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Operational efficiency and service delivery performance: A comparative analysis of Indian telecom service providers

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Operational efficiency and service delivery performance

A comparative analysis of Indian telecom service providers

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Abstract

Purpose – The purpose of this paper is to evaluate performance of Indian telecom service providers through a benchmarking study of their operational efficiency and service delivery effectiveness. The paper also carries out a peer-to-peer comparison and identifies-specific areas of improvement for different service providers to attain sustainable growth and profitability.

Design/methodology/approach – A two stage data envelopment analysis (DEA) model was used to compare the performances of the service providers. The first stage represents how efficiently a unit is able to use its infrastructure and resources to generate better quality services. The second stage captures how well the company is able to communicate and deliver these services to the customer.

Findings – The results of the study support the applicability of the two stage DEA for comparing the performances of the telecom service providers as they are in line with the financial performance indicators and brand ranking. It is observed that those companies which score high on both operational efficiency and service delivery effectiveness have achieved superior profitability.

Research limitations/implications – This study has been carried out at a pan-India level and hence does not take into account circle level or local performance which varies significantly for most service providers. Besides, this the analysis was constrained by limited data in the public domain, which necessitated estimations and extrapolations for some variables of few service providers.

Practical implications – The study has helped to provide inputs for the Indian telecom companies for potential performance improvements by providing a comparative analysis of their operational efficiency and service delivery effectiveness. It has enabled to derive deeper insights on potential target areas for managerial attention that could be translated into implementable actions. The benchmarking analysis has also helped to understand whether the current performance of the service provider is sustainable, unprofitable or ephemeral.

Originality/value – This paper goes beyond the traditional benchmarking studies of Indian telecom service providers introducing a two stage DEA model to understand the operational efficiency as well as the service delivery effectiveness. The study has helped to derive valuable academic and practical insights on the issue of performance measurement of the Indian telecom service providers.

Keywords Performance measurement, India, Operational efficiency, Service quality, Productivity, Benchmarking, Data envelopment analysis, Service delivery effectiveness, Telecom

Paper type Research paper

1. Introduction

The quality of telecommunication infrastructure plays a critical role in the economic progress and the development of a knowledge economy. Owing to a large population base and phenomenal growth of the industry, the Indian telecommunication subscriber base expanded at a CAGR of 26.8 percent during 2007-2012 to become the second largest network in the world. As per the Telecom Regulatory Authority of India (TRAI) (2013) report, the wireless subscriber base was 873 million and the urban tele-density

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was 147 percent while the rural tele-density was at 41 percent. There have been continued infrastructure investments into this sector and the country is projected to witness even higher penetration levels in the coming years.

Until the late 1980s, the Indian telecom industry was completely controlled by the government and the size of the market was very small. However, with the first phase of the liberalization initiatives of the Indian economy in 1991, private sector participation in the telecom industry increased significantly. The government continued to play a huge role in formulating the policies which shaped the structure of the telecom industry as seen today. The New Telecom Policy-1999 provided the impetus to the industry and set the trend for further liberalization. In 2003, the Department of Telecom issued guidelines for "unified access licensing" which allowed firms to provide access to telecom services based on any type of technology. This changed regulatory landscape triggered a price war that led to lower industry margins year on year, resulting in lower industry average revenue per user (ARPUs). By early 2011, Indian telecom sector had become hyper-competitive with more than 15 players. The intense competition to provide lower rates to the customer resulted in the prices being bottomed out by 2012 with most of the players offering similar rates. Thus, the call rates stopped being the differentiating factor post 2012. The wireless and wire-line revenues had grown at CAGR of 11.9 percent in the five years leading to an estimated USD 40.8 billion in 2012. Interestingly as per the TRAI (2013) report, 96.6 percent of total telephone subscriptions were wireless, which was further dominated by GSM services with 88.1 percent share. As per a recent report by Indian Brand Equity Foundation, the top five players – Bharti Airtel, Vodafone, Reliance, Idea and BSNL together accounted for nearly 80 percent of total subscribers.

Apart from a price war, the Indian telecommunications industry witnessed one of the biggest scams in the country – the 2G spectrum scam in 2008. The retrospective tax imposition by the Indian Income Tax Department over the Vodafone-Hutchison deal also received a lot of media attention. Besides, the heavy penalties imposed on players sharing spectrum for 3G intra-circle roaming and those who have exceeded the base transceiver station (BTS) radiation norms are among several reasons which have further squeezed margins of most telecom players. The recent Indian government efforts to ease some of the norms such as increasing the FDI limit and relaxing the Mergers and Acquisitions (M&A) norms are steps in the right direction to help the industry recover and yet at the same time encourage consolidation. Applying a single spectrum usage charge and allowing spectrum trading were some of the initiatives that were proposed, that further indicated the government's intention to support operators.

In the recent past, most operators have realized the importance of cutting costs through utilizing their assets more efficiently. In the absence of price as a differentiator, to remain competitive and profitable, a telecom service provider has to concentrate on reducing its internal costs and to provide best services to the customers. While the first objective could be achieved through internal operational efficiencies, the second could be a realized through superior service delivery and marketing effectiveness. This study attempts to address this issue by conducting a performance benchmarking exercise. The remaining part of this paper is structured as follows: The next section is on the background and the objectives of this study followed by Section 3 that briefly outlines the data envelopment analysis (DEA) methodology for performance benchmarking. Section 4 dwells on the application of DEA methodology while Section 5 contains the results and discussions. This is followed by Sections 6 and 7 that present limitations of the study and concluding remarks, respectively.

2. Background and objectives

There have been several studies reported in the literature that measure the productivity of the telecommunications industry using the DEA technique. Liao and González (2009) measured and compared the operational efficiency across leading telecom service providers among the BRIC nations using the DEA approach. They used number of employees, total assets and capital expenditure (CAPEX) as inputs and revenue as output. Their model enabled in measuring the partial factor productivity as well as the technical and scale efficiencies. While comparing telecom companies across countries, several studies including Giokas and Pentzaropoulos (2000) argue that DEA can be used as an effective tool to benchmark these decision making units (DMUs). However, it is difficult to understand the competitive landscape while comparing service providers across different countries owing to the plethora of dynamic variables emerging from the country-specific business environment.

