmquist Approach to Measuring Productivity and Efficiency of NSE Listed Telecom Companies in India

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Abstract

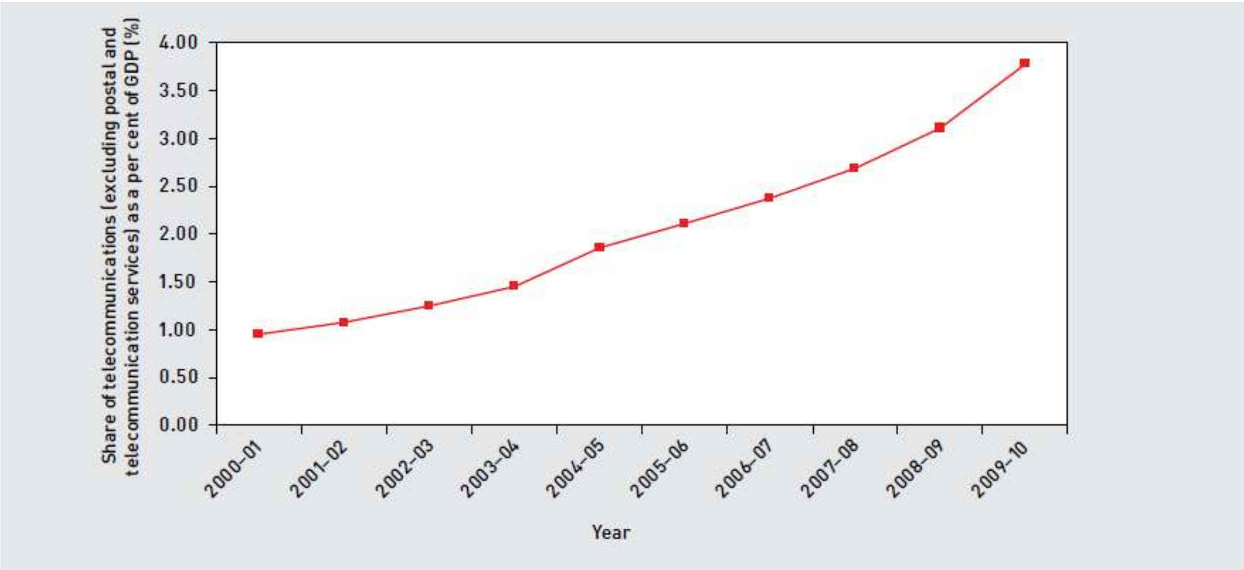
The present study investigates the technical efficiency of leading Indian telecom companies segmented in terms of ownership. For this purpose the Total Factor Productivity (TFP) of 5 leading listed telecom companies operating in India are considered .Malmquist Total Factor Productivity Index is used to analyze panel data. Malmquist Index measures the productive change and decomposes the TFP into two components, namely efficiency change and technical change. The efficiency change is further decomposed into pure technical efficiency and scale efficiency index. Malmquist indexes are constructed using the Data Envelopment Approach (DEA) and estimated using a software program developed by Coelli (1996) called DEAP version 2.1

Introduction

The telecommunications sector plays an increasingly important role in the Indian economy. It contributes to economic growth and the GDP and generates revenue for the government .India has witnessed rapid growth in mobile tele-density in last decade. From 2001 to 2011, the total number of telephone subscribers has grown at a compound annual growth rate (CAGR) of 35 percent (shown in Graph-1). Telecommunication companies are witnessing continuous technological changes and evolving regulatory climate. Indian telecommunication companies are increasingly buoyant and have started venturing outside the country and investing abroad. So it becomes extremely important for telecom companies to become efficient as more than five and six operators are operating in the single circle. Churn rates have escalated with increased competition and deregulation. Factors such as launching of mobile number portability scheme, introduction of 3G and 4Gservices and entry of new licenses are likely to further increase churn rates and reduce loyalty (TRAI, 2009).The high churn rates adversely affect mobile telecom operators because they stand to lose a great deal in price premium, decreasing profits levels and a possible loss of referrals from continuing service customers (Manero,2008). In the context of such an intensifying competition in the telecom sector, there is renewed interest in operator efficiency, because obtaining new customers is costlier than serving the existing ones. therefore, it makes sense to retain the existing customers (Reichheld, 1996).

Graph1

Share of Telecommunications as per cent of GDP, 2000–01 to 2009–10



Sources: National Accounts Statistics of India (2009) and various issues (NAS); EPW Research Foundation, Mumbai.

