Reorganization Health Care Delivery and Productivity Change: An Assessment of Turkish Public Hospital Performance with Malmquist Index

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Public Hospital Unions (PHU) were established with the aim of two pillars of Health Transformation Project. First was the regulatory and supervisory Ministry of Health (MoH) and the second was public health service providers with financial and managerial autonomy. Level of attaining the objectives of these entities compared the efficiency of input-output conversion processes with the hospitals managing pre and post era of the public hospital unions. Data Envelopment Analysis and Malmquist Total Factor Efficiency Indice were used as the analysis method. This study comprises 260 hospitals running between 2011 and 2013 period.

INTRODUCTION

The increase of life expectancy at birth has also increased the elderly population rate. A decrease in the infant mortality rate has been provided by preventive health services such as vaccination, pregnancy and child monitoring. Technological advances have broadened horizons in the diagnosis and treatment of illnesses. These advances have increased the demand for health care services, and growing health demand has also led policymakers to take measures regarding the sustainability of the healthcare services.

Health authorities have struggled to seek efficient, productive, fair and sustainable healthcare systems by initiating health reforms since the 1990's. Health reform all over the world has affected Turkey and led to dramatic changes in the Turkish health care system.

In 2003, a reform program named Health Transformation Program (HTP) was initiated because of improving structural and functional defects in the health system. The primary goal of the HTP is to create more efficient health system by enhancing governance, productiveness, patient and health care provider satisfaction, and long-run fiscal sustainability (OECD and Dünya Bankası, 2008: 369).

Based on regulatory and supervisory Ministry of Health (MoH) aim, one of the leading topics of the HTP, healthcare providers and policymakers were separated (Akdağ, 2007). At the end of 2011, healthcare providers had more autonomous structure, and organizational structure of the MoH was transformed into more functional units with the decree law concerning the organization and duties of the ministry of health (Lamba, Altan, Aktel and Kerman, 2014).

In this context, organization and provision of the hospital services underwent radical changes. Public Hospital Unions (PHU) were established as more autonomous structures in each county to deliver secondary and tertiary care. Hospitals began to carry on the activity under the PHUs.

With PHUs, it was aimed at efficient resource usage and taking advantage of economies of scale (Lamba et al., 2014). A scorecard practice was started to implement with the aim of assessing productivity and efficiency of service delivery and resource usage of the PHUs (Kamu Hastaneleri Birlikleri Verimlilik Karne Değerlendirmesi Hakkında Yönerge, 2012). Therefore, it was able to evaluate hospitals and their executives about performance criteria. Input-output conversion process efficiency of the healthcare organization can be assessed by using scorecards (Yiğit, 2016). An objective-driven employment model was adapted as a part of fiscal and managerial autonomy (*663 Sayılı Sağlık Bakanlığı ve Bağlı Kuruluşlarının Teşkilat ve Görevleri Hakkında Kanun Hükmünde Kararname*, 2011: m.32/1-5).

To sum up briefly, professional management and contract employee approaches have gained importance in the new organization structure (Aktel, Altan, Kerman and Eke, 2013), and hospital data were eligible for organizational – managerial performance assessment because the contract with health managers depended on managers' performance.

In this study, PHUs, emerging as a new actor and an autonomous structure, and affiliated service providers were examined regarding their expected efficiency and productivity roles. For that purpose, Data Envelopment Analysis (DEA) and Malmquist Index (MI), a total factor productivity measurement method, approaches were used to observe the efficiency structure of the service provider.

METHOD

DEA is a linear programming based technique for measuring the performance efficiency of decision-making units (DMU). This technique aims to measure how efficiently a DMU uses the available resources to produce a set of outputs (Charnes, Cooper and Rhodes, 1978).

The efficiency of commercial structures can be measured easily by their yearly profits, or their stock market indices, while such measurable factors are not implementable to non-profit organizations. When DMUs consume multiple inputs and also produce a variety of outputs, it is difficult to measure efficiency (Ramanathan, 2003: 26). For example, hospitals produce outputs (outcomes) such as patient visits, inpatient treatments, discharges, ex-cases by using some inputs such as personnel, beds, medical equipment. DEA that can measure multiple inputs and outputs in a scaler value facilitates the understanding of institutional efficiency.

Malmquist Index is a factor productivity indice that is used to measure DMUs performance changes over the periods. The index was developed by Sten Malmquist (1953) and adapted to DEA by Caves, Christensen and Diewert (1982). Fare, Grosskopf, Lindgren and Roos (1989) converted the index into a structure that can measure efficiency change and technological change separately.