For a hyper-competitive telecom market like India, several attempts have been made to benchmark Indian telecom service providers. Nigam *et al.* (2012), in their DEA-based study used Malmquist index to evaluate productivity performance of mobile telecom operators in India. The Quality of Service (QoS) metrics released by Telecom Regulatory Authority of India (TRAI) for all telecom service providers in India across all service circles, served as a major source for most of their subsequent analysis. These metrics covered attributes like call success rates, voice quality, call drop rate, percentage of calls answered by operator within 60 seconds, etc. which helped in analyzing the service quality provided by the telecom service providers. Among the other DEA-based studies, an interesting one was by Debnath and Shankar (2008) who benchmarked Indian telecom companies using QoS variables instead of traditional variables like revenue as output and number of employees, capital employed, etc. as inputs.

Mouzas (2006) introduced the concept of ephemeral, sustainable and unprofitable growth by linking efficiency and effectiveness to assess business orientation. In such a scenario, it is important to get a deep understanding of the differentiating factors for a telecom service provider to be the first choice of customers and at the same time to remain profitable. The nature of profitability, according to them, can be depicted by measuring the efficiency and effectiveness to compare multiple businesses as shown in Figure 1.

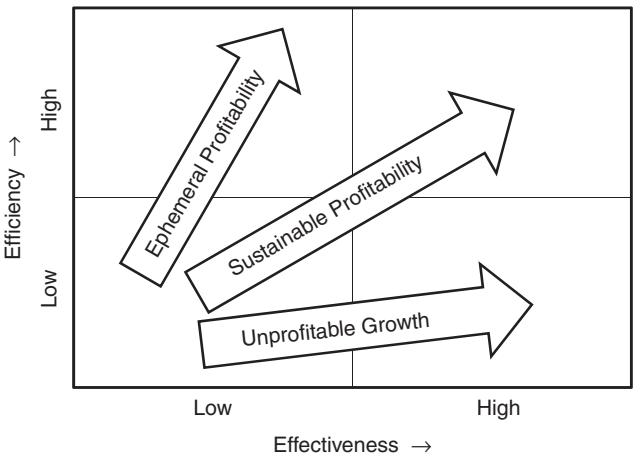

Figure 1.
Classification by Mouzas (2006)

Hallowell (1996) assessed the relationship between service quality and customer satisfaction resulting in profitability. Brown (1997) suggested norms to improve the interpretation of service quality measures. Nigam *et al.* (2012) went further to include variables such as capital employed and revenue along with QoS metrics for DEA application. However, in both the studies employing QoS variables, there still lies an ambiguity on the bucketing of different parameters under input or output. This issue has been particularly observed in the case of most single stage DEA applications where it is sometimes not possible to make distinction between internal and external environment of a DMU. Though multi-stage DEA has been widely used to benchmark firms across industries like life and health insurance (Yang, 2005) and Airlines (Zhu, 2011) among others, it was Jablonsky (2013) who emphasized on internal and external efficiencies emerging when using a two stage DEA model with interval inputs and outputs. Cook *et al.* (2010) used the game approach and efficiency decomposition analysis in a two stage DEA model.

In order to incorporate the impact of marketing on final customer acquisition and revenue realization, Papadimitriou and Prachalias (2009) introduced marketing expenses as input while Pramod and Banwet (2012) added PAT as one of the outputs for their respective DEA applications on telecom service providers. Haridasan and Venkatesh (2011) took a closer look at the CRM implementation and its impact on performance of Indian telecom service providers by assessing inputs and outputs which measured attributes such as customer loyalty, empathy, advocacy and customer perceived network quality. In addition, Zhu (2000) developed a performance measurement model incorporating multiple factors indicating that higher revenue earning companies might not have the highest performance and reduction in workforce or assets can translate into increased profit levels. On similar lines, Luo (2003) showed that profitability and marketability efficiency are crucial for a bank's competitive advantage and with the help of an overall efficiency value the likelihood of bank failure could be predicted.

An examination of the literature reveals that most studies on benchmarking telecom providers using DEA approach have adopted a single stage DEA model and relied on only terminal variables like capital employed, total assets, size of workforce, etc. on the input side and number of subscribers or revenue/profit on the output side. On account of the analysis at an aggregate level, the findings of most of these studies have not been effectively translated into implementable actions for the telecom service providers. Also, the attempts to incorporate QoS parameters in the analysis seemed to have failed to make a distinction between the internal operational efficiencies and external service delivery performance. Refer to Table I for a summary of main studies in the area of analysis of relative efficiencies using DEA to compare telecom service providers.

This paper attempts to make a clear distinction between the internal and external setting for a telecom service provider, in order to benchmark the Indian telecom industry across different players. It looks at the sources of competitive advantage for these companies by determining the key parameters using a two stage DEA approach. The model incorporates terminal variables (conventional input-output variables – capital employed, assets, workforce, revenue, subscriber base, etc.), QoS metrics along with selling and marketing expenses for a holistic analysis.

Operational efficiency refers to the utilization of assets and resources to deliver quality service. Higher the service quality and lower the cost of assets, higher the operational efficiency. Service delivery performance refers to the ability of the firm to effectively communicate, reach and deliver services to the end customers. This can be

Title	Author	Brief	Inputs	Outputs
Comparing the operational efficiency of the main European telecommunications organizations: a quantitative analysis	Giokas and Pentzaropoulos (2000)	Carried out operational efficiency comparison for main European public telecommunication organizations. They accounted for physical network infrastructure by including the number of access lines as an input along with other traditional variables used in similar DEA telecom benchmarking studies like subscriber base, number of employees and revenues at the output side	1. Access lines 2. Mobile subscribers 3. Number of employees	1. Revenues
The comparative productivity efficiency for global telecoms	Tsai *et al.* (2006)	Attempted to characterize the productivity efficiency of 39 Forbes ranked leading global telecom operators by using DEA. They compared the empirical results with financial indicators of the operators. They also drew interesting insights including performance based on geographic areas or based on ownership (state owned or privatized). The paper also assessed the impact of having full service (fixed, mobile and internet) as against fixed only or mobile only service among several structural differences	1. Total assets 2. CAPEX 3. Employee no.	1. Revenue 2. EBITDA 3. Operating profit (EBIT)
Benchmarking telecommunication service in India	Debnath and Shankar (2008)	One of the first papers to benchmark Indian telecom operators using DEA and incorporated quality of service parameters for the first time to determine the relative efficiencies for 42 operator-circle DMUs. They focussed primarily on quality of service of parameters for their input-output variables with the exception of number of subscribers and also determined circle wise rankings	1. No. of faults 2. Call success rate 3. Call drop rate 4. Good voice quality	1. Service access delay 2. Complaints per 1,000 bills 3. Complaints resolved within 4 weeks 4. No. of subscribers
Efficiency and productivity of major Asia-Pacific telecom firms	Hu and Chu (2008)	Used a two stage method to examine the efficiency scores for 24 major Asia-Pacific telecom firms using a single stage DEA at first stage and the score obtained from first stage DEA regressed upon environmental variables with Tobit regression in stage two	1. No. of Employees 2. Amount of fixed assets	1. Fixed-line revenue 2. Non fixed-line revenue

(*continued*)

Table I.
Summary of the literature: DEA in telecom

Table I.

