Comprehensive Efficiency Assessment of Turkish Teaching Hospitals: Technical, Pure Technical and Scale Efficiencies with Data Envelopment Analysis

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The purpose of this research is to point out detail performance analysis of general teaching hospitals and investigate of the efficiency pattern of them. For this research, Data envelopment analysis (DEA) approach is used to evaluate the relative technical and scale efficiencies of general teaching hospitals. Clinical service quality development strategies must be developed to decrease hospital mortality. Hospitals must put a lot of numbers of the beds and nurses to serve more suitable scale sizes.

INTRODUCTION

Resource utilization and hospital efficiency have become significant issues of the health policy because of the steady growth in hospital expenses. With the most complex and expensive treatment practices, teaching hospitals are one of the leading actors in the healthcare delivery system in Turkey. The objectives of this study are comprehensive performance analysis of general teaching hospitals and examination of the efficiency pattern of them. The scope of this study is 48 Ministry of Health (MoH) teaching hospitals. Data envelopment analysis (DEA) approach is used to evaluate the relative technical and scale efficiencies of the teaching hospitals. Empirical findings show that 15 hospitals (31%) are technically efficient with the average score of 0,878. 9 hospitals (19%) are pure technical efficient but scale inefficient, 11 hospitals (23%) are both pure technical and scale inefficient, and 13 hospitals (27%) are scale efficient but pure technical inefficient. 58% of the hospitals manage on Most Productive Scale Size, 29% of them have diseconomies of scale or decreasing return to scale, and 13% of them have economies of scale or increasing return to scale. The slack analysis shows that ex-cases must be diminished by clinical quality improvement and, for more productive scale size, nurses and beds numbers must also be decreased.

Medical and technological advances have increased the demand for health care services and the growth of health needs has led health authorities to seek more sustainable health systems. However, it is a difficult task for policymakers to accommodate scarce resources with increasing health needs.

The scarcity of the resources in health systems has brought along the questions of how to allocate resources and how to use them efficiently. Hospitals, among the health care providers, are the institutions consuming a significant amount of resources. For instance, while hospital expenses constituted one-third of all health expenses in Turkey in 2001, the rate increased almost half of the expenses in 2014 (Turkish Statistical Institute, 2016). As a result of the steady growth in expenses, resource utilization of the hospitals and their efficiency become a significant issue for health policymakers.

Distribution of the hospitals across the country is Ministry of Health (MoH) hospitals 58% (874), university hospitals 5% (69) and private hospitals 37% (550). MoH hospitals provide about 55% of all the hospital services.

Among the MoH hospitals, teaching hospitals are one of the leading actors in the healthcare delivery system in Turkey. Of all the 1,493 hospitals in Turkey, 74 are teaching hospitals, 48 general hospitals and 26 specialty hospitals. The services delivered in these hospitals constitute the significant amount of all hospital services. For example, the hospitals make up 20% of outpatients, 17.6% of inpatients and 21% of surgeries.

The main problem related to the hospitals has been inefficiency in the utilization of the existing resources rather than availability of these resources (Sahin & Ozcan, 2000). The effective maintenance of hospital services will enable more efficient and equitable use of health resources. DEA offers unique opportunities to evaluate hospital service activities.

DEA Literature

Assessment of the routine nursing service efficiency (Nunamaker, 1983) was the first DEA application in the healthcare area. Sherman (1984) study was also the first hospital efficiency application, and widely used thereafter.

Liu et al. (2013) conducted a literature survey of DEA applications and found that health care area was the second most popular area after the banking sector. According to another literature review studied by Hollingsworth (2008), hospital efficiency was the first ranking DEA application in the healthcare area.

As is seen from the studies, DEA is used intensely in healthcare and hospital services. Turkish researchers, with a similar tendency, carried out several DEA based efficiency studies in hospital services area. For instance, Ersoy et al (1997) firstly used DEA to measure efficiency of Turkish hospitals, Sezen & Gok (2011) assessed the efficiencies of Turkish hospitals regarding their ownership. Özgen Narcı et al. (2015) studied the impact of competition on technical efficiency for the hospital industry. They found that just 17% of hospitals were technically efficient. Bilsel & Davutyan (2014) examined the operational performance of 202 Turkish rural general hospitals by using mortality rate as an undesirable output. Sahin & Ozcan (2000) analyzed efficiencies of the public hospitals in 80 provincial markets. They found that 55% of the public hospitals served inefficiently. Some authors investigated the effect of the health reform on hospital efficiency by employing Malmquist Index approach (Sahin, Ozcan, & Ozgen, 2011; Sulku, 2012). Yiğit (2016) studied the efficiency of the Public Hospitals Association on province basis and found 69% of the hospitals are inefficient. Kacak et al. (2014) explored the effect of quality on efficiency level for the 245 MoH general hospitals. They used quality as an additional variable and found that quality variable added model had no significant effect on efficiency.

METHOD

DEA uses linear programming problems to evaluate the relative efficiencies and inefficiencies of peer decision-making units (DMU's) which produce multiple outputs by using multiple inputs (Hua & Bian, 2007).

Measuring productive efficiency of a firm with multiple inputs first emerged with Debreu (1951) and Koopmans (1951) studies. Farrell (1957) stated that firm efficiency consisted of technical efficiency and allocation efficiency on the Debreu and Koopsman studies basis. Besides, Farrel put frontier analysis into his study and provided the inspiration for the first DEA application developed by Charnes et al. (1978).

