Measuring Efficiency and Productivity Change of Multi-Specialty Private Sector Hospitals in India : A DEA Based Malmquist Productivity Index Approach

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Abstract

This study analyzed the efficiency of 28 un-listed standalone multi-speciality private sector hospitals in India with panel data from 2012-2013 to 2014-2015 using Malmquist data envelopment analysis. The study used number of beds, number of physicians, and number of other medical staff as input variables. Number of inpatients, number of outpatients, and number of major surgeries were used as output variables. While output oriented CCR and BCC models were used to estimate the technical and scale efficiencies, Malmquist productivity index was used to evaluate productivity changes over years in terms of technical efficiency change and technological change. The values by which inefficient hospitals should increase their outputs and/or decrease their inputs were estimated hospital wise across 3 years. The estimations presented current levels of different efficiency parameters and facilitated the overall evaluation of individual hospitals based on the values and their increase/decrease. It was found that the hospitals achieved a moderate productivity growth of 6.3% during the period of the study. The results of the study also provided critical implications for hospital managers.

Key words : **efficiency, productivity, private sector hospitals, data envelopment analysis, Malmquist productivity index, India**

JEL Classification : C14, C23, C61, D22, L25, O33

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The healthcare sector in India is experiencing momentous growth because of privatization and corporatization (Baru, 2006, 2013; McKinsey & Company, 2012). This has resulted in upgradation of standards of service delivery and also establishment of state of-the-art facilities in healthcare centres that are comparable with global benchmark hospitals. Growing incomes, better awareness of personal health, and easier access to good quality healthcare facilities have also contributed significantly to the exponential growth of the healthcare sector in India ("India's healthcare sector to grow to $158.2 bn in 2017," 2013). Further, introduction of structural reforms carried out by the Indian government with a vision of providing basic healthcare services for the society at large has also initiated transformation of the sector (McKinsey & Company, 2012). Infact, the Indian government has relaxed the taxes for hospitals in tier II and III cities for first 5 years of establishment as there is extensive demand for speciality healthcare services ("India's healthcare sector to grow to $158.2 bn in 2017," 2013).

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Favourable market entry conditions have ensured that many private players have entered the healthcare sector and this, therefore, has resulted in a surge in a number of private hospitals and healthcare centres in India (Mathiyazhagan, 2003). Dominance of the private sector in the Indian healthcare industry can be gauged from the fact that over 70% of the urban healthcare service market is being controlled by them (Mudur, 2003 ; Sengupta, 2010). However, the very dynamic nature of the Indian healthcare sector has put tremendous pressure on the private sector hospitals to maintain better financial and operational performance due to technological changes, changing customer expectations, and a constant need to expand and explore untapped segments. In this regard, it is quite evident that only those hospitals that are highly efficient and perform consistently well in delivering customer-driven quality services as compared to their peer groups will be able to compete and sustain their market position or even improve over it (Priya & Jabarethina, 2016 ; Shiri, 2014). Therefore, the need of the hour is to measure the performance of Indian private hospitals with an intention to capture early signs of inefficiencies. In fact, the DEA technique has been extensively used to measure efficiencies of different sectors in India like, for example, banking (e.g., Jain, Natarajan, & Ghosh, 2016 ; Naresh, Thiyagarajan, & Mahalakshmi, 2011; Narayanswamy & Muthulakshmi, 2014), bancassurance (Shetty & Basri, 2018), public transport (Agarwal, Yadav, & Singh, 2010), automobile (Nandy, 2012), iron and steel industry (Debnath & Sebastian, 2014), and food and grocery retail (Gupta & Mittal, 2010). However, few studies (e.g., Dash, Vaishnavi, & Muraleedharan, 2008, 2010 ; Mogha, Yadav, & Singh, 2012, 2014, 2015) attempted to measure hospital efficiency in India. Though these studies provide valuable insights into technical and scale efficiencies of different categories of hospitals, they reveal less on hospital productivity. This study, therefore, attempts to fill this gap. Filling this gap is important for many reasons. First, a comprehensive productivity analysis along with efficiency measurement of hospitals will offer insights into the patterns of productivity change (i.e. productivity progress or regress). Second, it will help identify the underlying source (i.e. technical efficiency change, technological change) of the observed productivity variation in hospitals.

The purpose of this study is manifold. First, this study intends to measure relative technical and scale efficiency of Indian private hospitals for the time-period between 2012-2013 and 2014-2015. For this purpose, the study uses data envelopment analysis (DEA) technique. Second, this study, for each year, seeks to estimate input and/or output slacks that would have been required by the inefficient hospitals to become efficient. Third, this study measures productivity change in hospitals over time. For this purpose, this study uses Malmquist productivity index technique. Lastly, this study, based on findings, offers suggestions to policy makers and administrators.

Review of Literature

➢ **Efficiency of Hospitals :** Empirical studies that have examined the relative efficiency and productivity of hospitals have grown exponentially across the world over the past three decades (e.g., Hollingsworth, 2003; Hussey et al., 2009 ; Kohl, Schoenfelder, Fügener, & Brunner, 2018; Pelone et al., 2015 ; Worthington, 2004). These studies have argued that, when compared to other available methods of estimating efficiency, for example - corrected ordinary least square and stochastic frontier analysis (SFA), DEA is the most widely used and sophisticated non - parametric linear programming based technique for evaluating relative efficiency and productivity of firms in the healthcare sector. The DEA approach is further enhanced with the application of Malmquist productivity index that analyses the efficiency of panel data by providing greater insights into changes in productivity.