Title	Author	Brief	Inputs	Outputs
Comparing operational efficiency among mobile operators in Brazil, Russia, India and China	Liao and González (2009)	Measured and compared the operational efficiency for dominant telecom players in the BRIC (Brazil, Russia, India and China) countries during the period between 2002 and 2006. The study also found based on sensitivity analysis that the input variable – total assets affected the most to the overall efficiency score	1. Number of employees 2. Total assets 3. Capital	expenditures 1. Total revenue
Estimating the efficiency of marketing expenses: the case of global telecommunication operators	Papadimitriou and Prachalias (2009)	Looked into the capability of 18 global telecom companies to maximize the efficiency of their productive factors. They introduced marketing expenses as an input to the DEA model and also split the traffic between mobile and fixed line into two separate inputs	1. Staff 2. Investments 3. Marketing expenses 4.Traffic of fixed telephony 5. Traffic of mobile telephony	1. Revenue
Benchmarking of Indian mobile telecom operators using DEA with sensitivity analysis	Nigam *et al.* (2012)	They benchmarked Indian telecom service providers for relative efficiencies and carried out a sensitivity analysis for the variables chosen. The papers compares 126 utilities (operator and circle combinations) to determine relative efficiencies incorporating quality of service parameters along with the traditional variables used in such analysis like expenditure, subscriber base and revenue in a single stage DEA	1. Expenditure 2. Call success rate 3. Call drop rate 4. Voice quality,	1. Service access delay 2. Complaints per 1,000 bills 3. No. of subscribers 4. Gross revenue
Benchmarking Indian telecom service providers: a data envelopment analysis	Pramod and Banwet (2012)	Estimated cost and allocative efficiency along with technical and scale efficiencies used in DEA for benchmarking Indian telecom service providers	1. Assets 2. Expenses	1. PAT 2. Income

measured through the active subscriber base and ARPUs earned by the telecom provider through its marketing and distribution efforts. It also takes into account aspects like brand perception, marketing reach and innovative schemes (Madden and Savage, 1999) to not only acquire more customers but also to extract higher revenues per user. By breaking the DEA model into two stages, it is possible to make this distinction. Further, by placing the input and output variables across these two stages, one could gain deeper managerial insights that could be translated into implementable actions. The overall performance of a telecom service provider could be obtained as the product of the operational efficiency and service delivery effectiveness scores.

3. DEA

DEA is a non-parametric mathematical programming technique that allows for the simultaneous evaluation of multiple inputs and multiple outputs to calculate a single comprehensive measure of efficiency. The traditional DEA developed by Charnes *et al.* (1978) computes the efficiency of a DMU in transforming inputs into outputs in relation to its peer group. It is based on the pioneering work of Farrell (1957) on relative efficiency. DEA defines the efficiency of each DMU as the ratio of the weighted sum of outputs to the weighted sum of inputs. The outputs are the products and services produced by the units and inputs are the resources used to produce these outputs. A unit with an efficiency score of 1 (100 percent) is considered as efficient and a score of less than one indicates that the unit is inefficient. Each unit is allowed to select the optimal weights that maximize its efficiency, subject to the condition that the efficiency of all the units in the set when evaluated with these weights are not allowed to exceed one. The CCR (Charnes *et al.*, 1978) method assumes constant returns to scale while BCC method (Banker *et al.*, 1984) allows variable returns to scale. An examination of the literature reveals that DEA has been used extensively across industries like public sector units, insurance, power plants, telecommunications, airlines, electricity distribution among others to provide organizational benchmarking and control. A brief review of the basic DEA model that is used in this paper for data analysis is provided below.

3.1 Basic DEA model (CCR model)

In the basic DEA model developed by Charnes *et al.* (1978), the objective is to maximize the efficiency value of a test DMU p from among a reference set of n by selecting the input and output weights associated with the inputs and outputs. Therefore, the weights for the inputs and outputs are the decision variables. The original mathematical model is formulated as follows:

$$Max \frac{\sum_{k=1}^{s} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}}$$

$$s \cdot t \frac{\sum_{k=1}^{s} v_k y_{ki}}{\sum_{j=1}^{m} u_j x_{ji}} \leqslant 1 \; \forall i$$

$$v_k, u_j \geqslant 0$$

where $k = 1, \ldots, s$ (outputs); $j = 1, \ldots, m$ (inputs); $i = 1, \ldots, n$ (DMUs); y_{ki} is amount of output k produced by DMU i; x_{ji} is amount of input j utilized by DMU i; v_k is weight given to output k; u_j is weight given to input j.

This fractional program can be solved as an LPP by setting its denominator equal to some arbitrary constant and maximizing its numerator. Alternatively it can be solved by setting the numerator equal to some constant and minimizing the denominator. Therefore, the equivalent LPP, which can be solved by commercial LP software, is formulated as follows:

$$Max \sum_{k=1}^{s} v_k y_{kp}$$

$$s \cdot t \sum_{j=1}^{m} u_j x_{jp} = 1$$

$$\sum_{k=1}^{s} v_k y_{ki} - \sum_{j=1}^{m} u_j x_{ji} \leqslant 0 \forall i \quad v_k, u_j \geqslant 0 \forall k, j$$

In some DEA implementations, for computational convenience, the dual of this program is solved since the computational efficiency of LP software depends to a greater extent on the number of constraints than on the number of variables. The number of constraints of the primal depends on the number of DMUs while the number of constraints of the dual upon the number of inputs and outputs. Therefore, when the number of DMUs is more than the number of variables (which is the case in most of the DEA applications) dual can be solved more efficiently (George and Rangaraj, 2008). Depending on whether inputs and outputs are controllable, a DMU can have either an input orientation or output orientation.