DEA determines best performers (benchmarks) by maximizing the combination of the outputs given the combination of the inputs. Therefore, DEA can provide performance frontier/benchmarking condition for a group of DMU's (Chou, Ozcan, & White, 2012).

DEA models are divided into input and output-oriented models according to the modeling orientations. Input and output-oriented models are designed to provide input minimization and output maximization.

Constant Return Scale (CRS) and Variable Return Scale (VRS) models were established with regard to return to scale conditions. CRS models assume a constant rate of substitution between inputs and outputs (Ozcan, 2014). The technical efficiency calculated by CRS model is also named overall technical efficiency (OTE). The CRS assumption is appropriate when all firms are operating at an optimal scale size. However, the factors such as imperfect competition, government regulations, and financial constraints may cause a firm to be not operating at optimal scale. The use of the VRS specification permits the calculation of technical efficiency (TE) to purify from scale efficiency effects (Coelli, Rao, O'Donnell, & Battes, 2005).

VRS models calculated by Banker et al. (1984) assume that a proportional increase in input level causes a proportionally more or less increase in output level. The efficiency measure under the VRS assumption represents pure technical inefficiency which emerges only because of managerial underperformance (Kumar & Gulati, 2008). Mathematical formulation of DEA may be useful to explain the difference between CRS and VRS models.

The mathematical formulation is presented below:

$$Maximize\ \ \theta_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \tag{1}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r\, y_{r0}}{\sum_{i=1}^{m} v_i\, x_{i0}} \leq 1$$
$u_r, v_i \geq 0$ *for all r an i.*

The formula shown above is a fractional structure and <u>is</u> needed to transform linear programming formulation.

$$Maximize\ \ \theta_0 = \sum_{r=1}^{s} u_r\, y_{r0} \tag{2}$$

Subject to:

$$\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} v_i\, x_{ij} \leq 0 \ \ j = 1, \dots n$$
$$\sum_{i=1}^{m} v_i\, x_{i0} = 1$$
$$u_r, v_i \geq 0$$

For calculating weights (λ), dual model is needed

$\theta = Min\ \theta$ (3)

Subject to:

$$\sum_{j=1}^{n} \lambda_j\, x_{ij} \leq\ \theta x_{io} \qquad i = 1,2, \dots , m;$$

$$\sum_{j=1}^{n} \lambda_j\, x_{rj} \leq\ y_{ro} \qquad r = 1,2, \dots , s;$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq\ 0 \qquad j = 1,2, \dots , n;$$

After calculating efficiencies with dual model (3), second stage linear model should be solved to obtain slacks.

$Maximize = \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$ (4)

Subject to:

$$\sum_{j=1}^{n} \lambda_j\, x_{ij} + s_i^- \leq\ \theta x_{io} \qquad i = 1,2, \dots , m;$$

$$\sum_{j=1}^{n} \lambda_j\, x_{rj} - s_i^+ \leq\ y_{ro} \qquad r = 1,2, \dots , s;$$

$$\lambda_j \geq\ 0 \qquad j = 1,2, \dots , n;$$

All the formulas above assess CRS efficiency. To calculate VRS efficiency, $\Sigma\lambda_j = 1$ constrain should be added to formula.

If CRS and VRS efficiency scores are not equal, this indicates that scale inefficiency exists. Scale efficiency (SE) expresses how close the firm is to the optimal scale size: the larger the scale efficiency, the closer the firm is to optimal scale (Most Productive Scale Size) (Bogetoft and Otto, 2011).

$$Scale\ Efficiency = \frac{CRS\ (Techical\ Efficiency)}{VRS\ (Pure\ Techical\ Efficiency)}$$

Sum of lambdas is used for assessing return to scale (RTS) regions. If the sum of lambdas is less than 1, the firm is below optimal scale size, and if it is above 1, the firm is above optimal scale size (Bogetoft & Otto, 2011).

$$\sum_{i}^{n} \lambda_i = 1 \ \text{ then Constant Return to Scale } (CRS)$$

$$\sum_{i}^{n} \lambda_i < 1 \ \text{ then Decreasing Return to Scale } (IRS)$$

$$\sum_{i}^{n} \lambda_i > 1 \ \text{ then Increasing Return to Scale } (DRS)$$

We can decompose CRS efficiency into two components: Pure Technical Efficiency and Scale Efficiency.

$$Techical\ Efficiency = \ Pure\ Techical\ Efficiency\ x\ Scale\ Efficiency$$

Data

The scope of this study is the Ministry of Health (MoH) general training and research hospitals. Twenty-six specialty training and research hospitals were excluded from the study in order to provide homogeneity and make reference sets (peer groups) comparison easily. There are 48 general training and research hospitals with 30.386 beds in service across the country.

The study drew its data from the annual statistical report of Public Hospitals Administration of Turkey for the year 2014. The number of beds, specialists and nurses were used as input variables and the number of outpatients, inpatients, weight adjusted surgeries (the weights for major surgeries = 1, moderate surgeries = 1/3, minor surgeries = 1/7 see Buyukkayikci and Sahin (2000)) and ex-cases were used as output variables (Table 1). Because ex-cases were an undesirable output and had to be diminished, these numbers (cases) were subjected to conversion (1/Ex-cases). There are two translation approaches to treat undesirable outputs: a linear monotone decreasing transformation and a nonlinear monotone decreasing transformation (e.g., 1/b). A linear monotone decreasing transformation is bj = − bj + v ≥ 0, where v is a proper translation vector that makes bj >0. That is, we multiply each undesirable output by (− 1) and find a proper translation vector v to convert negative data to non-negative data (Hua & Bian, 2007: 109). The second approach, nonlinear monotone decreasing transformation, can be obtained by dividing each undesirable output by (1). We used the second approach to convert undesirable output (1/Ex-cases).

