“Transformation of state-owned hospitals to private-owned: are selected hospitals more technical efficient?”

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Transformation of state-owned hospitals to private-owned: are selected hospitals more technical efficient?

Abstract

Business performance can be determined by several methods. Each method has its pros and cons. Slovak health, according to several studies, but also real experiences of people, is in the state, which is unsustainable. One of the methods for the measurement performance of health facilities is a method of evaluating the effectiveness – data envelopment analysis. This method is used in leading researches in the field of the health care management abroad. This study claims, with using bootstrapped confidence intervals of efficiencies within selected time period, that not all from the researched hospitals are more technically efficient since the time they undergone the transformation process. The authors have to point, that DEA is just one of the many indicators for measuring performance of hospitals. Additionally, it cannot prove, that selected hospitals are in better or in worse state than before transformation process, but according to DEA models, just one hospital is significantly more technically efficient after it became private-owned hospital.

Keywords: DEA, private hospitals, efficiency, Slovak Republic.
JEL Classification: I10, I19.

Introduction

In past years, many hospitals in Slovakia came through transformation from state-owned to private owned companies. Most of them are located in the region of eastern Slovakia. Now, in 2015, we can look backwards on efficiency of this transformation. Widely used method for measuring the efficiency is data envelopment analysis (DEA).

DEA is common method for measuring hospital efficiency in USA (O'Neill et al., 2008; Clement et al., 2008; Nayar and Ozcan, 2008; Hollingsworth et al., 1999; Ozcan, 1995). In the last decade, it started to be used in European countries. There is the study for measuring efficiency of hospitals in Portugal (Alfonso and Fernandes, 2008). DEA approach was used also in Austria (Hofmarcher et al., 2002). Hospital efficiency was measured in Germany, economical leader in EU countries, using method DEA Bootstrap (Staat, 2006). In Finland, the impacts of changes in their health care system were measured by this method (Häkkinen, 2005). Second-stage DEA was used to evaluate the efficiency of hospitals in Italy (Matranga et al., 2013).

Daidone and D'Amico (2009) found that after controlling for environmental variables and hospital case-mix, inefficiency is negatively associated with specialization and positively associated with capitalization. Capitalization is typical of private structures which, on average, use resources less efficiently with respect to Italian public and not-for-profit hospitals. Dismuke and Sena (1999) were using DEA to observe the effects of initiation of DRG (Diagnosys related groups) in Spain. They found evidence, that the DRG payment system does appear to have had a positive impact on productivity and technical efficiency of some commonly employed diagnostic technologies in Portugal during observed years. Ozcan et al. (1992) found, that government and nonprofit hospitals were somewhat indistinguishable from one another regarding their percentages of highly inefficient scores. For-profit hospitals also tended to use supply and capital asset (hospital size) inputs less efficiently, and service and labor inputs more efficiently than hospitals in the other ownership categories. Vakkuri (2003) aimed DEA applications in four non-profit environments. The aim was to pinpoint possibilities and limitations in using DEA-based efficiency information in the management process of NPOs (non-profit organizations). Nunamaker (1985) found that variable set expansion (either through disaggregation of existing variables or addition of new factors) should produce an upward trend in efficiency scores. In addition, ample opportunity exists for 'decision-making units' to increase their efficiency scores through manipulation of reported data. In real world applications of DEA, these problems must be resolved as much as possible (e.g. increased audit of data) in order to improve DEA's practical usefulness and reliability. Barbetta and Turati (2006) research showed a convergence of mean efficiency scores between not-profit and public hospitals, and seem to suggest that differences in economic performances between competing ownership forms are more the result of the institutional

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settings in which they operate than the effect of the incentive structures embedded in the different proprietary forms. They have found decline in technical efficiency, probably due to policies aimed at reducing hospitalization rates. Szabo & Sidor (2014) studied the performance measurement system – potentials and barriers for its implementation in healthcare facilities.

There are several studies using DEA to evaluate efficiency of hospitals in Slovak Republic. Lacko et al. (2014) were observing technical efficiency of 4 private hospitals. We have to mention the difference between this study and the study from year 2014. At first, not the same hospitals are used. Then, the efficiency will be evaluated for every hospital independently from each other hospital. In research from 2014, hospitals have been evaluated altogether. Šoltés and Gavurová (2014) evaluated the technical efficiency of Slovak hospitals according to regions of Slovak Republic.

1. Methods

For purpose of this study we use DEA approach to evaluate the technical efficiency of selected private hospitals. To evaluate the improvement we use DEA bootstrap approach. In this study CCR and BCC input models will be used.