4. Application of DEA methodology

4.1 Two stage DEA model

Basically, the implementation of DEA involves identifying the inputs and outputs of the units being assessed, identifying measures for the inputs and outputs, collecting data on the inputs and outputs, solving the appropriate models and interpreting the results (Thanassoulis *et al.*, 1987). Traditionally, DEA measures efficiency in terms of multiple inputs and outputs considering the DMU as a black box. This study breaks the DMU into two stages by considering the outputs of the "Stage 1 DMU" as inputs to the "Stage 2 DMU" as shown in Figure 2. This enables us to study the efficiencies of the different stages in isolation, identify the pain points and help optimize the resources of the required DMU.

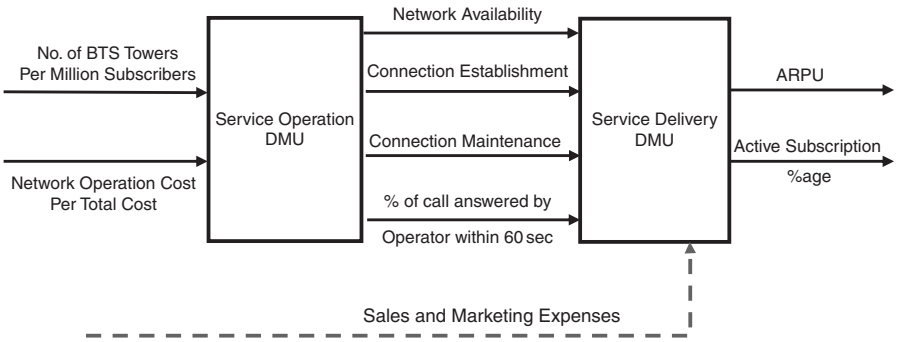

Figure 2.
Two stage DEA

The application of a traditional single stage DEA to the telecom industry will have the input parameters to the DMU as No. of BTS Towers per million Subscribers and Network Operation Cost per Total Cost. The outputs typically would be ARPU and active subscription percentage. Although these input-output combinations provide some indications to the telecom service providers on how to make improvements to certain factors, they miss out on important parameters like network availability, connection establishment, connection maintenance, etc. These parameters also pose a unique dilemma whether to be used as inputs or outputs depending upon the role they play. For example, network availability maybe an output of network operation costs but could be an input to ARPU. These issues are tackled by breaking the single stage DEA to a multi-stage analysis, in this case a two stage DEA.

The two stages of the DEA are represented by service operation and service delivery. The rationale behind the dual stage DEA is to bring out the variations occurring due to:

(1) infrastructural and structural inputs to the service operation stage; and

(2) service delivery stage which involves the customers and brings out aspects like reach, communication and delivery of service.

This stage wise division allows the analysis to be carried out for both the stages in isolation, hence bringing out the variation in the "service operational efficiencies" and the "service delivery effectiveness" more clearly. This also allows companies to concentrate on certain aspects of their operations/ services to gain maximum benefits.

4.2 Inputs and outputs

Selection of input and output variables is critical while performing a DEA. The number of inputs and outputs should be in synchronization with the number of DMUs selected. A very large data set may lead to reduced homogeneity which can result in unknown factors impacting the analysis. At the same time, to maintain the discriminatory power of the CCR and BCC models, a minimum number of DMU's are also required. Golany and Roll (1989) suggested that the number of DMU's should be more than twice the summation of number of input and output variables. Dyson *et al.* (2001) recommended the number of DMU's to be equal to twice the product of number of input and output variables. This study has selected 11 DMUs for which the data are available in public domain. With two input variables and four output variables, the selection of eleven DMUs is close to qualification for the thumb rule recommended by Golany and Roll (1989) and provides adequate discriminatory power while ranking the firms based on their DEA efficiency scores.

4.2.1 Service operations DMU. The DMU at the service operation level represents the process of investments in structural and infrastructural inputs and their conversion into outputs like network service quality. It essentially represents the internal operational capability of the service providers without taking into account the customer interface. The inputs considered for service operation DMU are No. of BTS towers/million subscribers and network operation cost/total cost:

(1) BTS is a tower that enables wireless communication between user equipment and a network. More the number of BTS towers per subscriber, the more would be the chance to provide a better reception. Hence, the number of BTS Towers is a strong indicator of the network availability and the connection establishment and maintenance and thus would play an important role in the overall service levels of the telecom operators. It is also an indicator of the CAPEX by the service provider that has been accumulated over the years. While CAPEX for

the single year 2012 could have been used as an input, these investments would vary significantly from year to year for different operators and hence could distort the analysis. BTS tower per subscriber on the other hand represents the operator's commitment to provide services over long term and the network quality it aims to deliver to the consumer.

(2) Network Operation Cost/Total cost explains the network operation cost as a percentage of the total cost. The higher this ratio for a service provider, the more are the chances to provide a better network with lesser breakdowns. The network operation development and maintenance is mostly outsourced to players such as Nokia Siemens and Ericsson and they are responsible for meeting most of the service levels. This variable is critical to determine the firm's dedication to provide quality services for day to day operations and a measure of the operating expenditure. Network operation cost would also capture a firm's ability to manage network traffic, switching services for roaming and network maintenance among several other activities.

The outputs from the service operation DMUs consist of the following parameters: network availability; connection establishment (accessibility); connection maintenance (retainability); and percentage of calls answered by operator within 60 sec:

(1) Network availability: the network availability is defined by the BTSs accumulated downtime (in percentage). This would have a direct correlation with the network operation cost to total cost ratio. This parameter is an obvious requirement for any customer and must be provided by the service provider to maintain high levels of service.

(2) Connection establishment has been quantitatively represented by call set-up success rate (within licensee's own network) or CSSR. This can be defined as the fraction of attempts to make a call that results in a successful connection to the dialed number. This fraction is mostly measured as a percentage of all call attempts made. Connection establishment is a function of the number of BTS towers available.

(3) Connection maintenance (retainability) has been represented by call drop rate in quantitative terms. This measures the fraction of the telephone calls that were cut off due to technical reasons before the speaking parties had finished their conversations and before either of them had hung up. Usually this fraction is measured as a percentage of all calls.

(4) Percentage of calls answered by operator within 60sec: This represents the level of customer service being extended to the subscribers of a telecom service in terms of call center response. It is an indicator of the wait times for a customer while trying to get answer to an inquiry or for addressing a grievance. It has a direct impact on customer satisfaction, apart from all other measures.