TABLE 1
INPUT and OUTPUT VARIABLES

Input Variables	***Output Variables***
Beds	*Outpatients*
Specialist physicians	*Inpatients*
Nurses	*Adjusted surgeries*
	Ex-cases

Correlation matrix for variables is shown in Table 2. As a result of correlation analysis, a strong association between input and output variables was found.

TABLE 2
CORRELATION MATRIX

	Bed	Specialist	Nurse	Outpatient	Inpatient	Surgery	Ex-case
Bed	1	0,7071372	0,8850724	0,5930986	0,8050145	0,6657775	0,6494456
Specialist	0,7071372	1	0,752476	0,6679874	0,6667122	0,6548501	0,6426648
Nurse	0,8850724	0,752476	1	0,6059995	0,81198	0,6041622	0,6294907
Outpatient	0,5930986	0,6679874	0,6059995	1	0,8104102	0,6555195	0,2852319
Inpatient	0,8050145	0,6667122	0,81198	0,8104102	1	0,6483248	0,4790685
Surgery	0,6657775	0,6548501	0,6041622	0,6555195	0,6483248	1	0,5125413
Ex-case	0,6494456	0,6426648	0,6294907	0,2852319	0,4790685	0,5125413	1

The analysis was carried out by input oriented CRS and VRS methods. Technical efficiency (TE), pure efficiency (PE) and SE scores belonging to hospitals were shown in Table 3.

TABLE 3
EFFICIENCY AND INEFFICIENCY LEVEL OF THE HOSPITAL

DMU No	OTE	OT Inff (%)	PT E	PT Inff (%)	SE	S Inff (%)	RTS of Projected DMU
H1	0,99	1%	1,00	0%	0,99	1%	Decreasing
H2	1,00	0%	1,00	0%	1,00	0%	Constant
H3	1,00	0%	1,00	0%	1,00	0%	Constant
H4	0,98	2%	1,00	0%	0,98	2%	Decreasing
H5	0,86	14%	1,00	0%	0,86	14%	Decreasing
H6	0,89	11%	0,96	4%	0,92	8%	Constant
H7	0,74	26%	0,78	22%	0,96	4%	Decreasing
H8	1,00	0%	1,00	0%	1,00	0%	Constant
H9	0,94	6%	0,98	2%	0,95	5%	Constant
H10	1,00	0%	1,00	0%	1,00	0%	Constant
H11	0,99	0%	1,00	0%	0,99	1%	Decreasing
H12	0,57	43%	0,60	40%	0,96	4%	Increasing
H13	0,95	5%	1,00	0%	0,95	5%	Decreasing
H14	0,94	6%	0,94	6%	1,00	0%	Constant
H15	0,58	42%	0,64	36%	0,91	9%	Increasing
H16	0,79	21%	0,80	20%	0,99	1%	Decreasing
H17	1,00	0%	1,00	0%	1,00	0%	Constant
H18	1,00	0%	1,00	0%	1,00	0%	Constant
H19	0,99	1%	1,00	0%	0,99	1%	Increasing
H20	1,00	0%	1,00	0%	1,00	0%	Constant
H21	0,82	18%	0,82	18%	1,00	0%	Constant
H22	1,00	0%	1,00	0%	1,00	0%	Constant
H23	0,91	9%	0,94	6%	0,97	3%	Increasing
H24	1,00	0%	1,00	0%	1,00	0%	Constant
H25	0,73	27%	0,73	27%	1,00	0%	Constant
H26	0,98	2%	1,00	0%	0,98	2%	Decreasing
H27	1,00	0%	1,00	0%	1,00	0%	Constant
H28	0,82	18%	0,83	17%	0,99	1%	Constant
H29	0,88	12%	0,88	12%	1,00	0%	Constant
H30	0,83	17%	1,00	0%	0,83	17%	Decreasing
H31	1,00	0%	1,00	0%	1,00	0%	Constant
H32	0,85	15%	0,86	14%	0,99	1%	Increasing
H33	0,68	32%	0,71	29%	0,96	4%	Decreasing

DMU No	OTE	OT Inff (%)	PT E	PT Inff (%)	SE	S Inff (%)	RTS of Projected DMU
H34	0,69	31%	0,74	26%	0,93	7%	Constant
H35	0,72	28%	0,87	13%	0,82	18%	Decreasing
H36	0,92	8%	0,92	8%	1,00	0%	Constant
H37	0,80	20%	1,00	0%	0,80	20%	Decreasing
H38	1,00	0%	1,00	0%	1,00	0%	Constant
H39	0,83	17%	0,89	11%	0,93	7%	Increasing
H40	0,64	36%	0,71	29%	0,90	10%	Decreasing
H41	0,70	30%	0,72	28%	0,97	3%	Constant
H42	0,73	27%	0,77	23%	0,95	5%	Constant
H43	1,00	0%	1,00	0%	1,00	0%	Constant
H44	0,77	23%	0,85	15%	0,91	9%	Constant
H45	0,91	9%	0,92	8%	0,99	1%	Decreasing
H46	1,00	0%	1,00	0%	1,00	0%	Constant
H47	1,00	0%	1,00	0%	1,00	0%	Constant
H48	0,70	30%	0,71	29%	0,99	1%	Constant