Importance of measuring hospital efficiency is well established in the literature. However, very few studies in India (e.g., Bhat, Verma, & Reuben, 2001; Dash et al., 2008; 2010; Jat & San Sebastian, 2013 ; Mogha et al., 2012, 2014, 2015; Patel & Ranjith, 2018) have measured the efficiency of hospitals. For example, Bhat et al. (2001), in their study, attempted to ascertain efficiency levels and in the process analyzed the variations that existed between district hospitals and grant-in-aid hospitals in the state of Gujarat, India. The efficiency of 20 district hospitals and 21 grant-in-aid hospitals was measured using input-oriented CCR - DEA model. The study used data from the year 2000 for analysis. Further, the study found that there was no significant relationship between the location and bed size characteristics of efficient and inefficient hospitals. The efficiency variations were found to be significant among district hospitals than among the grant-in-aid hospitals. Furthermore, the overall efficiency levels were higher for grant-in-aid as compared to the district hospitals. Dash et al. (2008) analyzed technical efficiency of 29 districts in the state of Tamil Nadu, India considering two output variables (life expectancy at birth and infant survival rate) and five input variables of which two were healthcare inputs (number of beds and number of doctors), and the rest were social environment inputs (real per capita GDP, literacy rate, degree of urbanization). The study used data from the year 2003 for analysis. It was found that 80% of the districts had to either reduce their use of inputs or increase their level of output so as to match with the 20% of the districts which were making optimum utilization of resources for generating their health outcomes. Dash et al. (2010) analyzed public hospitals in Tamil Nadu, India on their technical efficiency (TE) and scale efficiency (SE) with an aim of providing insights into policy implications in the sector. The data of input (number of staff and number of beds) and output variables (numbers of outpatients, inpatients, surgeries, deliveries, and emergency cases) used in the study were collected from 29 district hospitals for the year 2004 - 2005. Out of the 29 hospitals considered for the study, 15 hospitals were found to be technically efficient.

Mogha et al. (2012) identified the necessity to measure relative efficiency of private sector hospitals in India. The study evaluated the performance of 55 private hospitals using an output oriented DEA based CCR and BCC model. The study used data from the year 2009-10 for analysis. The input variables used in the study were net fixed assets, energy expenses, and salary and wage expenses. The output variable was operating income of the hospital. It provided a slack analysis to indicate the specific scope for improvement for 45 hospitals, relatively, to reach the efficiency level of 10 hospitals that were found to be efficient. A sensitivity analysis showed the stability of efficiency scores of hospitals even with the exclusion of the data of top performing hospitals from the data analysis. Jat and San Sebastian (2013) evaluated the technical efficiency of 40 district hospitals in Madhya Pradesh, India. The study used data of the year 2010 for the analysis. The input variables used in the study were number of doctors, number of nurses, and number of beds. The study used eight output variables : number of women with three antenatal check-ups, number of deliveries, number of cesarean - section deliveries, number of women receiving post-natal care within 48 hours of delivery, number of medical terminations of pregnancy, number of male and female sterilizations, number of inpatient admissions, and number of outpatient consultations.

Mogha et al. (2014) furthered their previous study on the efficiency of private hospitals by taking into consideration the data of 50 hospitals over a period of six years (2005 to 2010). The input variables used in the study were net fixed assets, energy expenses, salary and wage expenses, and current assets. The output variable was operating income of the hospital. It was found that only five hospitals were consistently efficient throughout the study period. Mogha et al. (2015) conducted another study that evaluated the efficiency of hospitals. This study was carried out in the state of Uttarakhand, India with the data of 36 public hospitals for the year 2011. The study used slack based DEA model to examine the technical efficiency of public sector hospitals. The input variables used in the study were number of beds, number of doctors, and number of paramedical staff. The output variables were numbers of out-door patients, in-door patients, major surgeries, and minor surgeries. It was found that only 10 hospitals were overall technically efficient units.

It is evident that though efficiency of the healthcare sector in India has been an area of research interest, the studies are mostly restricted to public hospitals of one state of the country (Bhat et al., 2001; Dash et al., 2008; Mogha et al., 2015). Though two studies have examined the efficiency of private sector hospitals (Mogha et al., 2012; Mogha et al., 2014), there is no application of Malmquist DEA, which facilitates the analysis of changes in productivity both in terms of technical efficiency and also technological efficiency, which will be discussed in detail in the later parts of this paper. Also, the time range of data used in the most recent study by Mogha et al. (2014) was 2005 - 2010. This calls for a study that can evaluate the efficiency with improved techniques like Malmquist DEA and take into consideration more recent panel data of private hospitals in the country.

Methods and Procedures

(1) Sampling Method and Sample Characteristics : This study adopted a combination of judgmental and snowball sampling for the survey. Further, the study focused on private hospitals located in urban areas. Rural areas are served by small clinics and nursing homes apart from government hospitals and have very few private hospitals. Furthermore, the study limited the scope and coverage of the survey to standalone multi-specialty hospitals with bed capacity of 100 to 250 beds, located in urban regions of the country. Choosing a homogeneous group of stand-alone private multi-specialty hospitals ensures that distinct economic and operating conditions of hospitals are accounted for and do not confound the statistical analysis (Zeller, Stanko, & Cleverley, 1996). Stand-alone private multi-specialty hospitals were approached for survey between February - October 2016. In all, 28 multi-specialty hospitals, spread over 9 states and one union territory of India, participated in the survey. In all, of the 87 multi-specialty hospitals approached, 28 hospitals participated in the survey. Therefore, the response rate for the survey was 32.18%. Care has been taken to exclude the names of the hospitals considered for this study against the backdrop of hospitals requesting us to maintain utmost confidentiality. Hospitals are thus coded as Hospital 1 (H1), Hospital 2 (H2), Hospital 3 (H3), and so on till Hospital 28 (H28).

(2) Input and Output Variables : Drawing from the past empirical research (e.g. Mogha et al., 2014 ; Pham, 2011) on hospital efficiency, this study has selected a number of hospital beds, total number of physicians, and other medical staff as input variables. A key point to note here is that other medical staff includes nursing and paramedical staff members. Further, the study has selected total outpatient visits, total inpatient visits, and major surgeries as output variables.

(3) DEA Framework : Data envelopment analysis (DEA) technique, which is a non-parametric (Liu & Wang, 2008) linear programming based model, is extensively used to measure firm - performance (Grilo & Santos, 2015). In particular, DEA allows for the measurement of relative efficiency (Ramanathan, 2003) of set of organizations or decision-making units (DMUs) such as hospitals (O'Neill, Rauner, Heindenberger, & Kraus, 2008) that use multiple inputs to produce multiple outputs. DEA method produces, therefore, efficiency score for each decision making unit (Cooper, Seiford, & Zhu, 2011) for the given set of inputs and outputs. Furthermore, DEA technique allows for estimating levels of efficiency of non-frontier DMUs and also helps identify efficient frontier units with whom inefficient units can compare their performance and, thereby, model their operations on them to become efficient units (Cook & Seiford, 2009).