The advantage of the MI over other TFP indices is that MI does not need any information on the prices of inputs and outputs or technological and behavioral assumptions. A further advantage of the MI approach is that one can decompose TFP change into two components: efficiency change and technical change (Rowena, Peter C. and Andrew, 2006: 130).

Malmquist Productivity Index can be stated as follows (Ramanathan, 2003: 99)

$$M^{t+1}(x^{t+1},y^{t+1},x^t,y^t)=\frac{d_0^{t+1}(x^{t+1},y^{t+1})}{d_0^t(x^t,y^t)}\ x\left[\frac{d_0^t(x^{t+1},y^{t+1})}{d_0^{t+1}(x^{t+1},y^{t+1})}\ x\ \frac{d_0^t(x^t,y^t)}{d_0^{t+1}(x^t,x^t)}\right]^{1/2}$$

or

Malmquist Index= Efficiency Change x Technological Change

$$Technological\ Change=\left[\frac{d_0^t(x^{t+1},y^{t+1})}{d_0^{t+1}(x^{t+1},y^{t+1})}\ x\ \frac{d_0^t(x^t,y^t)}{d_0^{t+1}(x^t,x^t)}\right]^{1/2}$$

Efficiency Change = $\frac{d_0^{t+1}(x^{t+1},y^{t+1})}{d_0^t(x^t,y^t)}$

Efficiency Change can also be decomposed as follows:

Pure Efficiency Change = $\frac{d_{VRS}^{t+1}(x^{t+1},y^{t+1})}{d_{vrs}^t(x^t,y^t)}$

Scale Efficiency Change = $\frac{d_{CRS}^{t+1}(x^{t+1},y^{t+1})}{d_{VRS}^{t+1}(x^{t+1},y^{t+1})} x \frac{d_{CRS}^t(x^t,y^t)}{d_{VRS}^t(x^t,y^t)}$

i.e.

$$Efficiency\ Change = Pure\ Efficiency\ Change\ x\ Scale\ Efficiency\ Change$$

and Malmquist Index :

$$Malmquist\ Index = Pure\ Efficiency\ Change\ x\ Scale\ Efficiency\ Change\ x\ Technological\ Change$$

When observing components of the MI:

Efficiency change states the achievement level of the efficient frontier of DMUs between two periods. Technological change indicates the frontier shift in the periods. Technological change in health care services is usually related to new equipment, new forms of organization, surgical procedures, drugs and patient management method (Chowdhury, Wodchis ve Laporte, 2011). Pure technical efficiency change emerges only because of managerial underperformance in Variable Return to Scale (VRS) assumption (Kumar, 2008). Scale efficiency change shows how DMUs or hospitals run as scale efficiency between two periods. Scale efficiency differs from managerial efficiency, and scale inefficiency can be handled by adopting the new technology or new service production processes (Ozcan, 2014: 18).

If MI >1, there is an improvement of the efficiency level, and if MI <1, there is the regression of the efficiency level. When MI =1, there is no change in the efficiency level.

As mentioned above, decomposing the components of MI provides an easy interpretation and comprehension of the efficiency change.

DATA

This study comprises 260 MoH general hospitals, and data of these hospitals were collected from the statistical yearbook of MoH for the years 2011 and 2013. These years show pre and post-PHUs periods. The analysis was conducted with MI method and used input-oriented constant and variable return to scale. Besides, DEA efficiency scores belonging to 2011 and 2013 years incorporated into the analysis. Technical, pure and scale efficiencies of the hospitals were calculated for assessing inefficiencies level of them. Therefore it is revealed how close the hospitals are to their efficient frontier.

Input and Output Variables used in the study are seen below:

Input Variables	***Output Variables***
Number of Beds	*Number of Outpatients*
Number of Specialist Physicians	*Number of Hospital Days*
Number of General Practitioners	*Number of Adjusted Surgeries**
Number of Nurses	
Number of Other Health Personnel	

Major surgeries = 1, moderate surgeries = 1/3, minor surgeries = 1/7

Correlation matrix for variables is shown in Table 1 and Table 2. As a result of correlation analysis, we found a strong association between input and output variables ranging from 0.63 and 0.94.