While there are more than 15 QoS parameters as released by TRAI, these can be divided into two categories: network-related parameters and customer service quality parameters. Four QoS parameters have been used for this study. BTS accumulated downtime measures network "Availability," call set-up success rate measures "Accessibility" and call drop rate measures "Retainability." These three attributes cover the network-related parameters for QoS. While percentage of calls answered by

operator within 60 sec measures the response time to the customer for assistance, an important attribute of customer service quality.

As per "The Indian Telecom Services Performance Indicators January-March 2013" report by TRAI, the satisfactory levels or boundary conditions to be met to ensure quality standards for the above metrics are shown in Table II.

4.2.2 Service delivery DMU. The DMU at the service delivery level represents the involvement of customer through interface at the service delivery point. It takes network availability, connection establishment (accessibility), connection maintenance (retainability) and percentage of calls answered by operator within 60 sec as the inputs and gives the output in the form of active subscription rate and ARPU, describing how the customer reacts to the telecom provider's service. The outputs from the service operation DMU act as the inputs to the service delivery DMU. These inputs to the service delivery DMU generate outputs like ARPU and active subscription rate, which are typically parameters that represent the returns to the company and customer satisfaction. The outputs from service delivery DMU consist of the following parameters: ARPU and active subscription percentage.

(1) ARPU is a measure of the total revenue divided by the number of subscribers. This captures the price paid by the customer to the firm for consuming various services in the form of voice, data, value added services, etc. This metric provides a good indication for both top line of the service provider and customer satisfaction. In addition, it represents the willingness of the customer to consume more services. While most related studies (summarized in Table I) have used output parameters like "Revenue," "PAT" and "EBIDTA" in their model, this paper attempts to eliminate the impact of their current scale of operations on analysis and identify efficient firms irrespective of their size. In order to capture operational efficiencies better, it is important to eliminate the impact of capital structures of the firms, which might arise when using parameters like PAT.

(2) Active subscriber percentage represents the percentage of active subscribers to the total subscribers for particular service provider. This metric represents the proportion of people who use the service provider for their primary needs over total "Sim cards" of the company in the market which include inactive "Sim cards" post purchase. A low-active subscriber percentage indicates that customers usually buy a firm's offering for a low price but soon abandon it, after experiencing their poor service quality. Higher percentage value would indicate higher customer loyalty and lower churn rates. This output parameter is closely tied to the consumer's perception of the QoS received from the firm.

QoS metric	Indicator type	Boundary level (%)
Network availability	BTSs accumulated downtime (not available for service)	$\leqslant 2$
Connection establishment (accessibility)	Set-up success rate (within licensee's own network)	$\geqslant 95$
Connection maintenance (retainability)	Call drop rate	$\leqslant 2$
Wait time at customer care service	Percentage of calls answered by operator within 60 sec	$\geqslant 90$

Table II. TRAI service recommendations

The operational efficiency coupled with the service delivery effectiveness gives the overall performance for that service provider.

4.3 Marketing expenses as an additional input

The model proposes the service delivery DMU as having an additional input in the form of sales and marketing expenses. This input is not part of the output generated from the service operation DMU but a direct input to the service delivery DMU. It represents the expenditure made by the service provider to communicate with the market and reach to their customers. It indicates the effort toward building a brand, creating awareness through campaigns and investing in channels for delivery. It helps in creating a "connect" and influences the perception of the customer. The two stage DEA model has been operationalized and the results have been presented with marketing expenses and without marketing expenses.

4.4 Data collection

Relevant data of all active private telecommunication service providers in India as on December 31, 2012 was collected for the study. Each operator's capital employed in the form of BTS towers was taken from RTN Asia report on Indian Telecom base stations. The Network operating costs of these DMUs were retrieved from company annual reports. For unlisted firms in India the parent firm's data were used to apply an average value (in case of Vodafone India). The QoS metrics were obtained from TRAI's "The Indian Telecom Services Performance Indicators" report. Lastly, the ARPU and active subscriber percentage were retrieved from CRISIL Industry Reports. For those companies of which data network operating costs and sales and marketing expense were not readily available, these were either estimated or extrapolated by authors using the existing information in public domain for analysis (Refer to Table AI for the complete data).

5. Results and discussion

The analysis of data were conducted using the basic CCR model of DEA to identify the relatively efficient units. Table III shows various companies with their operational efficiencies (Stage 1), service delivery effectiveness (Stage 2) and overall performance measure.

Table III. DEA output

DMU No.	DMU Name	Stage 1	Stage 2	Overall
1	Bharti Airtel	0.8535	1.0000	0.8535
2	Vodafone Limited	1.0000	0.9859	0.9859
3	Reliance Communications	0.7292	1.0000	0.7292
4	Idea Cellular	0.7626	1.0000	0.7626
5	Tata Teleservices	0.8301	0.8077	0.6704
6	Aircel	0.7606	0.7323	0.5570
7	Uninor	1.0000	0.7694	0.7694
8	Sistema Shyam (MTS)	0.7837	0.5006	0.3923
9	Videocon Telecom	0.6903	0.5384	0.3717
10	Loop	0.8771	1.0000	0.8771
11	HFCL Infotel	1.0000	1.0000	1.0000

5.1 Stage 1

The analysis shows that Vodafone, HFCL and Uninor are the benchmarks for the industry in terms of operational efficiency. However, it is to be noted that the study has been conducted on a pan-India level. While Vodafone has presence in most circles in India, the other two companies are present only in selected areas. Hence, Vodafone is a better benchmark for the industry as its metrics are a representation of a larger base.

It can be observed from Table III that both Reliance communications and Videocon have fared poorly in terms of operational performance. However, the reasons are different for the two firms. Reliance communication ranks high in network availability, accessibility and retainability but due to its poor call center service quality, the overall performance has dipped. This means that its customers may have good coverage, connectivity and call success rates but may be unhappy with the response time of the toll free customer care centers. Both Reliance Communications and Aircel fare poorly on customer services with high waiting times, which could be addressed by having more number of customer care executives or setting up new call centers. Apart from this, the utilization of BTS towers by Reliance Communications has been very low till 2012. Videocon has very high number of BTS towers in proportion to its current subscriber base and hence the operational efficiency is low till 2012. However this could be due to its expansion strategy to add more subscribers in the coming years.