The original Charnes, Cooper, and Rhodes (CCR) - DEA model is based on the assumption of constant return to scale (CRS) of firm activities. The condition of CRS exists when, for example, increase in inputs leads to a proportionate increase in firm outputs (Charnes, Cooper, & Rhodes, 1978). The CCR - DEA model produces an overall technical efficiency (OTE) score for each DMU. Technical efficiency reflects the ability of a DMU to produce maximum outputs from the available inputs (Salvatore, 2008). Furthermore, a DMU that attains an OTE score of 1 is considered to be efficient and, therefore, termed as an efficient frontier. On the other hand, DMUs that do not attain the OTE score of 1 (i.e. these units attain a score $0 < x < 1$) are considered to be inefficient or non - frontier units.

CCR – DEA model, however, does not take into account the scale size of the DMU for calculating the technical efficiency score. This becomes an important limitation in the CCR- DEA model as a DMU may encounter a situation of increasing return to scale - irs (i.e. when increase in outputs is proportionately more than increase in inputs) or decreasing return to scale - drs (i.e. when increase in outputs is proportionately less than increase in inputs) (Salvatore, 2008) due to diseconomies of scale (Koutsoyiannis, 1979). Therefore, Banker, Charnes, and Cooper (BCC) model is applied to identify whether inefficiency exhibited is on account of the size of the DMU or for other possible reasons that relate to inefficient production processes. BCC – DEA model is based on the assumption of variable return to scale (VRS) of firm activities (Banker, Charnes, & Cooper, 1984). Application of the VRS model produces pure technical efficiency (PTE) and scale efficiency (SE) scores. Pure technical efficiency score offers insights into how a DMU, for its given scale size, is able to efficiently convert inputs into desired outputs (Charnes, Cooper, Lewin, & Seiford, 1994). Scale efficiency, on the other hand, measures the effect of scale size on the efficiency of the DMU (Mogha et al., 2012). In fact, CCR - efficient DMUs are always scale- efficient. Also, for any DMU, VRS efficiency (PTE) score will always be greater or equal to CRS efficiency (OTE) score (Coelli, Rao, O'Donnell, & Battese, 1998). Comparing PTE score of individual DMUs to their respective OTE score offers insights into whether or not scale size of the DMU contributes to the observed inefficiency. Scale efficiency is the ratio of OTE to PTE scores.

Technical efficiency of DMUs can be estimated by adopting an input-oriented DEA model or output-oriented DEA model. In fact, researchers, based on their research question(s), can choose from input-oriented CCR and/or BCC model or output-oriented CCR and/or BCC model to identify efficient frontiers (Zhu, 2008). Input - orientation is adopted in scenarios where the DMU exercises significant control over its inputs. In such cases, inputs are flexible for manipulation. Input-oriented efficiency estimates the quantity of inputs that can be proportionally reduced without altering the output quantities. On the other hand, output - orientation is used in cases where a DMU's objective function is to maximize outputs with the available levels of resources (inputs) that are fixed and not easily alterable (Coelli, 1996). For this study, assuming that the key objective of hospitals is to maximize outputs (e.g., surgeries, out-patient visits) with the available inputs (e.g., capital, labor), output-oriented DEA model is used to measure technical efficiency of hospitals. Further, this study adopts the output - oriented CCR and BCC models to estimate OTE, PTE, and SE. Furthermore, the mathematical linear programming model for output - oriented CCR and BCC DEA technique for measuring hospital efficiency is extensively addressed in the literature (e.g., Kirigia & Asbu, 2013 ; Ramanathan, 2005). Readers are ,therefore, requested to refer to these empirical papers to gain further insights into output-oriented CCR and BCC mathematical models used for this study.

(4) Productivity Change in Hospitals : This study uses the Malmquist productivity index (Malmquist, 1953) to measure productivity change in 28 private Indian hospitals during the period of study (i.e. between 2012 - 2013 and 2014 - 2015). Further, productivity changes were decomposed/split into technical efficiency change (ΔTE) and technological change (ΔTC) with the help of Malmquist productivity index. In so doing, the study also attempted to determine whether the observed variation in productivity of hospitals during the time-period of 3 years was on account of ΔTE or ΔTC or both (Grilo & Santos, 2015).

Technical efficiency change estimates the change or variation in OTE (i.e. CRS technical efficiency) in a DMU, in this case a hospital, for the time period $t+1$ over period t. A ΔTE score of 1 would imply that the hospital has made no movements (i.e. retains same distance) in time period $t+1$ as compared to period t towards the efficient frontier. However, $\Delta TE > 1$ would signify that there was an augmentation in technical efficiency of the hospital in period $t+1$ as compared to period t. On the other hand, $\Delta TE < 1$ would signify that the hospital has moved away from the efficient frontier in the period $t+1$ as compared to period t. Technological change (ΔTC), in this study, refers to the level of variation in the technology frontier of a hospital between time periods $t+1$ and t. A ΔTC score of 1 for a hospital would signify that there has been no shift in the technology frontier. It indicates a scenario where the hospital has witnessed neither a progress nor a regress in terms of technology. On the other hand, $\Delta TC > 1$ would indicate a technological progress and $\Delta TC < 1$ would indicate a technological regress in the hospital under consideration over time periods of $t+1$ and t (Färe, Grosskopf, Lindgren, & Roos, 1992).