Table 1 shows the total outlay on telecommunications has increased from Rs 47 crore in the First Five Year Plan to Rs 2,58,439crore in the Eleventh Five Year Plan (EFYP) (2007–12).Share of telecommunications in the total Plan outlay has increased from 2.27 per cent to 7.09 per cent during the same Plan period. The growth rate of the plan outlay on communications shows that the big change came in the Sixth Five Year Plan.

Table 1

Total Plan Outlay and Outlay for Communications in Five Year Plans (Rs crore)

Plan	Communications outlay	Growth rate of communications outlay	Total outlay	Percentage of communications outlay
First Five Year Plan (1951-56)	47		2,069	2.27
Second Five Year Plan (1956-61)	66	40	4,800	1.38
Third Five Year Plan (1961-66)	164	148	7,500	2.19
Fourth Five Year Plan (1969-1974)	415	153	15,901.47	2.61
Fifth Five Year Plan (1974-78)	781	88	38,853.24	2.01
Sixth Five Year Plan (1980-85)	2,722	249	97,500	2.79
Seventh Five Year Plan (1985-1990)	8,123	198	1,80,000	4.51
Eighth Five Year Plan (1992-97)	25,110	209	4,34,100	5.78
Ninth Five Year Plan (1997-2002)	47,280	88	8,59,200	5.50
Tenth Five Year Plan (2002-2007)	98,968	109	15,25,639	6.49
Eleventh Five Year Plan (2007-2012)	2,58,439	161	36,44,717	7.09

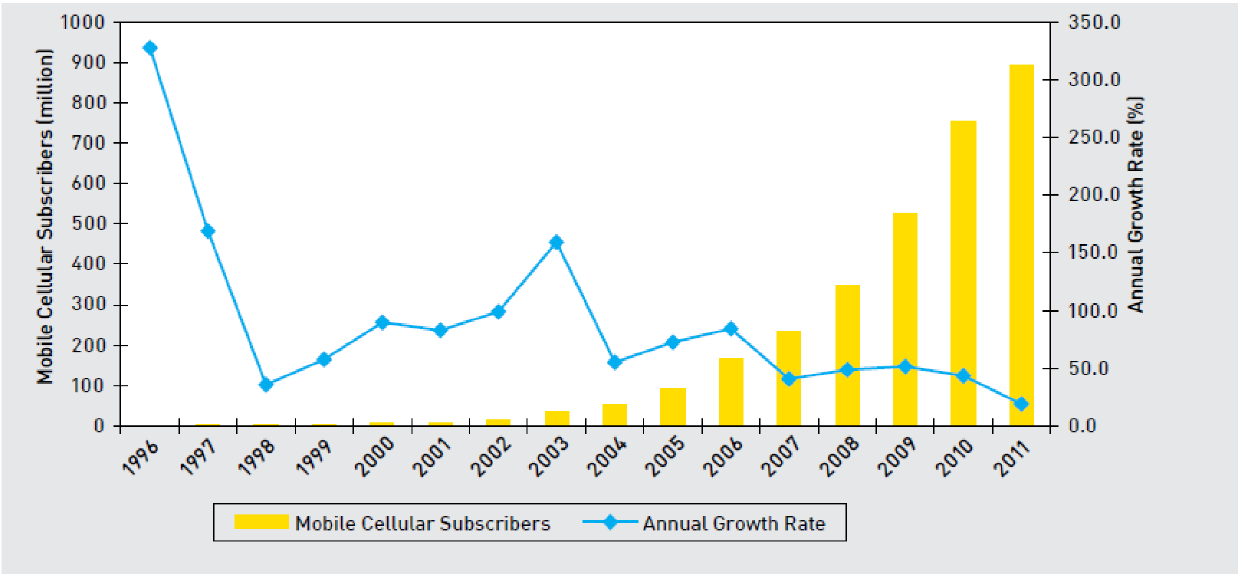
Source: Department of Telecommunications (DoT), Ministry of Communications, Government of India (2006), *Report of the Working Group on the Telecom Sector for theEleventh Five Year Plan*. Available online at www.planningcommission.nic.in

Cellular or mobile segment has been the key contributor to record growth in telecom sector as phone subscriptions with its wide range of offers of services. It has led the growth wave of telecom sector in the country. After triple digit growth rate in the first two years, growth rate reduced to 35.6 percent in 1998. The annual growth rate of wireless phones increased again till 2003 and peaked at 159.2 per cent. Since then the growth rate has tapered down and has averaged around 51.8 per cent during 2004–11. In 2011 growth rate significantly came down to 18.8 per cent (Graph 2). Mobile phones accounts for nearly 96.6 percent of the total telecom subscriptions as of February2012. More than 95 per cent of wireless connections are prepaid.