A sensitivity analysis of this stage of the model was carried out. The results of the analysis are presented in Table IV. The values represent the sensitivity of operational efficiency with respect to the inputs (in this case number of BTS towers/million subscribers and network operating cost as a percentage of total cost). For Tata Teleservices, Videocom Telecom, Loop and HFCL Infotel, the operational efficiency is more sensitive to the network operating cost as a percentage of the total cost. On the other side, for Idea, Sistema Shyam and Aircel, the operational efficiency is more sensitive to the number of BTS towers over million subscribers.

5.2 Stage 2

The results of this analysis show that Airtel, Reliance, Idea, Loop and HFCL are able to effectively leverage their service quality to increase the top line. This is not only a function of the marketing expenditure of the company but also the QoSs which are created. However to maintain a common comparison ground, it could be inferred

DMU No.	DMU name	No. of BTS towers/million subscribers	Network operation cost/total cost
1	Bharti Airtel	0.73	0.73
2	Vodafone Limited	0.72	1.30
3	Reliance Communications	0.72	0.49
4	Idea Cellular	0.67	0.60
5	Tata Teleservices	0.68	0.82
6	Aircel	0.66	0.64
7	Uninor	1.09	0.60
8	Sistema Shyam (MTS)	0.75	0.59
9	Videocon Telecom	0.27	0.69
10	Loop	0.83	0.76
11	HFCL Infotel	1.19	1.26

Table IV. Results of sensitivity analysis of operational efficiency – stage 1

that Airtel, Reliance and Idea are the benchmarks in this industry for effectiveness of their services.

Service delivery effectiveness gets impacted when the analysis is carried out with and without marketing expenses. It was found that regional players like "Loop Mobile" and "HFCL" get improved ranking on adding marketing expenses as an input in the second stage (see Table V). This would imply that marketing expenses have diminishing returns with scale or geographical expansion across multiple circles. The service delivery effectiveness is captured more holistic by incorporating marketing expenses as an additional input to the QoS parameters in the second stage.

Table VI shows the results of the sensitivity analysis of Stage 2 of the model. The values represent the sensitivity of effectiveness with respect to the inputs: in this case

Table V.
Change in rankings with and without marketing expenses

SNo.	Service Provider	Ranking as per overall DEA efficiency scores: Without marketing expenditure	With marketing expenditure	Change in rank
1	Vodafone Limited	1	2	↓ 1
2	Bharti Airtel	2	4	↓ 2
3	Idea Cellular	3	6	↓ 3
4	Loop	4	3	↑ 1
5	Reliance Communications	5	7	↓ 2
6	HFCL Infotel	6	1	↑ 5
7	Tata Teleservices	7	8	↓ 1
8	Uninor	8	5	↑ 3
9	Aircel	9	9	→ 0
10	Sistema Shyam (MTS)	10	10	→ 0
11	Videocon Telecom	11	11	→ 0

Table VI.
Results of sensitivity analysis of service delivery effectiveness – stage 2

DMU No.	DMU name	Network availability	Connection establishment (accessibility)	Connection maintenance (retainability)	Percentage calls answered by operator within 60 sec	Sales and marketing expenses/ total expenses
1	Bharti Airtel	1.1	1	1	1	0.27
2	Vodafone Limited	0.98	0.98	0.99	0.97	0.20
3	Reliance Communications	0.44	0.82	0.82	1.00	0.38
4	Idea Cellular	0.87	1.00	1.00	0.99	0.19
5	Tata Teleservices	0.74	0.75	0.74	0.75	0.24
6	Aircel	0.64	0.64	0.64	0.73	0.19
7	Uninor	0.63	0.63	0.63	0.53	0.35
8	Sistema Shyam (MTS)	0.50	0.50	0.50	0.49	0.07
9	Videocon Telecom	0.38	0.38	0.38	0.39	0.22
10	Loop	0.88	0.54	0.54	0.48	0.35
11	HFCL Infotel	0.65	0.53	0.53	0.52	1.00

network availability, connection establishment, connection maintenance, percentage of calls answered by operator within 60 sec and sales and marketing expenses/total expenses. In the case of Reliance, the delivery effectiveness is more sensitive to connection establishment, connection maintenance and percentage of calls answered by operator within 60 seconds. On the other hand, network availability affects the delivery effectiveness the most. For established players like Vodafone and Airtel the output is almost equally sensitive to most of the input factors.

For simplicity of analysis, this paper has discussed the methodology which can be used to arrive at a decision using the independent units of inputs. However, for business judgements, it would be more meaningful to analyze the sensitivity of efficiency to its inputs in monetary terms. This analysis gives an indication of not only how to improve a firm's standing within the industry but also to focus on high-impact inputs which can affect its business significantly.

The graph in Figure 3 represents the multiplication of the efficiency and effectiveness of each company. This shows that HCFL, Vodafone, Loop and Airtel are able to utilize their assets for revenue generation better than other companies. It is also interesting to see that among the top 4 players, the difference in the overall performance is due to their operational efficiencies as their service delivery effectiveness is same at 100 percent.

It can be seen that the companies which rank higher are the companies which have exhibited good performance in both the stages. So it is imperative for a company to concentrate on both the aspects, namely, service operation and service delivery. It is also observed that although Idea and Uninor have similar overall performances, there is marked difference in their efficiency and effectiveness. Idea is doing well in effectively delivering its services while Uninor is generating its services more efficiently.

As many companies under analysis (like HCFL, Loop, Uninor) do not have pan-India presence, a more meaningful comparison could be made among the companies which have operations across many states within India.

Figure 4 shows the various telecoms on the efficiency vs effectiveness classification given by Mouzas (2006). The area of the circle in this plot indicates the subscriber base