Malmquist (1953) defined productivity index as follows :

$$M^{t+1}(I^{t+1}, o^{t+1}, i^{t}, o^{t}) = [(D^{t}(I^{t+1}, o^{t+1})/D^{t}(i^{t}, o^{t})) \times (D^{t+1}(i^{t+1}, o^{t+1})/D^{t+1}(i^{t}, o^{t}))]^{1/2} \text{ ------ (1)}$$

where,
D^{t} is a function that measures the efficiency of the DMU in converting inputs (i^{t}) to outputs (o^{t}) in the time period t. If technology change in the period ($t+1$) is taken into account, then equation (1) of Malmquist productivity index equation modifies to :

$$M^{t+1}(I^{t+1}, o^{t+1}, i^{t}, o^{t}) = [(D^{t+1}(I^{t+1}, o^{t+1}) / D^{t}(i^{t}, o^{t})] \times [(D^{t}(i^{t+1}, o^{t+1})/D^{t+1}(i^{t+1}, o^{t+1}) \times (D^{t}(i^{t}, o^{t})/D^{t+1}(i^{t}, o^{t}))]^{1/2} \text{ ------ (2)}$$

$$\textit{Malmquist productivity index} = [\textit{Technical efficiency change } (\Delta TE)] \times [\textit{Technological change } (\Delta TC)]$$

Further, with the possibility that hospitals may experience variable returns to scale (VRS), ΔTE was estimated by using CRS assumption, which can be further decomposed into pure technical efficiency change (ΔPE) and scale efficiency change (ΔSE) (Grosskopf, 2003), such that :

$$\textit{Malmquist productivity index} = \Delta PE \times \Delta SE \times \Delta TC \text{ ------ (3)}$$

Results and Discussion

The Table 1 presents the descriptive statistics of inputs and outputs of 28 single-unit private multi-specialty hospitals considered for this study. For example, for the year 2012-13, 28 hospitals received a total of 223339 inpatient and 354900 outpatient visits. Hospitals produced these outputs by employing a total of 374 physicians, 2419 other medical staffs, and 3790 operational beds. The results from Table 1 also suggest that there existed a wide variation in both outputs produced and inputs used by hospitals. For example, in the year 2014 - 15, the outpatient visits ranged from a minimum 4803 to a maximum of 26624. Similarly, with regard to inputs in the year 2014 - 15, the number of physicians employed by different hospitals varied from a minimum 8 to a maximum of 22 physicians.

(1) Technical Efficiency : The technical and scale efficiency scores of 28 hospitals for the time-period between 2012-2013 and 2014-2015 are presented in the Table 2. In particular, Table 2 presents information with regard to OTE, PTE, SE scores, return to scale (RTS), and peer counts obtained from CRS and VRS output oriented model.

(i) OTE : From the results reported in Table 2, it is observed that in the years 2012-2013, 2013-2014, and 2014-2015, 11 (39%) hospitals out of 28 hospitals considered for this study are overall technically efficient (i.e. $OTE = 1$). In fact, six hospitals, in particular, H6, H8, H17, H19, H20, and H22, are found to be consistently CRS efficient across all 3 years. Further, hospitals H1, H2, H4, H7, H14, H16, and H25 showed considerable improvement in efficiency scores from the year 2012-2013 to 2014-2015. Out of the above-mentioned seven hospitals, H1, H2, and H16 achieved technical efficiency in the year 2014-2015. However, some hospitals like H9,

Table 1. Descriptive Statistics of Inputs and Outputs

For *n* = 28 hospitals		*Inputs*			*Outputs*		
Year	**Statistics/ Variables**	**Beds**	**Physicians**	**Other Medical Staff**	**Total Inpatients**	**Total Outpatients**	**Major Surgeries**
2012-2013	Total	3790	374	2419	223339	354900	18574
	Mean	135.36	13.36	86.39	7977	12675.00	663.36
	Std Deviation	43.99	4.99	40.11	5398	4852.61	386.85
	Min	100	8	42	2477	4985	39
	Max	250	28	185	21561	26806	1347
2013-2014	Total	3790	352	2341	236031	351175	19813
	Mean	135.36	12.57	83.61	8429.68	12541.96	707.61
	Std Deviation	43.99	4.10	34.01	3705.27	4401.29	406.01
	Min	100	8	44	2137	3261	44
	Max	250	23	177	15314	23715	1746
2014-15	Total	3790	343	2373	257218	352936	20425
	Mean	135.36	12.25	84.75	9186.36	12604.86	729.46
	Std Deviation	43.99	3.68	32.61	5265.44	4927.19	412.69
	Min	100	8	49	2881	4803	75
	Max	250	22	173	21462	26624	1951

H10, H12, H21, H23, H24, and H27 witnessed a drop in efficiency over the years. For some hospitals though, the efficiency fluctuated across the years. For example, H15 showed a marginal improvement in efficiency ($OTE = 0.633$) in the year 2013-2014 when compared to the efficiency ($OTE = 0.446$) in 2012 - 2013. However, the hospital witnessed a drop in the efficiency ($OTE = 0.451$) again in 2014 -15.

The mean score of OTE for the year 2012-2013 is 0.828, implying that inefficient hospitals could become efficient, had they been able to increase their outputs by 17.2% with their existing level of inputs. The mean OTE score of 28 hospitals decreases to 0.823 in the year 2013-2014 when compared to 0.828 in the year 2012-2013. However, the mean OTE score further increases to 0.849 in 2014 - 2015. This implies that there was an overall upward growth in the efficiency scores of the hospitals, and the level of technical efficiency scores of the hospitals improved over time.

The Table 2 also provides information on the level of robustness of CRS efficient hospitals. The robustness of a particular efficient hospital can be gauged by comparing its peer count scores with other efficient hospitals for a specific year under consideration. An overview of peer count frequencies presented in Table 2 suggests that H20 exhibited highest robustness for two years 2012-2013 and 2013-2014 with peer counts of 15 and 13, respectively. For the year 2014-2015, however, H2 exhibited highest robustness with peer counts of 15, followed by H20 with peer counts of 13.