1.1. DEA CCR input model. CCR model of linear programming has the following form:

$$max_{\mu,\nu}\, \theta = \mu_1 y_{1o} + \cdots + \mu_s y_{1s}, \quad (1)$$

such that:

$$\nu_1 x_{1o} + \cdots + \nu_m x_{mo} = 1,$$

$$\mu_1 y_{1j} + \cdots + \mu_s y_{sj} \le \nu_1 x_{1j} + \cdots + \nu_m x_{mj} (j = 1,2,\ldots,n)$$

$$\nu_1, \nu_2, \ldots, \nu_m \ge 0,$$

$$\mu_1, \mu_2, \ldots, \mu_s \ge 0,$$

where the optimal solution is $\nu = \nu = \nu^*$, $u = \mu = \mu^*$ and $\theta = \theta^*$, DMU_j is CCR efficient if optimal $\theta^* = 1$ and there exists at least one optimal (u^*, v^*) fulfilling the condition $u^*, v^* > 0$. In other case is DMU_j CCR inefficient (Banker et al., 1984).

1.2. DEA BCC input model. Input oriented BCC model evaluates the efficiency of DMU_o $o = (1, ..., n)$ by solving the following linear programming model (cover form):

$$min_{\theta_B,\lambda}\, \theta_B, \quad (2)$$

such that

$$\theta_B x_o - X\lambda \ge 0,$$

$$Y\lambda \ge y_o,$$

$$e\lambda = 1,$$

$$\lambda \ge 0,$$

where θ_B is scalar (Banker et al., 1984).

Difference between BCC and CCR models is in the free variable u_o limited by the sum $e\lambda$=1. Model works in two phases. First phase minimizes θ_B and the second maximizes the sum of excesses of inputs and shortage of outputs while maintaining θ_B = θ_B*, as optimal value achieved in phase one. When optimal solution obtained in double-phase model $(\theta_B^*, \lambda^*, s^{-*}, s^{+*})$ – where s^{-*} is maximal input excess and s^{+*} is maximal output shortage – fulfils condition $\theta_B^* = 1$ and has no slack then DMU_o is called BCC-efficient, otherwise it is BCC-inefficient (Banker et al., 1984).

1.3. DEA bootstrap approach. If we want to prove that there is or is no increase in efficiency in selected hospitals, it will be helpful to use DEA bootstrap approach, which is described in Simar and Wilson (1998). We will compute confidence intervals for bootstrapped efficiencies. If there is at least one value (or interval conjunction for continuous variables) which is common for two intervals for year *x* and *y*, we will say that the increase or decrease is not significant. In other words, it can happen that the bootstrapped value of efficiency could be the same in selected intervals.

2. Data

Data have been collected from 4 private hospitals for the time period from 2007 to 2014. Because the hospitals provided the data without permission to mention name of the hospitals we will entitle them as Hospital A, B, C and D. According to reviewed literature we selected the most frequently used variables with regards to specific conditions in Slovak Republic. We chose 4 input variables: *number of doctors*, *number of nurses*, *number of other staff* and *number of beds*. We chose these 2 variables as output variables: *number of days on bed* and *number of inpatients.* Each input and output variable is the value from the end of the selected year. Selected hospitals are private since year 2011.

3. Efficiency measurement and results

Once the data are collected, the analysis can be made. We have used RStudio to compute the results (efficiencies) of selected models. Following table shows measured efficiencies for each hospital during selected time period.

Table 1. Values of efficiencies for hospitals A, B, C, D

DMU	Eff CCR	Eff BCC	DMU	Eff CCR	Eff BCC	DMU	Eff CCR	Eff BCC	DMU	Eff CCR	Eff BCC
A07	0.9347	0.9427	B07	0.8569	0.9117	C07	1	1	D07	1	1
A08	1	1	B08	0.8132	0.8913	C08	1	1	D08	0.9857	0.9953
A09	0.9876	1	B09	0.8296	0.8656	C09	0.8712	0.9994	D09	0.9545	0.9569
DMU	Eff CCR	Eff BCC	DMU	Eff CCR	Eff BCC	DMU	Eff CCR	Eff BCC	DMU	Eff CCR	Eff BCC
A10	0.9684	0.9799	B10	0.8450	0.8957	C10	0.9390	0.9993	D10	0.9277	0.9341
A11	1	1	B11	0.8894	0.9110	C11	0.9490	0.9970	D11	0.9395	0.9414
A12	1	1	B12	0.8705	0.8922	C12	0.9396	0.9946	D12	0.9172	0.9190
A13	0.9295	0.9300	B13	1	1	C13	1	1	D13	0.8710	0.8787
A14	0.9399	0.9449	B14	0.9737	1	C14	1	1	D14	0.9636	0.9942

Source: author's calculations.

As we can see, the development of efficiencies in selected hospitals was different. In Hospital A, there were values of efficiencies fluctuating around the value 1, according to both models. There were no significant inefficiencies. We cannot say, there is some positive or negative trend in development of efficiency. In hospital B, there is visible positive trend in development of evaluation, especially in last 2 years. We can say, that according to both models there is significant increase of efficiency in last 2 years. Values were fluctuating around the value 0.85, between years 2007 and 2012. Hospital C was efficient in first two years and last two years. We can see increase of efficiency from year 2009, according to CCR model. According to both models, hospital C was efficient just in first observed year. In other years, the hospital was not that much inefficient. In table 2, there are displayed values of lower and upper intervals for bootstrapped efficiencies. It was computed for both models, CCR and BCC.