In India GSM mobile system is pre-dominant. There is a clear distinction between the Global System for Mobile Communications (GSM) and Code Division Multiple Access (CDMA) technologies. At the end of December 2011, GSM accounted for 87.9 per cent of the wireless subscriptions and was growing at a faster rate

Graph 2

Total Number of Wireless Subscribers and Growth Rate in India, 1996–2011



Source :World Development Indicators. Available online at www.worldbank.org, Telecom Regulatory Authority of India (2011).
Note: These are subscriptions at the end of each calendar year.

Objectives of the Study

1 The main objective of this study is to measure the total factor productivity changes of Indian telecom from 2006 to 2011 by means of DEA Malmquist index.

2 To draw out implications in the light of above study

Methodology

Sample of the Study

All telecom leading companies listed in National Stock Exchange constitute the universe of the study.

Panel Data, Data Envelopment Analysis (DEA) and Malmquist Index

It was found that the choice of technique plays an important role in estimating efficiency. DEA technique permits an assessment of the performance or Technical Efficiency(TE) of an existing technology relative to an ideal, best practice or frontier technology (Coelli *et al.,* 1998). The best practice technology or frontier is a reference technology or production frontier that depicts the most technically efficient combination of inputs and outputs. Efficiency is a broader concept and involves choosing of optimum levels of and mixes of inputs and outputs. It has been a matter of constant debate when it comes to defining the inputs and outputs. Overall telecom company's efficiency can be divided into scale, scope, pure, technical and allocative efficiency. Charnes-Cooper-Rhodes (CCR) (1978) proposed this model with the assumption of CRS. Hence, this model was named after the researchers and called as the CCR model. Ferrell (1957) defined the technical efficiency as the producers' ability to produce as much output as input usage and allows avoiding the waste of resources. TE is defined as a ratio of minimum costs that could have expended to produce a given output bundle to the actual costs expended. There are four types of technical efficiency estimations based on different assumptions. They are: DEA, Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA). They can be categorized into two categories: Parametric approaches—SFA, TFA and DFA and Non-parametric approaches—DEA. For the present study we have used non-parametric approach, i.e., DEA. DEA is a non-stochastic, non-parametric, Linear Programming (LP) to measure the relative efficiency of similar Decision Making Units (DMUs) with common inputs and outputs. DEA estimate compares each of the telecom company in the sample with the one that is the best practice observation or DMU in the sample. It separates efficient DMUs from non-efficient DMUs. As the survey of literature suggests, DEA has gained more and more acceptability as a tool for efficiency analysis of financial institutions. DEA is a non-parametric LP algorithm. As opposed to parametric methodologies, e.g., regression analysis, DEA does not assume that the same optimized regression equation applies to all observations, which are termed as DMUs. In this, an optimization procedure is carried out on each DMU, the results of which are distilled into a single efficiency score DEA has several advantages over regression analysis and ratio analysis, both of which are commonly employed in performance measurement. Primarily, regression analysis considers the average behavior of all units in order to explain the maximal amount of variance within the data. DEA focuses on the outliers within the data set. Specifically, it identifies those units, which achieve the best results, thus allowing their best practices to be exercised. As optimality is determined through comparison with a reference set of comparable firms (based on inputs consumed/outputs produced. DEA also identifies potential improvements and targets for inefficient units based on the exposed best practices. It is a non-stochastic, non-parametric, Linear Programming (LP) to measure the relative efficiency of similar Decision Making Units (DMUs) with common inputs and outputs. The DEA technique has been used to compute the technical efficiency scores especially in non profit organizations here efficiency cannot be calculated directly. DEA model is used to evaluate the relative efficiency of a DMU in their use of multiple inputs to produce multiple outputs. The DEA estimate compares each of the banks in the sample with the one that is the best practice observation or DMU in the sample. DEA has gained more and more acceptability as a tool for efficiency analysis of financial institutions. DEA is a non-parametric LP algorithm. As opposed to parametric methodologies, e.g., regression analysis, DEA does not assume that the same optimized regression equation applies to all observations, which are termed as DMUs.