OTE Overall Technical Efficiency **OT Inff** Overal Technical Inefficiency **PTE** Pure Technical Efficiency **PT Inff** Pure Technical Inefficiency **SE** Scale Efficiency **S Inff** Scale Inefficiency

As a result of the TE analysis of the hospitals, it was observed that 15 hospitals were efficient and 33 hospitals were inefficient. The average TE score of the hospitals was 0.878, and average inefficiency level was 12%. TE scores ranged from 0.574 to 1, which was the considerably higher difference. Inefficient hospitals had average 0.822 efficiency score, and the average inefficiency level was 18%. Inefficiency levels of the hospitals ranged from 0.3% to 43% (Table 5). This means that inefficient hospitals were able to decrease input usage between this range between 0.3% and 43% without changing their output level.

TABLE 4
DESCRIPTIVE STATISTICS OF CRS EFFCIENCY SCORES

		ALL	Efficient	Inefficient
N		48	15	33
Mean		,878046	1,000,000	,822612
Median		,919560	1,000,000	,827930
Std. Deviation		,1305153	,0000000	,1219772
Minimum		,5743	10,000	,5743
Maximum		10,000	10,000	,9968
Percentiles	25	,777593	1,000,000	,721305
	50	,919560	1,000,000	,827930
	75	1,000,000	1,000,000	,930990

When examining input-output variables of the inefficient hospitals, average bed size was 702. These hospitals employed approximately 272 specialists and 573 nurses. These hospitals produced an average of 1,513,509 outpatients, 42,646 inpatients 5,563 surgeries and 920 ex-cases. On the other hand, efficient hospitals served with an average of 480 beds, 188 specialists, and 411 nurses and produced an average of 1,294,932 outpatients, 35,209 inpatients 4,443 surgeries and 524 ex-cases.

Classification of Efficient Hospitals

The efficient DMU that appears in reference sets most frequently becomes the global leader (Necmi K. Avkiran, 2006). Charnes et al. (1984) suggested counting the frequency of the efficient DMU's in the reference set for ranking technically efficient hospitals. Similarly, we ranked efficient DMU's and classified them into four categories (Table 5): Strong efficient, weak efficient, below average, and above average. The most and least frequently appeared DMUs in the reference set (Table 6) were named strong and weak efficient respectively. Remaining DMU's classified as below and above average regarding their frequency count.

H20 and H47 had the highest frequency count with 22 and 16 respectively. These hospitals were the best practice hospitals followed by inefficient hospitals as a benchmark.

H2, H3, H24, H31, and H38 were classified as weak efficient hospitals with the least frequency count. These hospitals would be ranked as inefficient hospitals if the utilization of one or several input variables slightly increased.

TABLE 5
CLASSIFICATION OF FFICIENT HOSPITALS

Weak Efficient		Below Average		Above Average		Strong Efficient	
DMU	**Ref. Freq.**	**DMU**	**Ref Freq.**	**DMU**	**Ref. Freq.**	**DMU**	**Ref. Freq.**
H2	2	H22	3	H8	7	H47	16
H3	2	H17	4	H10	7	H20	22
H24	2	H43	4	H18	10		
H31	2			H46	10		
H38	2			H27	11		

TABLE 6
REFERENCE SETS AND λ (LAMDA) VALUES

Hospital ID	**Score**	**Reference Set**														
		H2	H3	H8	H10	H17	H18	H20	H22	H24	H27	H31	H38	H43	H46	H47
H1	0,99						0,16	0,17							0,56	0,64
H4	0,98							0,16		0,35		0,81				
H5	0,86			0,59			0,42	0,30							0,02	
H6	0,89						0,01	0,06						0,19	0,55	0,01
H7	0,74							0,79		0,16		0,18				
H9	0,94				0,48			0,12			0,18					
H11	0,99			0,29				0,66							0,26	0,51
H12	0,57		0,30		0,06						0,43					
H13	0,95	0,55									0,18					0,55
H14	0,94					1,05					0,09					0,15
H15	0,58			0,20				0,18							0,13	0,21
H16	0,79		0,38		0,08						0,08		0,35	0,19		
H19	0,99			0,11	0,01			0,49								
H21	0,82				0,10			0,70			0,20					
H23	0,91				0,10			0,74								
H26	0,98						0,05	0,90							0,27	
H28	0,82			0,19				0,88								
H29	0,88						0,11	0,78							0,06	0,11
H30	0,83				0,34			0,77			0,17					
H32	0,85							0,97								
H33	0,68			0,03			0,10	0,74							0,41	
H34	0,69						0,21	0,28							0,09	0,12
H35	0,72			0,09				0,09	0,25							0,93
H36	0,92												0,81	0,02		0,18
H37	0,80	0,55									1,08					0,01
H39	0,83					0,07	0,06	0,45								0,15
H40	0,64							0,02	0,34		0,17					0,61
H41	0,70					0,29	0,02									0,58
H44	0,77								0,07		0,02			0,06		0,57
H45	0,91						0,07	0,30							0,55	0,33
H48	0,70					0,32					0,38					
Count Freq		**2**	**2**	**7**	**7**	**4**	**10**	**22**	**3**	**2**	**11**	**2**	**2**	**4**	**10**	**16**

Classification of Inefficient Hospitals

Inefficient hospitals were also classified into four categories: marginally inefficient, most inefficient, below average and above average (Table 7). Marginally inefficient hospitals were placed in the fourth quartile, and their efficiency scores ranged between 0.93 and 0.99. These hospitals could rise as efficient hospitals if there were a small improvement in the input levels.