(ii) PTE : The results reported in Table 2 suggest that for the period of 2012-2013, 2013-2014, and 2014-2015, out of 28 hospitals, 16 (57%), 14 (50%), and 20 (71%) are VRS efficient (i.e. $PTE = 1$). This suggests that VRS efficient hospitals had no scope to further augment their outputs with their current level of inputs. Furthermore, 5 (18%), 3 (11%), and 9 (32%) hospitals are found to be only VRS efficient ($PTE = 1$) but CRS inefficient ($OTE < 1$), suggesting that, for these hospitals, the inefficiencies were because of the scale size of the hospitals. Furthermore, the average PTE scores for three years are 0.913, 0.893, and 0.936 respectively, meaning thereby, for the given

Table 2. Technical and Scale Efficiencies During 2013 - 2015

DMU	EFFICIENCY 2012-13						EFFICIENCY 2013-14						EFFICIENCY 2014-15					
	CRSTE	VRSTE	SE	RTS	Peers (CRS)	Peer Count	CRSTE	VRSTE	SE	RTS	Peers (CRS)	Peer Count	CRSTE	VRSTE	SE	RTS	Peers	Peer Count
H1	0.446	0.555	0.804	drs	H8,H20	0	0.691	0.712	0.971	drs	H20, H17,H2	0	1.000	1.000	1.000	-	H1	0
H2	0.917	0.921	0.996	drs	H20,H8	0	1.000	1.000	1.000	-	H2	6	1.000	1.000	1.000	-	H2	15
H3	0.834	0.896	0.931	drs	H23,H20,H19	0	0.743	0.808	0.920	drs	H2,H8,H22	0	1.000	1.000	1.000	-	H3	1
H4	0.690	1.000	0.690	irs	H8,H20	0	0.784	0.964	0.813	irs	H20	0	0.957	1.000	0.957	irs	H20,H8,H2	0
H5	1.000	1.000	1.000	-	H5	3	0.592	0.828	0.715	irs	H8,H22,H20	0	1.000	1.000	1.000	-	H5	0
H6	1.000	1.000	1.000	-	H6	1	1.000	1.000	1.000	-	H6	0	1.000	1.000	1.000	-	H6	0
H7	0.390	0.548	0.711	drs	H8	0	0.544	0.770	0.706	drs	H2,H20	0	0.604	0.823	0.734	drs	H20,H2	0
H8	1.000	1.000	1.000	-	H8	9	1.000	1.000	1.000	-	H8	4	1.000	1.000	1.000	-	H8	10
H9	1.000	1.000	1.000	-	H9	0	1.000	1.000	1.000	-	H9	1	0.859	1.000	0.859	irs	H8,H16,H2	0
H10	1.000	1.000	1.000	-	H10	0	1.000	1.000	1.000	-	H10	3	0.836	1.000	0.836	irs	H8,H20,H2	0
H11	0.707	0.980	0.722	irs	H8,H20	0	0.835	0.898	0.930	irs	H20	0	0.808	0.878	0.921	irs	H8,H16,H2	0
H12	0.776	1.000	0.776	irs	H20,H19, H23	0	0.738	1.000	0.738	irs	H23,H20	0	0.688	1.000	0.688	irs	H8,H20, H2	0
H13	0.593	0.711	0.835	irs	H5,H20, H19	0	0.702	0.709	0.990	irs	H17,H2	0	0.675	0.809	0.834	irs	H2,H20	0
H14	0.732	1.000	0.732	irs	H20	0	0.886	0.954	0.930	irs	H20	0	0.906	1.000	0.906	irs	H20,H2	0
H15	0.446	0.555	0.804	drs	H8,H20	0	0.633	0.754	0.839	drs	H8	0	0.451	0.555	0.813	drs	H20,H2	0
H16	0.961	0.970	0.991	drs	H8,H20	0	1.000	1.000	1.000	-	H16	2	1.000	1.000	1.000	-	H16	4
H17	1.000	1.000	1.000	-	H17	0	1.000	1.000	1.000	-	H17	3	1.000	1.000	1.000	-	H17	0
H18	0.910	1.000	0.910	irs	H6,H20	0	0.602	0.637	0.944	irs	H20,H16, H10	0	0.835	0.900	0.927	irs	H8,H20, H2	0
H19	1.000	1.000	1.000	-	H19	4	1.000	1.000	1.000	-	H19	0	1.000	1.000	1.000	-	H19	0
H20	1.000	1.000	1.000	-	H20	15	1.000	1.000	1.000	-	H20	13	1.000	1.000	1.000	-	H20	13
H21	0.892	0.894	0.998	irs	H5	0	0.523	0.726	0.721	drs	H20,H17,H2	0	0.494	0.744	0.664	drs	H20	0
H22	1.000	1.000	1.000	-	H22	0	1.000	1.000	1.000	-	H22	3	1.000	1.000	1.000	-	H22	2
H23	1.000	1.000	1.000	-	H23	4	1.000	1.000	1.000	-	H23	3	0.937	1.000	0.937	irs	H8, H22, H20,H2	0
H24	1.000	1.000	1.000	-	H24	0	0.864	1.000	0.864	irs	H10,H22, H8,H20	0	0.720	1.000	0.720	irs	H3,H8, H20	0
H25	0.580	0.739	0.785	irs	H8,H20	0	0.602	0.662	0.909	irs	H20	0	0.797	0.886	0.900	irs	H8,H16, H2	0
H26	0.678	1.000	0.678	irs	H8,H20,H5	0	0.758	1.000	0.758	irs	H20, H16,H10	0	0.667	1.000	0.667	irs	H8,H20, H2	0
H27	0.810	0.840	0.965	irs	H20,H23, H19	0	0.760	0.764	0.995	drs	H2,H9,H23	0	0.598	0.612	0.979	drs	H20,H2	0
H28	0.809	0.949	0.852	irs	H23,H20	0	0.798	0.828	0.963	irs	H20,H23	0	0.932	1.000	0.932	irs	H22,H16, H2	0
Mean	**0.828**	**0.913**	**0.899**				**0.823**	**0.893**	**0.918**				**0.849**	**0.936**	**0.902**			