Specification of Model (**DEA Malmquist Approach)**

DEA involves the use of linear programming methods to construct a non-parametric piecewise surface (or frontier) over the data, so as to be able to calculate efficiencies relative to this surface. More detailed reviews of the DEA methodology were also presented by Seiford and Thrall (1990), Lovell (1993), Lovell (1994), Charnes et al (1995) and Seiford (1996). Fare et al. (1994) listed several traditional methods to calculate the Malmquist productivity index. But most of them require specification of a functional form for technology. Charnes et al. (1978) proposed the Data Envelopment Approach to construct a best-practice frontier without having to specify the production technology. Unlike traditional analysis techniques that look for the average path through the middle points of a series of data, DEA looks directly for a best-practice frontier within the data. Using a non-parametric linear programming technique, DEA takes into account all the inputs and outputs as well as differences in technology, capacity, competition, and demographics and then compares each firm with the best-practice (efficiency) frontier. According to Ali and Seiford (1996), DEA is a well-established non-parametric efficiency measurement technique which has been used extensively in over 400 studies of efficiency in management sciences. The Malmquist Index measures the productive change and decomposes the TFP into two components, one measuring the change in efficiency (movement towards the production frontier) and the other, the change in the frontier technology. The productivity of a firm is measured by the quantity of output produced per unit of input. In case of Single Input, Single Output (SISO), it is merely the ratio of the Decision Making Unit (DMU) output and input quantities. Total factor productivity (TFP) includes all categories of productivity change, which can be decomposed into two components: (i) technological change and (ii) efficiency change. Technological change measures shifts in the production frontier. Efficiency change measures changes in the position of a production unit relative to the so called 'catching up' frontier (Fare et al.,1994).First, Malmquist TFP is applied in an output-based measure of TFP which assumes revenue maximization allowing inefficiency in each decision units (Fare et al.,1994). It measures the TFP change between two data points by calculating the ratio of two associated distance functions (Caves et al., 1982). Using the distance function specification, the problem can be formulated as follows.

$$P^t = \{(x_t, y_t) : x_t \text{ can produce } y_t\} \qquad (1)$$

Estimation of efficiency relative to production frontiers relies on the theory of distance or gauge functions. In economics, distance functions are related to the notion of the coefficient of resource utilization (Debreu, 1951) and to the efficiency measures (Farrell, 1957). The distance function is defined at t as:

$$d_o^t(y_t, x_t) = \min\{\phi : (y_t/\phi) \in P(x^t)\}, \text{on the output set, } P(x^t) \qquad (2)$$

Output-oriented Malmquist productivity index under constant returns to scale (CRS) is:

$$M_o(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{d_o^t(y_{t+1}, x_{t+1})}{d_o^t(y_t, x_t)} \times \frac{d_o^{t+1}(y_{t+1}, x_{t+1})}{d_o^{t+1}(y_t, x_t)}\right]^{1/2}$$

This index is a geometric mean of the period t (the first ratio) and period tþ1 (the second ratio) Malmquist indices, in order to avoid an arbitrary selection among base years. The above can be geometrically decomposed into two components:

$$M_o(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{d_o^{t+1}(y_{t+1}, x_{t+1})}{d_o^t(y_t, x_t)} \times \left[\frac{d_o^t(y_{t+1}, x_{t+1})}{d_o^{t+1}(y_{t+1}, x_{t+1})} \times \frac{d_o^t(y_t, x_t)}{d_o^{t+1}(y_t, x_t)}\right]^{1/2} \tag{3}$$

where the first ratio represents efficiency changes and the second geometric product of ratios represents technological change.

Data Overview

Data was obtained through website moneycontrol.com

Specification of Inputs and Outputs

Productivity of telecom companies are dependent on

Output : Sales Turnover

Inputs : Employee Cost and Selling and Admistration Expenses

Empirical Implementation

This study adopts the generalized output-oriented Malmquist index, developed by Fare et al. (1957), to measure the contributions from the progress in technology (technical change) and improvement in efficiency (efficiency change) to the growth of productivity in Indian telecommunication industries. The Malmquist indexes are constructed using the Data Envelopment Approach (DEA) and estimated using a program developed by Coelli (1996) called DEAP version 2.1. **.** Malmquist index is chosen as there are a number of desirable features for this particular study