Most inefficient hospitals were in the first quartile, and their efficiency scores ranged between 0.57 and 0.71. These hospitals were the worst performer hospitals and needed to be re-examined structurally and operationally.

TABLE 7
CLASSIFICATION OF INEFFICIENT HOSPITALS

	Quartile	Score	DMU's								
Marginally Inefficient	100%	0.93-0.99	H11	H1	H26	H4	H13	H14	H19	H9	
Above Average	75%	0.83-0.92	H36	H45	H29	H5	H30	H6	H23	H39	H32
Below Average	50%	0.72-0.82	H28	H37	H16	H44	H42	H25	H7	H21	H35
Most Inefficient	25%	0.57-0.71	H12	H33	H40	H48	H41	H34	H15		

Assessment of Pure and Scale Efficiencies

In DEA literature, if PE and TE scores of DMUs equal to 1, these DMUs are called *"globally efficient."* If TE scores are smaller than 1 and PE scores equal to 1, these DMUs are referred to as *"locally efficient"* (CRS<1 and VRS=1) (Kumar & Gulati, 2008).

From the SE perspective, sum of lambdas (λ) is used to estimate return to scale in DEA. It is assumed that DMUs with a sum of lambdas equal to 1 operate in CRS, less than 1 increasing return to scale (IRS), and greater than 1 decreasing return to scale (DRS). In CRS, increasing the number of inputs leads to an equivalent increase in the output and this is the most productive scale size of the DMU's. In IRS, augmentation of output quantity is greater than the rise of input quantity and DMU should increase its input level, which is referred to as "*upsizing decision*." In DRS, this is opposed to IRS situation, and DMU should make downsizing decision.

For investigating both PE and SE, a quadrant (Figure 1) was prepared. As shown in Table 6, of the 48 hospitals, 15 hospitals (31%) were found to be globally efficient (Q1) and 9 hospitals (19%) were locally efficient (Q2). If their scale inefficiency improved, locally efficient hospitals could promote globally efficient ones.

As a SE, 28 hospitals (58%) were efficient and 20 hospitals (42%) (14 of which were DRS and 6 of which were IRS) did not operate at optimal scale size.

Eleven hospitals (23%) were inefficient regarding managerial and scale efficiency (Q4). In other words, these hospitals managed with poor input utilization and inappropriate scale size. Thirteen hospitals (27%) were scale efficient but managerially inefficient (Q3). If managerial capacity improved, these hospitals would be globally efficient.