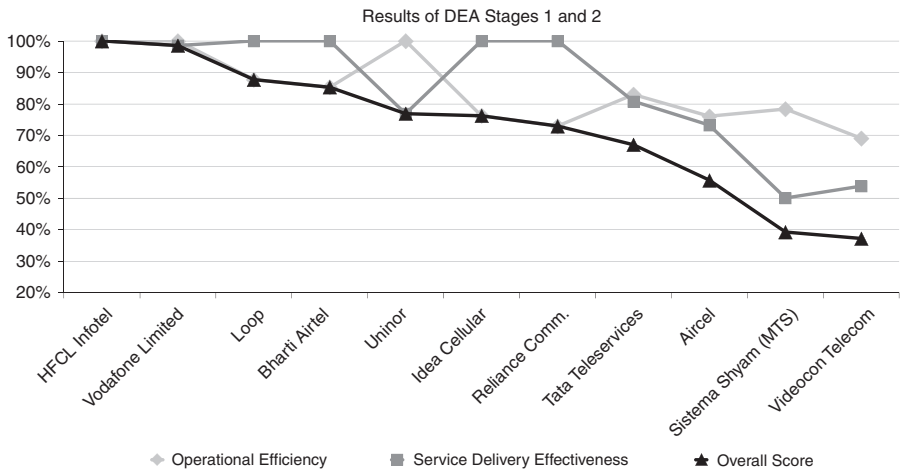

Figure 3.
Overall scores

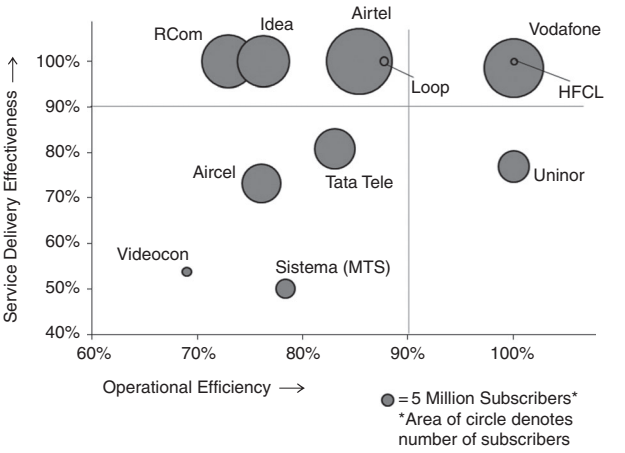

Figure 4.
Classification of DMUs

of the firm. It is seen that those companies which are high on both operational efficiency and service delivery effectiveness like Vodafone represent sustainable profitability. Sistema and Uninor may show ephemeral growth in the medium term. Though most M&A decisions in the Indian telecom industry are likely to be influenced more by the spectrum held by the target firm, the above analysis could also be used to identify whether the target firm is likely to achieve sustainable, unprofitable or ephemeral growth in the future. Companies whose plots are closer to each other are more likely to have successful post merger integration as they are likely to have similar strategies resulting in similar scores in efficiency and effectiveness in this study.

5.3 A Comparison of DEA scores with other performance indicators

Table VII lists companies along with comparison of brand value, asset turnover, net profit margin, ROA against results of the DEA models made. Asset turnover ratio for the company has been taken as a measure of the operational efficiency of the DMU. This is a reflection of the utilization of the assets of the company. Similarly, net profit margin has been considered as a proxy for the service delivery effectiveness of the company. The company financial ratios are compared against the two sets of results, namely, with marketing expenditure as an input to the second stage and without that parameter.

It can be seen that there is strong correlation between the brand ranking and the overall performance values of the DEA model. Operational efficiency is well correlated to the asset turnover ratio of the company. It can be observed that Vodafone has the maximum ratio of 1.5 with a considerable difference in the second position. This is clearly reflected in the results of the DEA also for both the cases. Interestingly, regional companies like HFCL, Loop, Uninor show significant improvement in their overall DEA efficiencies when marketing expenditure parameter is taken into account. As these companies have operations limited to smaller geographies, the amount of money spent in marketing and advertising is much less as compared to companies like Vodafone and Airtel which have pan-India operations. Hence their ratios of marketing expenses to total expenses are very less contributing to a significant increase in the overall efficiencies. Therefore, a comparison among Airtel, Vodafone, Idea, Reliance and Tata Teleservices would be more meaningful.

Table VII.
Comparison of DEA results with financial ratios

Company	Brand ranking	Company financials Asset turnover operational efficiency (%)	Net profit margin service delivery effectiveness (%)	ROA – overall (%)	With marketing expenditure DEA – efficiency (%)	DEA –effectiveness (%)	DEA – overall (%)	Without marketing expenditure DEA – efficiency (%)	DEA – effectiveness (%)	DEA– overall (%)
HFCL Infotel	*	*	*	*	100	100	100	100	63	63
Vodafone Limited	1, Global	151.0	5.0	7.9	100	99	99	100	99	99
Loop	*	*	*	*	88	100	88	88	84	74
Bharti Airtel	27, India	70.0	11.0	7.6	85	100	85	85	100	85
Uninor	*	*	*	*	100	77	77	100	56	56
Idea Cellular	93, India	84.0	3.0	2.5	76	100	76	76	100	76
Reliance Communications	96, India	23.0	5.0	1.1	73	100	73	73	100	73
Tata Teleservices	163, India	63.0	−4.0	−2.4	83	81	67	83	75	62
Aircel	*	*	*	*	76	73	56	76	73	56
Sistema Shyam (MTS)	*	*	*	*	78	50	39	78	50	39
Videocon Telecom	*	*	*	*	69	54	37	69	39	27

Note: *Data points for these companies are not available in public domain and hence could not be calculated

The service delivery effectiveness results of the model are also in line with the net profit margin. There is however, some deviation for few DMUs. This could be attributed to the fact that DEA has considered only quality of the service in the model. However, the net profit margin also takes into account the capital structure, depreciation, amortization, etc. which may not be reflected in the quality of the service provided. Return on assets, reflects the overall performance of the company with the available assets. This is also in line with the results of the analysis. The above comparison shows that there is a fair coherence in the financial performance of the company against the results obtained from the DEA models.

5.4 A Comparison of the results with similar work from the literature

As mentioned in Section 2 of this paper, Nigam *et al.* (2012) used single stage DEA analysis to study the telecom landscape in India. Their study made use of variables like capital employed and revenue along with QoS metrics which are comparable to the input-output metrics used in the current study. However, the current study also takes into account factors like the number of BTS towers per million subscribers and the marketing expenses incurred by the company. These additional factors and a detailed two stage DEA analysis have provided interesting results and deeper managerial insights. The results presented by Nigam *et al.* (2012) place Vodafone, Bharti Airtel and Reliance as the top three telecom operators in India. At the same time, it places smaller firms like Tata Teleservices and Systema at the bottom rung of operators. This is in agreement with the results of this paper which not only places the likes of Vodafone and Airtel on the top but also reveals whether the position is due to the efficiency or the effectiveness of the operator. As is clear from Figure 4, Vodafone is both efficient in operation (1.0) and effective in providing its service (0.986) whereas Airtel has potential to improve on the efficiency front (0.853). Likewise, this paper not only classifies some of the players as poor performers but attempts to give reasons behind this performance. Thus, the major contribution of this paper when compared to others is that it not only rates the different telecom operators but also highlights the potential areas for managerial attention for performance improvement.