Source: Based on calculation of efficiencies by using DEAP software

Table 3. Input-Output Slacks for Inefficient Hospitals

DMU	2012-13						DMU	2013-2014						DMU	2014-2015					
	I1	I2	I3	O1	O2	O3		I1	I2	I3	O1	O2	O3		I1	I2	I3	O1	O2	O3
H1	-	17 (57%)	23 (19%)	-	-	109 (27%)	H1	12 (8%)	-	-	-	-	351 (91%)	H4	-	1 (13%)	-	-	-	367 (95%)
H2	53 (30%)	-	133 (72%)	-	-	98 (16%)	H3	-	-	38 (26%)	-	2835 (41%)	-	H7	74 (29%)	-	56 (32%)	4721 (32%)	-	-
H3	36 (23%)	-	86 (52%)	-	-	-	H4	-	2 (22%)	8 (11%)	3494 (71%)	-	163 (40%)	H9	-	-	-	-	-	127 (91%)
H4	-	1 (16%)	6(9%)	-	-	232 (77%)	H5	-	6 (26%)	7(7%)	-	-	-	H10	-	3 (25%)	-	-	-	454 (142%)
H7	-	-	70 (41%)	-	4679 (94%)	668 (52%)	H7	67 (27%)	-	51 (29%)	-	-	192 (35%)	H11	-	11(61%)	-	-	-	367 (128%)
H11	-	7 (47%)	8 (11%)	-	-	309 (122%)	H11	-	8 (53%)	7 (10%)	4483 (102%)	-	365 (141%)	H12	-	1(13%)	-	-	-	436 (197%)
H12	12 (12%)	-	5(10%)	-	-	-	H12	6(6%)	-	10 (14%)	4855(227%)	-	-	-	H13	21(14%)	-	6(6%)	1807(20%)-	-
H13	49 (33%)	-	29 (37%)	-	-	-	H13	1(0.06%)	-	-	-	6867 (147%)	117 (22%)	H14	-	12 (67%)	13 (12%)	-	-	235 (55%)
H14	-	11 (61%)	29 (31%)	1165 (47%)	-	130 (33%)	H14	-	11 (61%)	26 (29%)	5647 (155%)	-	223 (56%)	H15	-	11 (50%)	31 (24%)	-	-	1233 (416%)
H15	-	11 (50%)	29 (23%)	-	-	916 (230%)	H15	-	7(32%)	51 (40%)	-	1753 (24%)	644 (146%)	H18	-	2 (20%)	-	-	-	432 (146%)
H16	35 (20%)	-	56 (45%)	-	-	538 (63%)	H18	-	2 (20%)	-	1493 (38%)	-	-	H21	63 (25%)	-	5 (4%)	3954 (27%)	900 (23%)	-
H18	6 (6%)	2 (24%)	-	1107 (33%)	-	-	H21	47 (19%)	-	-	-	-	582 (155%)	H23	-	3 (30%)	-	-	-	-
H21	93 (37%)	-	37 (33%)	-	2346 (39%)	804 (218%)	H24	-	2 (15%)	-	-	-	-	H24	-	5(38%)	-	-	-	284 (70%)
H25	-	8 (50%)	9 (13%)	-	-	54 (15%)	H25	-	9 (56%)	8 (11%)	2443 (56%)	-	81 (23%)	H25	-	8(50%)	-	-	-	393 (133%)
H26	6 (6%)	-	-	-	-	-	H26	-	-	-	3825	-	-	H26	-	1(14%)	-	-	-	378 (148%)
H27	42 (28%)	-	43 (40%)	-	-	-	H27	5 (3.3%)	-	-	-	2090 (22%)	-	H27	9(6%)	-	29(22%)	3465 (39%)	-	-
H28	-	10 (53%)	25 (28%)	1824 (74%)	-	-	H28	-	10 (52%)	25 (28%)	3470 (96%)	-	-	H28	-	12(63%)	-	192 (6%)	-	-

Note : I1 - Beds, I2 - Physicians, I3 - Other medical staff, O1 - Inpatient visits, O2- Outpatient visits, O3 - Major surgeries scale size, inefficient hospitals on an average had to augment their outputs by 8.7% in 2012-2013, 10.7% in 2013-2014, and 6.4% in 2014-2015 to become VRS efficient.

(iii) SE : Comparing PTE score of individual hospitals to their respective OTE score offers insights into whether scale size of the hospital contributed to the observed inefficiency. SE is the ratio of OTE to PTE scores. Drawing from the results reported in Table 2, for the period between 2012 - 2013 and 2014 - 2015, 11 (39%) hospitals are found to be scale-efficient across all 3 years, thereby meaning that these hospitals were operating at the optimal size. Further, 11 (39%), 11 (39%), and 13 (46%) hospitals have increasing rate of returns (irs), suggesting that the inefficient hospitals had to expand their scale of operations to become scale-efficient. Furthermore, 6 (21%), 6 (21%), and 4 (14%) hospitals have decreasing rate of returns (drs), suggesting that these inefficient hospitals had to scale down their size to become scale efficient.

(2) Target Input(s) Reduction and Output(s) Augmentation : The Table 3 reports the values by which inefficient hospitals should increase outputs and/or reduce inputs for them to achieve technical efficiency for the time period between 2012-2014 and 2014-2015. In the year 2012-2013, for example, the CRS efficiency score of H2 is 0.917 (Refer Table 2). This suggests that if all other outputs (i.e. inpatient visits, outpatient visits, and major surgeries) were increased by a factor equivalent to reciprocal value of CRS efficiency, and major surgeries were further increased by 98 (16%), H2 would have become CRS efficient. Alternatively, proportionate reduction in all the inputs (i.e. beds, physicians, and other medical staffs) by a factor of CRS efficiency and an increase in major surgeries by 98 (16%) would have helped H2 achieve an OTE score of 1.

(3) Productivity Changes and Hospital Efficiency - Malmquist Productivity Index : The first stage of this study involved estimation of OTE, PTE, and SE by using CRS and VRS models for each hospital for the time-period between 2012-2013 and 2014-2015. Further, analysis on slacks provided useful insights into how inefficient hospitals, by input reductions and/or output augmentations, could have achieved technical efficiency. In the second stage, changes in productivity over the time-period of three years were established, first, by estimating Malmquist indices for the years 2013 - 2015 and 2014 - 2015 by situating 2012-2013 as the technological reference year and, second, by analyzing the extent and the source of productivity changes within each hospital considered for this study. In this regard, an important point to note is that Malmquist index ($\Delta MTFP$) or its components (i.e. technical efficiency change (ΔTE), technological change (ΔTC), pure efficiency change (ΔPE), and scale efficiency change (ΔSE)) score greater than 1, which implies improvement in performance ; whereas, a score less than 1 signifies deteriorating performance of the hospital.