FIGURE 1
TECHNICAL, PURE TECHNICAL (MANAGERIAL) AND SCALE EFFICIENCY MATRIX BY QUADRANT

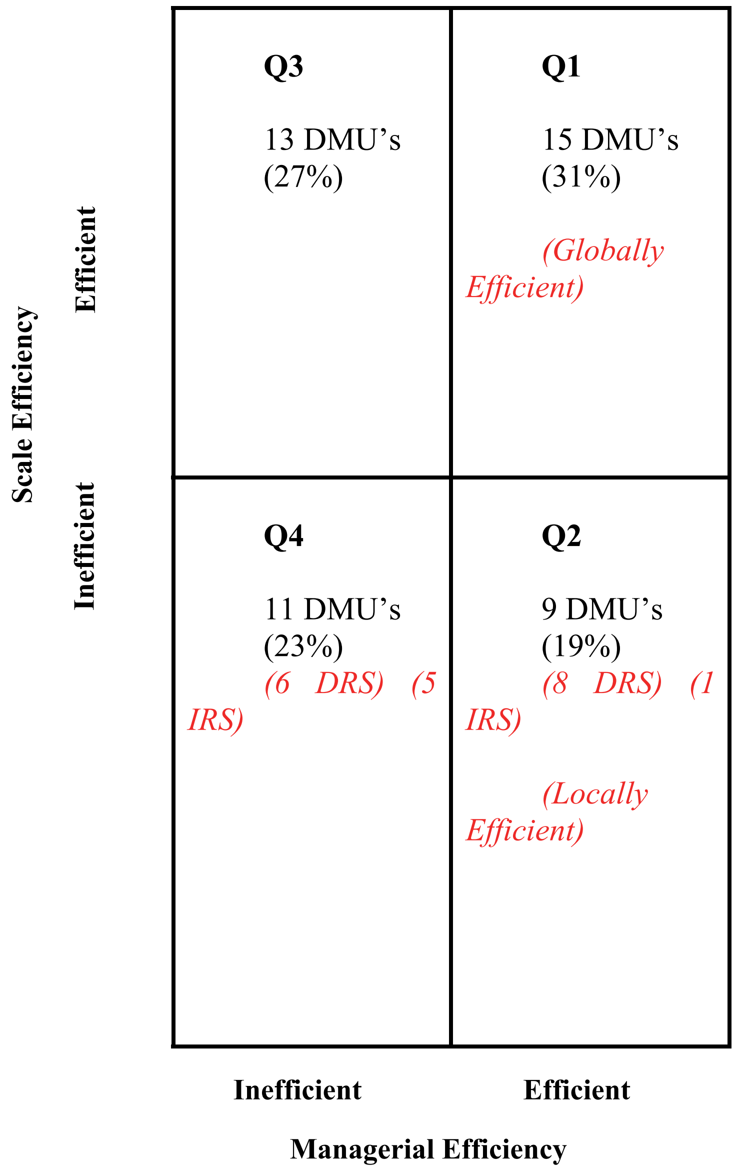
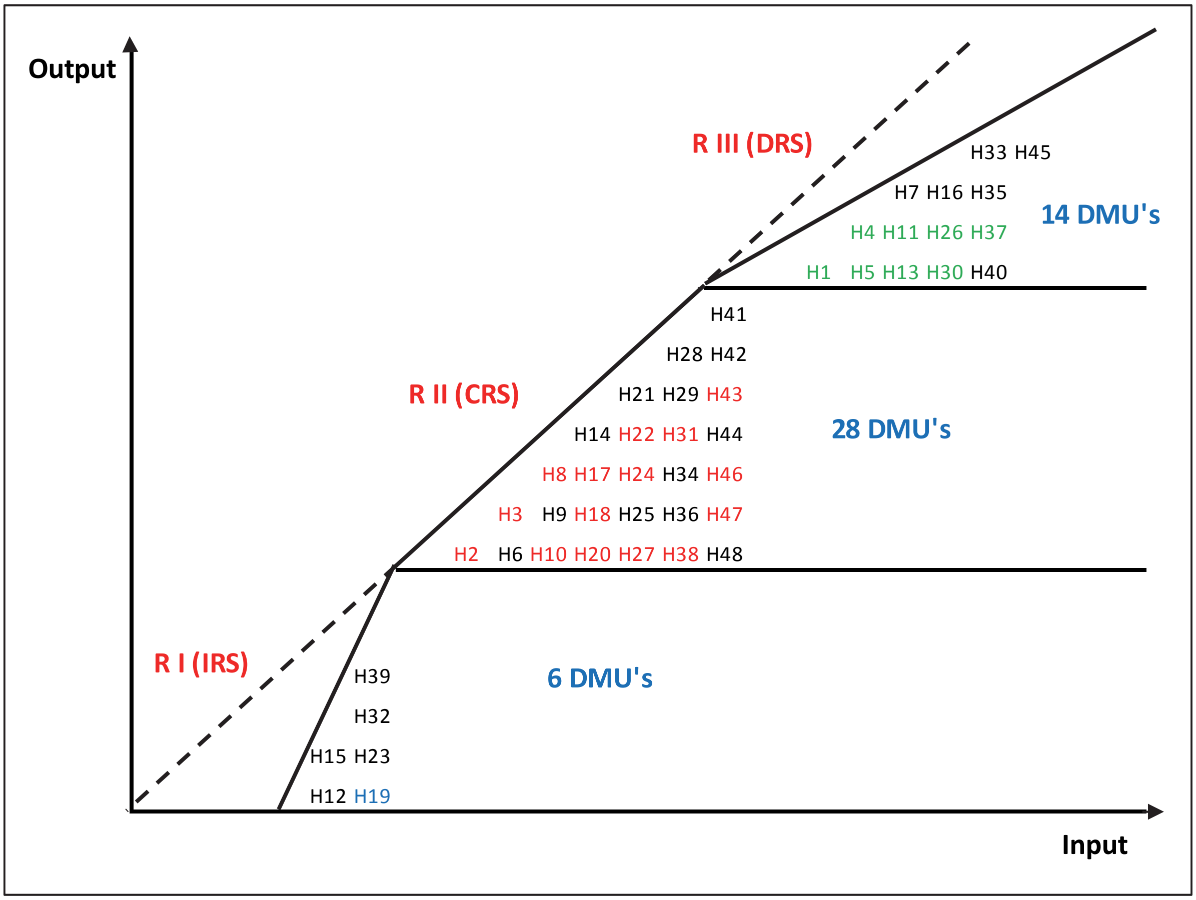