Empirical Results

Since the basic component of the Malmquist productivity index is related to measures of efficiency, the paper first reports efficiency change for the five operators from 2006 to 20011 in

Tables 3. A value of one imply that the firm is on the industry frontier in the associated year, while a value less than one imply that the firm is below the frontier or technically inefficient

Table 3

Average Productivity Change score of telecom companies

Telecom Companies DMUs	Total Factor Productivity Change	Efficiency Change	Technical Change	Pure Efficiency Change	Scale Change
Reliance communication	1.000	0.987	1.000	1.000	0.987
Bharti Airtel	1.093	1.030	1.054	1.037	1.126
Idea Cellular	1.058	1.007	1.000	1.058	1.066
Tata Communications	1.000	0.964	1.000	1.000	0.964
BSNL	0.947	0.973	1.000	0.947	0.921
Mean	1.018	0.992	1.011	1.008	1.010

Source: Output is generated through DEAP version 2.1

Interpretation of Data Under Output Maximization Mode

- Table 3 presents the geometric mean of Malmquist TFP change scores of the telecom companies for the period 2006 to 2011. All the telecom companies exhibit positive , except BSNL exhibited negative TFP growth . TFP declined at 7.9 percent [= (0.921–1) × 100]. Bharti Airtel turned out to be the star performer with a TFP growth of 12.6 percent [= (1.126–1) × 100] percent. All other telecom companies listed in NSE displayed TFP scores of greater than 1.
- Efficiency change scores indicate that all general insurers, except BSNL experienced a movement closer to the frontier, from the year 2006-07 to 2010-11
- Bharti Airtel obtained the highest efficiency score, followed by idea cellular.

- Technical change index indicates that Bharti Airtel showed the maximum progress on the technological front, By 3 percent. All the general insurers, except idea all other , recorded a technical productivity
- Further comparison of efficiency and technical change index establishes that out of the selected 5 telecom companies , Bharti Airtel and Idea reported more progress on efficiency grounds than technical progress, during the period under review
- Further decomposition of efficiency into pure technical efficiency and scale efficiency, shows that idea has the highest pure technical efficiency growth of 5 percent, followed by Bharti airtel a growth of 3.7 percent other companies have seen negative growth.
- Bharti Airtel and Idea cellular appears to be more scale-efficient than the other telecom companies.

Table 4

Malmquist Productivity Index for the Entire Industry, 2007-2011

Year	Efficiency Change Index	Technical Change index	Pure Efficiency Change Index	Scale Efficiency Change Index	TFP Change Index
2007-08	0.966	1.043	1.043	0.926	1.008
2008-09	1.110	0.875	1.000	1.110	0.972
2009-10	1.042	0.978	1.000	1.042	1.019
2010-11	0.963	1.085	1.000	0.963	1.044
Mean	1.018	0.992	1.011	1.008	1.010

Source: Output is generated through DEAP version 2.1

Table 4 year-wise Malmquist Index results for each ownership group and for the whole industry resents the average TFP scores of telecom companies for the telecom industry in the from the 2007 to 2011 .Analysis of the TFP scores reveals that all telecom companies having reported a growth in4.4 TFP for year 201-2011, followed for year 2009-10 as TRAI take major steps in the light

Conclusion

Malmquist TFP has been applied to selected Indian telecom companies from the period 2006 to 2011. Present case involves sales turnover as the output, with the employee cost and selling and admin expenses as inputs. TFP scores in all the cases indicates that Idea cellular and Bharti Airtel are productive in TFP. The rule of thumb regarding the sample size for TFP as the number of DMUs in the sample should be at least thrice the sum of the number of outputs and inputs. If the numbers of DMUs in the sample is less than this, it can inflate the productivity scores. Thus, the study was restricted to one output and two input data sets. Productivity of the telecom companies can be reexamined by considering different sets of inputs and outputs. Indian mobile telecommunication industry has great potential to further increase its output through an improvement in the efficiency component In addition, greater intensification of technology should also be accorded high priority. Existing technology has to be exploited further via infrastructure-sharing to reduce wastage resulting from underutilization of assets. Though domestic free roaming is underway in future has been significant to the industry, a lot more can be done to speed up the technological adaptation and knowledge dissemination through healthy competition among the telecommunication companies and market liberalization of the industry. Further research needs to be directed to Indian mobile u industry to be in a better position in this fast growing and very competitive industry.

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