The Malmquist summary with regard to productivity change estimates for the years 2013-2014 and 2014-2015 are reported in Table 4. It is observed that, on an average, Malmquist total factor productivity ($\Delta MTFP$) increased by 6.3% during the years 2012 - 2013 to 2014-2015, thereby suggesting that Indian private hospitals considered for this study achieved a moderate productivity growth during the period. The growth in productivity was maximum in 2014-2015 at 9.2% ($\Delta MTFP = 1.092$) and lowest in 2013-2014 at 3.4% ($\Delta MTFP = 1.034$).

Table 4. Malmquist Index Summary of Annual Means

Year	ΔTE	ΔTC	ΔPE	ΔSE	ΔMTFP
2013-14	0.999	1.007	0.981	1.009	1.034
2014-15	1.069	1.045	1.033	1.023	1.092
Mean	1.034	1.026	1.007	1.016	1.063

Table 5. Malmquist Total Factor Productivity Change Summary for 28 Hospitals

DMU	ΔTE	ΔTC	ΔPE	ΔSE	ΔMTFP
H1	1.498	1.280	1.221	1.227	1.917
H2	1.044	1.191	1.044	1.000	1.243
H3	1.106	1.445	1.092	1.013	1.598
H4	1.177	1.315	1.000	1.177	1.548
H5	1.000	0.997	1.000	1.000	0.997
H6	1.000	1.132	1.000	1.000	1.132
H7	1.290	0.937	1.056	1.221	1.209
H8	1.000	0.958	1.000	1.000	0.958
H9	0.971	0.963	1.000	0.971	0.935
H10	0.914	1.010	1.000	0.914	0.923
H11	1.089	0.834	1.000	1.089	0.908
H12	0.952	0.925	1.000	0.952	0.881
H13	1.067	0.911	1.034	1.032	0.972
H14	1.132	0.832	1.000	1.132	0.942
H15	1.006	0.902	1.017	0.989	0.907
H16	1.023	0.981	1.016	1.007	1.004
H17	1.000	1.195	1.000	1.000	1.195
H18	0.992	0.846	1.000	0.992	0.839
H19	1.000	0.959	1.000	1.000	0.959
H20	1.000	1.176	1.000	1.000	1.176
H21	0.724	1.168	0.805	0.899	0.846
H22	1.000	0.987	1.000	1.000	0.987
H23	0.968	0.935	1.000	0.968	0.905
H24	0.848	1.081	1.000	0.848	0.917
H25	1.196	0.864	1.000	1.196	1.033
H26	0.991	0.889	1.000	0.991	0.881
H27	0.871	1.098	0.925	0.942	0.956
H28	1.083	0.907	1.000	1.083	0.982
Mean	1.034	1.026	1.007	1.016	1.063

Furthermore, average growth in productivity is attributed to both technological change and technical efficiency change. Mean technical efficiency change (ΔTE) improved by 3.4% ; whereas, mean technological change (ΔTC) improved by 2.6% for the time-period under consideration for this study. Furthermore, improvement in technical efficiency is attributed to increase in mean pure-efficiency change of 0.7% ($\Delta PE = 1.007$) and an increase in mean scale efficiency change of 1.6% ($\Delta SE = 1.016$).

The Table 5 provides Malmquist indices for each hospital. Out of the 28 hospitals considered for this study, 10 (36%) hospitals showed improvement in total factor productivity as they have total factor productivity ($\Delta MTFP$) score, which is greater than 1. Of these hospitals, H1, H3, H4, and H2 showed maximum productivity growth of 91.7%, 59.8%, 54.8%, and 24.3%, respectively. Except for H7, H16, and H25, for all the other seven hospitals, positive productivity change was attributed to improvements in both technical efficiency and technological change. For H7, H16, and H25, the productivity growth was due to improvement in technical efficiency alone (i.e. ΔTE = 1.290, 1.023, and 1.196, respectively). Also, technological change (ΔTC) score is greater than technical efficiency change (ΔTE) in six of the above-mentioned seven hospitals, suggesting that total factor productivity improvements were strong because of technological progress. On the other hand, 18 (64%) hospitals witnessed deterioration in productivity over the years as they have total factor productivity score, which is less than 1. Productivity decline was the greatest in H18 ($\Delta MTFP$ = 0.839) and H21 ($\Delta MTFP$ = 0.846). For H18, the deterioration in productivity was attributed to decline in both technical efficiency (ΔTE = 0.992) and technological change (ΔTC = 0.846) ; whereas, productivity decline in case of H21 could be attributed only to deteriorating technical efficiency (ΔTE = 0.724).

Further, it is observed from Table 5 that pure efficiency change (ΔPE) increased for seven (25%) hospitals (i.e. $\Delta PE > 1$), remained same for 19 (68%) hospitals (i.e. $\Delta PE = 1$), and regressed for 2 (7%) hospitals (i.e. $\Delta PE < 1$) during the period. H1 registers the highest pure efficiency change score (i.e. ΔPE = 1.221). The mean pure efficiency score is 1.007. Furthermore, scale efficiency change (ΔSE) improved for 10 (36%) hospitals (i.e. $\Delta SE > 1$), remained constant for 10 (36%) hospitals (i.e. $\Delta SE = 1$), and declined for 8 (28%) hospitals (i.e. $\Delta SE < 1$). H1 registers the highest scale efficiency change score (ΔSE = 1.223). The mean scale efficiency score is 1.016. Since the mean $\Delta PE < \Delta SE$, it can be safely inferred that poor utilization of resources (i.e. beds, physicians, and other medical staff) and not the scale of operations was a major source of inefficiencies in hospitals.