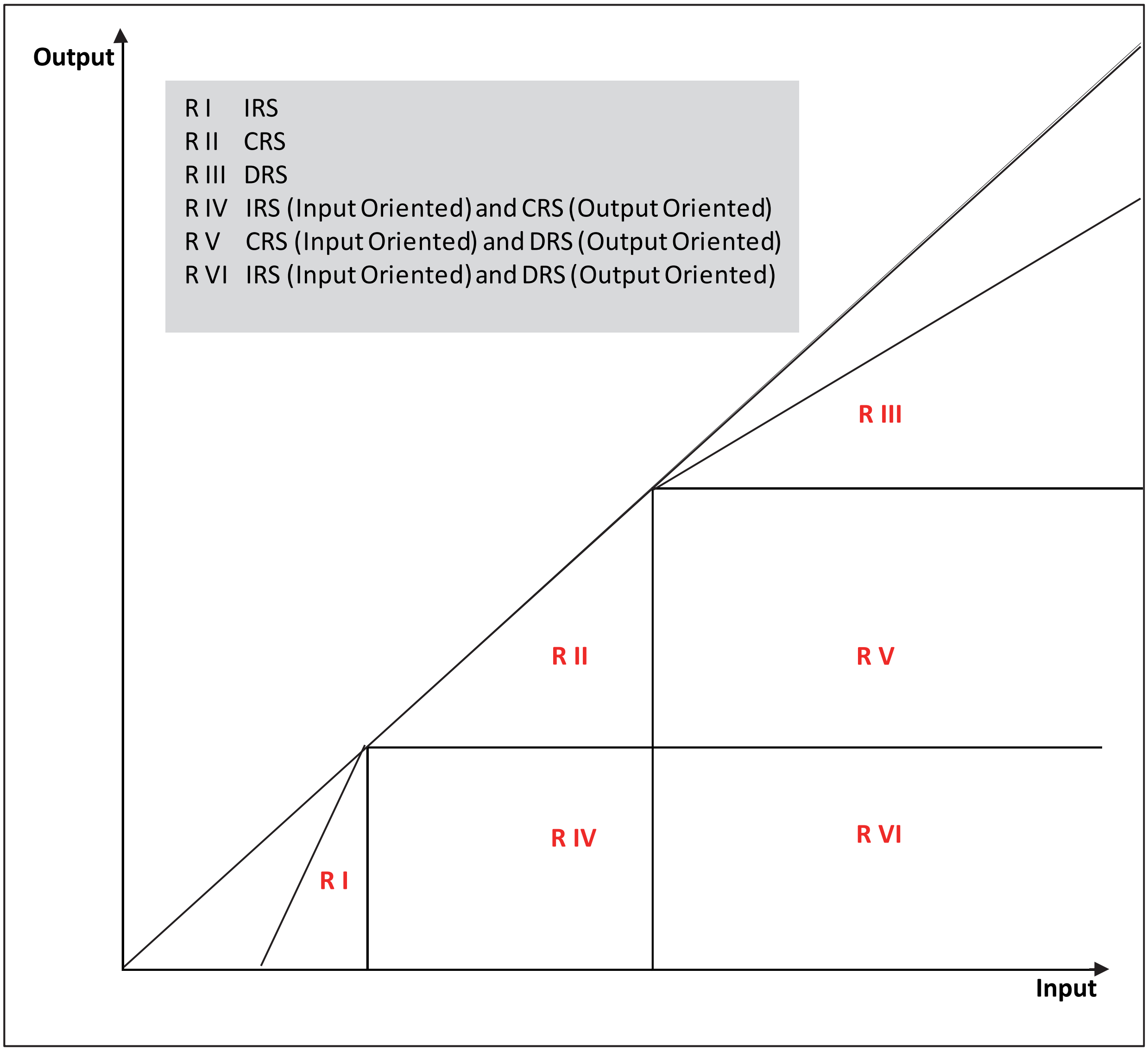
Figure 2 depicts the distribution of the hospitals in three RTS region (RI - RII and RIII). According to Figure 2, 28 hospitals operate at most productive scale size (RII), 14 hospitals have diseconomies of scale (RIII), and 6 hospitals have economies of scale (RI).

FIGURE 2
STANDARD RTS REGIONS and THE HOSPITALS



Zhu (2003) developed this standard RTS model and defined six RTS regions by combining input and output oriented RTS models. These regions are shown in Figure 3: First three regions (RI, RII, RIII) are identified by standard RTS approach. Fourth Region (RIV) is of IRS (Input Oriented) and CRS (Output Oriented). Fifth Region (RV) is of CRS (Input Oriented) and DRS (Output Oriented). Sixth Region (RVI) is of IRS (Input Oriented) and DRS (Output Oriented).