TABLE 1
CORRELATION MATRIX (2011)

	Bed	Specialist	General Practitioner	Nurse	Other Health Professional	Outpatient	Hospital Day	Adjusted Surgery
Bed	1	0.765511	0.62387	0.885065	0.782447	0.694419	0.937116	0.76691
Specialist	0.765511	1	0.689153	0.83569	0.761264	0.900909	0.801038	0.874257
General Practitioner	0.62387	0.689153	1	0670998	0.626873	0.69625	0.67262	0.678751
Nurse	0.885065	0.83569	0.670998	1	0.82763	0.746403	0.901067	0.817378
Other Health Professionals	0.782447	0.761264	0.626873	0.82763	1	0.698649	0.801947	0.792646
Outpatient	0.694419	0.900909	0.69625	0.746403	0.698649	1	0.73222	0.821136
Hospital Day	0.937116	0.801038	0.67262	0.901067	0.801947	0.73222	1	0.819248
Adjusted Surgery	0.76691	0.874257	0.678751	0.817378	0.792646	0.821136	0.819248	1

TABLE 2
CORRELATION MATRIX (2013)

	Bed	Specialist	General Practitioner	Nurse	Other Health Professional	Outpatient	Hospital Day	Adjusted Surgery
Bed	1	0.759243	0.717998	0.864883	0.754891	0.701294	0.930372	0.779432
Specialist	0.759243	1	0.628986	0.828102	0.712408	0.906425	0.764223	0.8439
General Practitioner	0.717998	0.628986	1	0.721502	0.662442	0.638639	0.740816	0.65209
Nurse	0.864883	0.828102	0.721502	1	0.792941	0.75565	0.863001	0.827334
Other Health Professionals	0.754891	0.712408	0.662442	0.792941	1	0.685127	0.769463	0.767878
Outpatient	0.701294	0.906425	0.638639	0.75565	0.685127	1	0.712578	0.808496
Hospital Day	0.930372	0.764223	0.740816	0.863001	0.769463	0.712578	1	0.814061
Adjusted Surgery	0.779432	0.8439	0.65209	0.827334	0.767878	0.808496	0.814061	1

FINDINGS

146 hospitals (56%) increased total factor productivity (MI>1), 6 hospitals (2%) stayed indifferent and 108 hospitals (42%) declined (MI>1).

Despite the average 1% decline in technical efficiency, 4% technological improvement occurred. When decomposing technical efficiency, pure efficiency (managerial efficiency) increased 1% and scale efficiency decreased 2%.

When assessing average CRS efficiency scores for the years of 2011 and 2013, average scores were 0.814 and 0.800 respectively. On the other hand, VRS (pure – managerial) efficiencies for the same years were 0.879 and 0.880 respectively and scale efficiency 0.926 and 0.907. In other words, average technical, pure (managerial) and scale inefficiency were 20%, 12% and 9% respectively.

TABLE 3
DESCRIPTIVE STATISTICS

		Malmquist Index	Efficiency Change	Technological Change	Pure Efficiency Change	Scale Efficiency Change
N		260	260	260	260	260
Mean		1.03	0.99	1.04	1.01	0.98
Median		1.04	1.00	1.05	1.00	0.99
Mode		.9600[a]	1.00	1.07	1.00	1.00
Std. Dev.		.1963549	.1775453	.1014567	.1457371	.1012209
Min		0.47	0.53	0.60	0.65	0.55
Max		1.81	1.60	1.24	1.52	1.47
Quartiles (%)	25	0.90	0.89	0.99	0.93	0.95
	50	1.04	1.00	1.05	1.00	0.99
	75	1.15	1.09	1.10	1.08	1.02

On assessing scale efficiencies of the hospitals, 31% increased scale efficiency, 51% decreased scale efficiency and 18% had no change (Table 5). Average scale efficiency of the hospitals, which were increased scale efficiency, was 0.879 (2011) and 0.933 (2013). On the other hand, average scale efficiency of the hospitals, which were decreased scale efficiency, was 0.936 (2011) and 0.866 (2013).

Even though the proportion of the hospitals, which run appropriate scale size was 15% in 2011, this rate regressed to 13% in 2013. 71% of the hospitals were classified as IRS and 16% of them in the zone of DRS. 185 hospitals in the IRS zone must expand their scale size and 41 hospitals must experience downsizing to achieve appropriate scale size (Table 4).