Debnath and Shankar (2008) benchmarked Indian Telecom Companies only based on QoS variables instead of metrics like capital employed and revenue thus adopting a different approach. Even though the analysis carried out by them summarizes circle wise performance of the telecom operators instead of the national level, it can be seen that Bharti Airtel and Idea have done exceptionally well in most circles which concurs with the results of this paper as well. In addition, an analysis of the their results reveals the maximum and minimum efficiency score of 1.00 and 0.94 which provides a very small range when compared to this paper; Vodafone (0.986) and Videocon (0.372). This could probably be attributed to a superior selection of the input and output metrics in this research study.

6. Limitations of the study

Due to limited data availability in public domain for all 11 telecom providers in India, this analysis was carried out for a single year and does not consider performance variations across the years. Metrics like "Network Operating Costs" and "Sales and Marketing Expenses" can vary significantly across the years, and are a function of company's strategic priorities. In terms of CAPEX, this study has attempted to eliminate the impact of variations across years by using number of BTS towers accumulated over a period of time. Perhaps, there is scope to perform this analysis across years (subject to availability of data) to evaluate the performance that could potentially minimize the impact of one off

strategic decisions. Further analysis using Malmquist productivity index to depict efficiency change over the years could also be insightful.

This benchmarking exercise using DEA has been carried out for services at a pan-India level, which includes services across all telecom circles in India. QoS metrics have been averaged for all telecom circles. Hence this study does not take into account the local or circle-level performance, but evaluates efficiencies at a national level. For instance, a service provider might invest heavily in one circle with high realizations and provide good network availability, accessibility and reliability, while on the other hand it may choose to deliberately not invest heavily and provide better service levels in another circle. The study assumes that the operator gives equal importance to all circles where it is present in terms of QoS to be provided to its consumers.

For non-listed firms where data were unavailable in the public domain, the data were extrapolated by using industry averages. For instance, BTS towers for HFCL, network operating costs/total costs for Videocon and Loop are based on approximations of industry averages. Also, the regulatory landscape and litigations specific to firms which might have had a crucial impact on its performance could not be captured in this study due its dynamic and subjective nature.

7. Concluding remarks

This paper has made an attempt to understand the key focus areas of competitive importance for Indian telecom service providers that play a major role in variation in efficiency and performance when benchmarked with other companies. The study has gone beyond ranking the telecom service providers on their efficiency scores and attempted to look into potential areas of improvement by breaking down overall performance into internal operational efficiency and service delivery effectiveness. This has enabled to identify the key metrics where the firms would need to focus more to achieve sustainable profitability in the future. Among other insights, the study has found diminishing returns of marketing expenditure with increase in coverage area and that the operational efficiency is affected the most by the network operating costs. This framework applied to the telecom industry can potentially find application across various sectors of the service industry as well.

With the Indian telecom industry now moving beyond the era of hyper-competition, it is likely to undergo a phase of consolidation. Many circles in India have more than ten players while the norm in more developed economies is around four to five players. This study can be find potential application in identifying target firms based on their operational efficiency and service delivery effectiveness for M&A activity in future. The model in this paper helps to provide valuable insights on whether a firm is likely to have sustainable growth in the future or whether its profitability in the medium to long term would be only ephemeral.

For future work in this area, there is a potential scope to account for spectrum held by the firms based on the frequency band as well as the bandwidth with the incumbents. Besides this, there could be a possibility to include brand equity scores along with the marketing expenses as a second stage input for providing a more comprehensive assessment. On the final output side, several other variables such as rate per minute, minutes of usage per month among others could be analyzed. The authors also strongly feel that with the changing trends in the Indian telecom industry, especially with respect to data usage which is at an inflexion point, a detailed analysis that individually looks at voice and data could be of significant value to the industry players.

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Further reading

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(The Appendix follows overleaf.)

Table AI.
Master data

No.	Telecom service provider	Telecom service provider inputs		Service provider quality outputs/inputs for customer service[c]						
		No. of BTS towers/mn subscribers[a]	Network operation cost/total cost[b]	Network availability	Connection establishment (accessibility)	Connection maintenance (retainability)	% of call answered by operator within 60 sec	Sales and marketing expenses/ total expenses[b]	Customer output/ return to company	
	Standard boundary conditions	600-800	20-40(%)	⩽2(%)	⩾95(%)	⩽2(%)	⩾90(%)		ARPU[d]	Active subscription (%)[d]
1	Bharti Airtel	811	33.0	0.102	99.504	0.573	92.227	10.66	209	95.0
2	Vodafone Limited	804	24.0	0.256	99.443	0.883	94.051	14.45	198	94.1
3	BSNL	1,028	28.1	1.304	97.519	1.582	86.700	0.13	84	54.0
4	Reliance Communications	806	49.5	0.232	99.444	0.081	79.751	6.87	87	86.4
5	Idea Cellular	868	39.7	0.466	98.928	0.960	94.003	15.66	172	98.2
6	Tata Teleservices	964	29.2	0.038	98.793	0.718	91.477	8.59	155	66.8
7	Aircel	887	37.5	0.496	98.285	0.790	81.092	10.20	103	62.6
8	Uninor	576	40.0	0.820	98.721	1.130	96.274	4.79	65	54.9
9	Sistema Shyam (MTS)	774	44.2	0.254	99.278	0.569	95.297	22.44	90	48.9
10	Videocon Telecom	2,221	35.0	0.071	99.321	0.215	91.620	4.98	80	36.3
11	MTNL	534	10.7	0.803	97.863	1.393	94.340	0.27	87	38.6
12	Loop	725	40.0	0.040	99.240	0.520	98.830	3.91	175	45.4
13	HFCL Infotel	588	31.3	0.330	98.220	1.150	90.500	1.460	130	47.9

Sources: [a]RTN. (n.d.). Airtel owns 20 percent of base stations in India. Retrieved September 23, 2013, from Real Time News: http://rtn.asia/1475_airtel-owns-20-mobile-towers-india; [b]Company annual reports for FY 2010-11 and FY 2011-12; [c]TRAI. (2013, 5 6). Indian Telecom Services Performance Indictors October-December 2012. Retrieved September 25, 2013, from TRAI Government of India: www.trai.gov.in/WriteReadData/PIRReport/Documents/Indicator%20Reports%20-%20Dec-12.pdf; [d]CRISIL Research

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