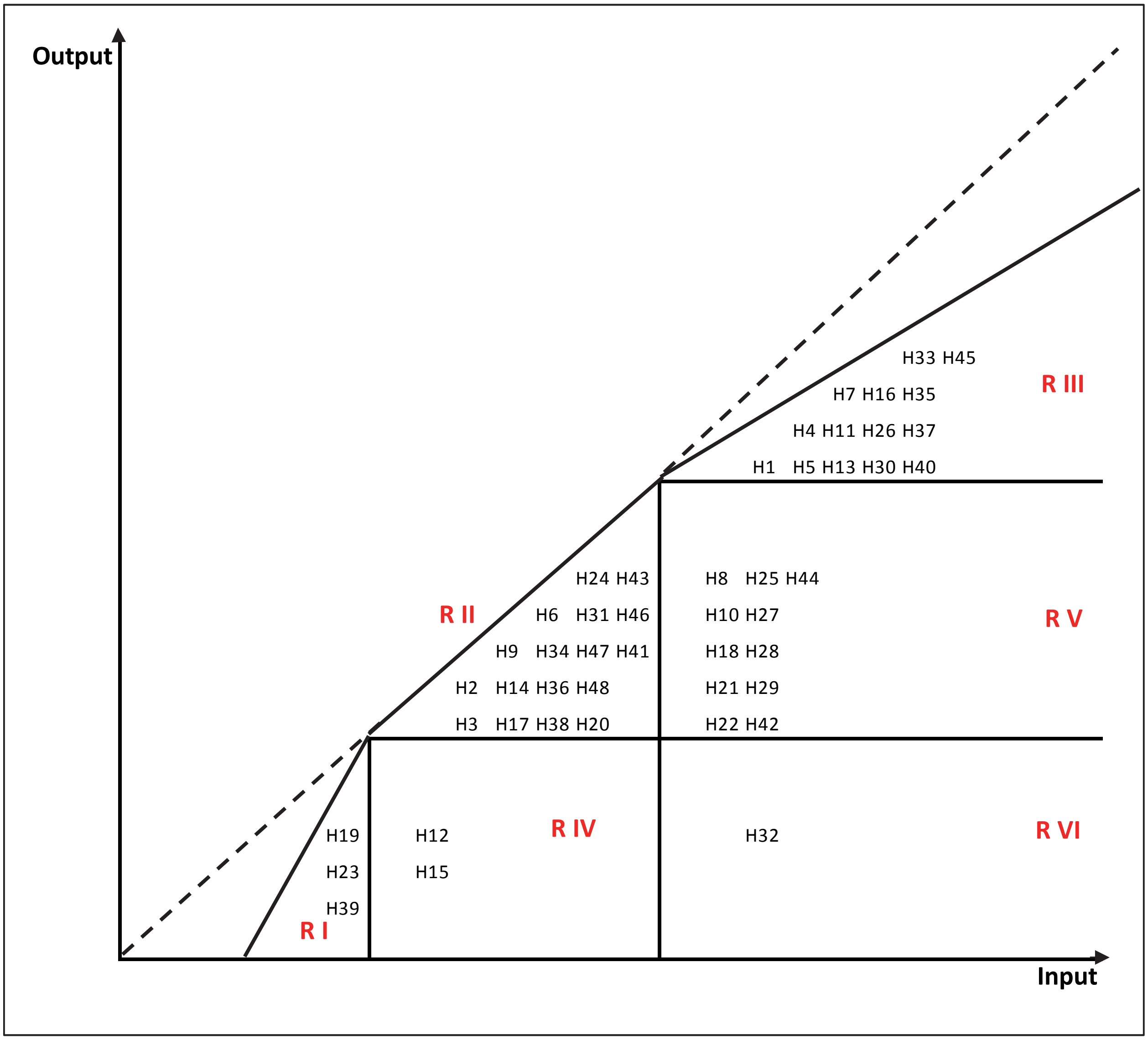
FIGURE 3
RTS REGIONS



Source: Sherman, H. D., & Zhu, J. (2006). Service Productivity Management: Improving Service Performance Using Data Envelopment Analysis (DEA). New York: Springer Science + Business Media p.140

Gregoriou and Zhu (2005) emphasize that RTS regions are a classification tool for DMUs, but the relation with the performance of DMUs is limited. This classification method can be used as an indicator to assess the future state of the DMUs. In the study, three DMUs (H12-H15-H32) were in the IRS region when computed with the input-oriented model. However, the output-oriented model showed that H12 and H15 were in R-IV (CRS) and H32 was in R-VI (DRS). While assessing these DMUs, it must be considered that return to scale can be limited or diminished tendency. Similarly, the fact that 10 DMUs in R-V serving with most productive scale size can approach DRS region should be kept in mind. When viewed from this aspect, RTS regions may contribute to downsizing and upsizing decisions (Figure 4).

FIGURE 4
RTS REGION OF THE HOSPITAL



Analysis of Slack Values

The amount of the inefficiency can be estimating by subtracting 1 from efficiency score (1-Efficiency Score). But, it is essential to know which variables effect on inefficiency level. Slack value serves this aim and shows us which variables can be improved.

The relationship between the amount of input-output and that of slack value, which was produced by inefficient hospitals is shown in Table 8. The number of ex-cases (22 slack value frequency), nurses (19 slack value frequency) and beds (12 slack value frequency) must be decreased by 50%, 6.3% and 3.6%, respectively.

TABLE 8
NON-ZERO SLACKS OF INEFFCIENT DMUs AND FREQUENCIES

	Bed	Specialist	Nurse	Outpatient	Inpatient	Surgery	Ex-case
Number of DMU	33	33	33	33	33	33	33
Slack **(1)**	840	162	1.184	2.107.645	42.631	3.943	15.416
Total Input/Output Level of Inefficient DMUs **(2)**	23.159	8.976	18.891	49.945.811	1.407.312	183.577	30.357
Percent Difference **(1/2)**	3,6%	1,8%	6,3%	4,2%	3,0%	2,1%	50,8%
Slack Frequency	12	6	19	8	9	7	22

As a result of the slack value analysis, inefficient hospitals must improve clinical quality to decrease ex-cases, and decline the number of beds and nurses to serve with more suitable scale size. Therefore, inefficiencies can be removed.

CONCLUSION

In the study, overall efficiency decomposed into pure technical and scale efficiencies and found that both input utilization and size of the hospitals were the main problems. Managerial capacity, at the micro level, and policy-making capacity, at the macro level, should be improved. The study underlines the importance of the improvement in both managerial and policy-making capacity.

Classification of the efficient DMUs with reference set frequency is a useful method to assess how strong efficient DMU's are and which of them can be benchmarks. Of the 15 efficient hospitals, 2 of them were strong efficient and able to be a good example for inefficient hospitals. Five of them were weak efficient and must be concerned with their efficiencies.

Twenty-Nine percent of hospitals had diseconomies of scale or decreasing return to scale and needed downsize strategy to gain efficiency. Thirteen percent of them had economies of scale or IRS and needed to increase their size. Zhu's RTS regions can be used as an indicator of the future state of DMUs. We found that 13 DMUs in Region IV – V and IV should be investigated carefully.

Non-zero slacks frequency is also the useful approach to find the main areas of the inefficiency. Slack analysis shows that some precaution must be taken by policymakers and hospital managers to compensate for efficiency gaps. First, clinical services quality improvement strategies must be developed to decrease hospital mortality, and second, the hospitals must put a lot of emphasis on numbers of beds and nurses to serve more suitable scale sizes.

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