Table 2. Values of lower and upper interval boundaries for CCR and BCC model

DMU	CCR		BCC	
	2.50%	97.50%	2.50%	97.50%
A07	0.87318	0.932747	0.893316	0.941309
A08	0.945589	0.998115	0.942439	0.99904
A09	0.936222	0.985232	0.954083	0.998753
A10	0.917685	0.966422	0.931138	0.978881
A11	0.90562	0.998035	0.912748	0.998734
A12	0.892018	0.997606	0.898889	0.999083
A13	0.892891	0.927206	0.888959	0.929032
A14	0.900866	0.937418	0.905363	0.943165
B07	0.821055	0.855089	0.859116	0.910847
B08	0.783767	0.811083	0.849832	0.890156
B09	0.802833	0.827857	0.834684	0.864318
B10	0.817303	0.843652	0.856741	0.894606
B11	0.860133	0.88771	0.867097	0.90984
B12	0.838971	0.868506	0.849698	0.891256
B13	0.953054	0.998336	0.889059	0.99924
B14	0.926978	0.971499	0.917629	0.999314
C07	0.851803	0.998129	0.883892	0.998503
C08	0.869645	0.998008	0.888831	0.998372
C09	0.778868	0.869917	0.921214	0.998382
C10	0.865415	0.938001	0.934319	0.998794
C11	0.893393	0.946861	0.937575	0.996044
C12	0.890844	0.937794	0.947845	0.993349
C13	0.895423	0.998035	0.907593	0.998329
C14	0.906577	0.99791	0.912743	0.998727
D07	0.928121	0.997091	0.884229	0.998583
D08	0.918004	0.983312	0.91366	0.994624
D09	0.894521	0.953575	0.901041	0.956163
D10	0.880062	0.925843	0.889219	0.933219
D11	0.906507	0.93766	0.906102	0.940444
D12	0.885505	0.915046	0.886496	0.917743
D13	0.827004	0.869939	0.843555	0.877639
D14	0.915321	0.961788	0.952394	0.99299

Source: author's calculations; number of repetitions, $\alpha = 0.05$.

These values take into account the possibility of existence of statistical noise, since the common DEA is deterministic. Now, we are going to evaluate the significance of increase of efficiencies after the transformation from public hospitals to private hospitals. In following tables we are going to show, how we evaluate the significance of change according to transformation. We will use only CCR model, because the values of efficiencies between CCR and BCC are not that much different.

Table 3. Significance of increase of the efficiency in Hospitals A and B

Year	Hospital A			Hospital B		
	UB (2010) < LB		Significance	UB (2010) < LB		Significance
2011	0.966422	0.90562	FALSE	0.843652	0.860133	TRUE
2012	0.966422	0.892018	FALSE	0.843652	0.838971	FALSE
2013	0.966422	0.892891	FALSE	0.843652	0.953054	TRUE
2014	0.966422	0.900866	FALSE	0.843652	0.926978	TRUE
	Result		FALSE	Result		TRUE

Note: UB – Upper boundary, LB – Lower boundary.

The main point of this analysis is to compare the upper value of confidence interval of year 2010 to lower boundary values of years 2011 to 2014. If there is no conjunction for these intervals, there is significant increase in efficiency. So there is significant increase in efficiency. In hospital A, there is conjunction of intervals in all given years. So we can say, in general, there is no significant increase. On the contrary, there was significant increase in efficiency in hospital B. Just in one year there was not significant increase, but in 3 years, there was.

Table 4. Significance of increase of the efficiency in Hospitals C and D

Year	Hospital C			Hospital D		
	UB (2010) < LB		Significance	UB (2010) < LB		Significance
2011	0.938001	0.893393	FALSE	0.925843	0.906507	FALSE
2012	0.938001	0.890844	FALSE	0.925843	0.885505	FALSE
2013	0.938001	0.895423	FALSE	0.925843	0.827004	FALSE
2014	0.938001	0.906577	FALSE	0.925843	0.915321	FALSE
	Result		FALSE	Result		FALSE

Note: Note: UB – Upper boundary, LB – Lower boundary.

If we look at the results in table 4, we can say that there was no significant increase of efficiencies in both hospitals, C and D. In all 8 cases, there was conjunction in confidence intervals.

Conclusion

We proved, that significant increase of efficiency was only in one hospital evaluated. The results were the same in using common DEA methods and in DEA bootstrap. The point is, we have measured just the technical efficiency not the economic effectivity. There might be increase in economic effectivity. Also, it cannot be said, that the transformation was pointless. We have to take look at more evaluation of other business processes.

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