Managerial and Policy Implications

The managerial implications of hospital efficiency are too important to be ignored. Efficiency analysis of 28 standalone multi-speciality Indian private hospitals, using output oriented CCR and BCC based DEA models, has thrown up some interesting results. First, majority of the hospitals were found to be CRS inefficient across years, implying that these hospitals were unable to effectively utilize their available inputs (i.e. beds, physicians, and other medical staff) to achieve maximum outputs. Further, diseconomies of scale have contributed to inefficiencies only among a few Indian private hospitals. One of the most critical implications that emerge out of this study for policy makers in the Indian healthcare management is to have a re-look at the numbers as well as the quality of physicians and medical staff employed as full time employees with hospitals. The study importantly draws attention towards a need for systematic analysis and monitoring of competency of this unique human resource (Lakshminarayanan, Pai, & Ramaprasad, 2016) in the healthcare sector. Though, this study points towards a possible need to reduce the number of physicians and other medical staff to attain efficient frontiers, it also indicates the hospitals' inability to achieve desired quantity of outputs with the available inputs. The most important challenge, therefore, that the hospitals face is the recruitment and retention of qualified and reputed doctors and also the competent support staff members who constitute the 'intellectual capital' of a hospital. The 'outputs' of hospital efficiency, that is, the number of patients and number of surgeries can increase only if the hospital enjoys the services of well-qualified doctors and support staff. Therefore, a hospital should invest not only on the expansion of infrastructure, but also on attracting those medical staff who can significantly contribute to the brand image of the hospital, which is created by the presence of efficient services rendered by highly skilled and competent medical professionals. This is essential to strengthen the quality of 'inputs' of hospital efficiency index.

Second, findings from this study suggest that the best-performing hospitals are those whose productivity growth has been contributed by both technical efficiency change and technological change. This would imply that for these hospitals, increased investments in innovation, newer technologies, and newer processes (i.e. technological progress) together with experienced, competent, and motivated workforce (i.e. technical efficiency) contributed to higher levels of productivity and hospital performance. Advanced equipments, innovative technologies, highly skilled doctors, and medical staff can systematically reduce the average length of stay by simultaneously increasing the occupancy rate. In fact, the inefficiency in hospitals that are found to have slack in input variable related to number of beds is attributed to lower occupancy rate. Non - frontier hospitals should analyze the possible reasons responsible for lower occupancy rates. Service delivery problems, in terms of effectiveness and quality, if any, should be addressed to improve patients' perception of services and their quality. Furthermore, hospitals can consider strengthening of specific departments like maternity care or other departments that engage in surgical interventions for treating their patients. Also, hospitals should try to strengthen those departments in which they have a competitive advantage over other hospitals. Alternatively, a hospital's management should examine the trade-off that exists between investment in 'intellectual capital' and on 'systemic interventions' vis-à-vis the investments on physical expansion of the hospital in terms of number of beds. Therefore, it is crucial for the hospital administration to calculate the point at which the marginal cost of investment in increasing the number of beds and the related investments in fixed assets equates the marginal revenue that gets generated from such incremental investments. This point of equivalence of marginal cost and marginal revenue that emanates from additional investments is the point at which the cost of capital of additional long-term investments is the most minimum, and the return generated from such investments is the maximum. At this point, the hospital management should stop investing on creation of physical infrastructure and should, instead, concentrate on building the 'intellectual capital' and the degree of technological progress achieved by the hospital that enables not only the increase in the efficacy of medical interventions, but also its efficiency.

This will thus contribute to additional revenue generation, increase in perceived service quality, and reduction in average length of stay, and the higher incidences of the occurrence of major, critical surgeries conducted in the hospital. As a result, the 'outputs' of hospital efficiency will outweigh its 'inputs.'

Lastly, there should be an institutionalized scheme of health insurance initiated either by the hospital itself or in conjunction with health insurance agencies. Availability of health insurance can induce potential patients to opt for the hospital that provides health insurance benefits. Therefore, a hospital needs to initiate marketing efforts to popularize the enrolment of their target patient segment with health insurance schemes that can be availed in hospitals. For this, the hospital management should strive to empanel their hospital with the health insurance companies. Furthermore, hospitals can consider a differential pricing policy based on the levels of income of the target group of patients. This will ensure the possible increase in fixed cost of treatment - beyond the contribution generated by treating high net worth individuals - reduces. The high price charged on the high net worth individuals will bring down their average length of stay. Further, the availability of health insurance schemes and the differential pricing will enable low-income patient segment to avail the medical services of the hospital. This will increase the patient visits and also the occupancy rate. These 'systemic' interventions will supplement the presence of an efficient 'intellectual capital' and, thus, increase the number of outpatient, inpatient visits and surgeries. Accordingly, the 'outputs' of hospital efficiency index will exceed its 'inputs.'

Conclusion

This study analyzes 28 private sector hospitals in India using their panel data for three years. The various scores of efficiency that are estimated in the study provide insights into specific efficiency levels of the hospitals. Further, input and output slack estimates suggest ways to improve efficiency of the hospitals. Furthermore, the paper suggests several alternative ways in which hospitals can achieve better productivity without altering, significantly, the input variables. The suggested ways are, therefore, expected to assist hospital managers to formulate plans to improve their current status of efficiency crucial for a hospital's sustainability and profitability in the long run.

Limitations of the Study and Future Directions

This study is not without limitations. First, the study has focused on standalone multi-specialty private sector hospitals in India. A noteworthy point in this regard is that only 28 hospitals participated in this study. Though the sample size is comparable with other similar studies in the area of hospital performance, future studies are encouraged to target more number of hospitals across India to compare and validate their findings against the findings of this study. Future studies can also measure efficiencies of single-speciality hospitals and health centres. Second, this study has measured technical and scale efficiencies of private Indian hospitals. In this regard, hospital efficiency studies in future can focus on estimating allocative efficiency. From a hospital's perspective, combination of inputs should be chosen in a manner that would produce outputs at a minimum cost. Third, this study has focused on measuring hospital efficiencies and productivity change over the time-period of 3 years. However, not much is revealed with regard to the effect of hospital efficiency on the financial performance of hospitals. In this regard, future studies can examine whether higher levels of efficiency exhibited by hospitals lead to favorable financial performance, thereby establishing an antecedent - consequent relationship between hospital efficiency and financial performance.

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