TABLE 4
RETURN TO SCALE OF THE HOSPITALS

Return to Scale	*2011*	*(%)*	*2013*	*(%)*
Constant Return to Scale (CRS)	40	15%	34	13%
Decreasing Return to Scale (DRS)	50	19%	41	16%
Increasing Return to Scale (IRS)	170	65%	185	71%
Total	260	100%	260	100%

There is a benefit to put forward some caveats while assessing scale efficiency. Adjusting scale size may not work in reality if markets aren't competitive or firms cannot change their scale of operation for natural reasons: e.g., they may serve a geographically isolated area of sub-optimal size. The optimal scale size depends on the exact direction in the input and output space. Therefore, a decision with only one measure may not achieve correct results for determining optimal scale size (Bogetoft ve Otto, 2011: 101).

Regarding pure efficiency change, 43% of the hospitals increased efficiency, but 37% of those decreased and 20% of those had no efficiency change. Average pure efficiency scores of the improved hospitals were 0.795 in 2011 and 0.896 in 2013. In spite of the improvement, there was still an inefficiency of 10%. Average efficiency scores of the regressed hospitals were 0.92 in 2011 and 0.80 in 2013, but still, it had a 20% technical inefficiency. Stable hospitals with the average of 0.986 efficiency score were the closest hospitals of the efficient frontier.

Regarding technical efficiency change, as 41% of the hospitals improved 47% of those regressed and 12% of those stayed stable.

As mentioned above, there is no significant difference in technical efficiency, but assessment of the technological change may be useful. There has been substantial progress concerning technological efficiency change. While 69% of the hospitals increased technological efficiency, 26% of those had regression and 5% of those had no difference.

TABLE 5
EFFICIENCY CHANGE OF HOSPITALS (%)

	Malmquist Index		*Efficiency Change*		*Technological Change*		*Pure Efficiency Change*		*Scale Efficiency Change*	
	n	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*
Improvement	146	56%	107	41%	180	69%	111	43%	80	31%
Stable	6	2%	31	12%	13	5%	52	20%	47	18%
Regression	108	42%	122	47%	67	26%	97	37%	133	51%
Total	260	100%	260	100%	260	100%	260	100%	260	100%

When observing input and output composition of the hospitals, the output level of the improved hospitals had a significant increment, and the input level of those had no change or even slightly decreased. For example, despite a 4% increase in the number of beds, the amounts of specialist and GP dropped by 3% and 12% respectively. The number of visits, hospital days and the number of adjusted surgery increased by 10%, 13%, and 22% respectively (Table 5). It was pointed out that TFP decreased hospitals increased the number of their inputs. It was observed that numbers of beds (15%), physicians (12%), nurses (16%) and other health professionals (7%) have increased. On output side, whereas numbers of visits and surgeries increased by 2% and 6% respectively, hospital days decreased by 1% (Table 6).

TABLE 6
INPUT AND OUTPUT COMPOSITION CHANGE (%)

INPUT							OUTPUT		
MI	N	Bed %	Specialist %	GP %	Nurse %	OHP %	Visit %	Hospital Days %	Surgery %
Improvement	146	4%	-3%	-12%	7%	-2%	10%	13%	22%
Stable	6	6%	0%	9%	8%	10%	1%	4%	10%
Regression	108	15%	12%	12%	16%	7%	2%	-1%	6%
Mean	260	9%	3%	-1%	11%	2%	6%	7%	15%

CONCLUSIONS

This study has set out to assess the hospital efficiency on Public Hospital Unions (PHUs) basis. It has demonstrated how hospital performance over the periods has been affected by the establishment of the PHUs as regards its objectives such as the executive employment with contract employee approach, usage of economies of scale and performance scorecard practice. On being assessed managerial efficiency on the employment of the hospital executives, contract employee method has less or no contribution on efficiency. PHUs weakness is in the usage of economies of scale. (Scale efficiency decreased by 2%.) Putting managerial and scale efficiency changes together, technical efficiency has declined (1%).

On the other hand, an increase in technological efficiency (4%) contributed to a 3% increase in TFP. In this period, there were technological advancements in hospitals concerning medical devices. For example, the number of MR, CT and hemodialysis devices increased by 6%, 9%, and 3%, respectively. Capital expenditures rose from 1,928 million dollars (2011) to 2,463 million dollars (2013) with a 28% increase ("TUİK Temel İstatistikler" 2016). Taking the family practices (GP) system into consideration, it can be stated that significant part of these capital expenditures used for hospitals (seconder and tertiary care) and their spending led to technological advancement.

In conclusion, when being compared hospital performances between pre and post period of the PHUs, it is impossible to say that expected utilities are achieved. In the micro assessment, there was not any improvement in managerial efficiency and we were not able to utilize scale economies in the macro framework.

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