A COMPARISON OF EFFICIENCY OF HOSPITALS IN THE INDIVIDUAL REGIONS OF THE CZECH REPUBLIC

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Abstract: *The main goal of this paper is to compare the efficiency of health care in the individual regions of the Czech Republic. Key consideration is given to the efficiency of hospitals for these subjects account for more than half of the health care expenses. The DEA method, precisely the input-oriented CCR, was chosen for the analysis. This method allows for the evaluation of several inputs and outputs. For the purpose of our research, we utilized one output, i.e. the number of hospitalized patients, and on the other hand, we examined several inputs, i.e. the number of beds, operating costs and the number of physicians. The analysis showed that the Královehradecký region is the least efficient and, on the other side of spectrum, there are 4 efficient regions - Karlovarský, Ústecký, Vysočina and Zlínský. The level of efficiency in other regions varies between 79,4 % and the above-mentioned 100%. Looking at the structure and the number of hospitals in the regions, we cannot see any significant correlation so we cannot say that efficiency is correlated to the number or structure of hospitals in any given region.*

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Introduction

Efficiency of health care is currently a very much discussed topic. The reason for this is that the trend of ageing populations and declining birth rates in economically developed countries bring with them higher health care expenses. Authors of scientific papers often approach this topic from the national politics point of view or by evaluating the efficiency of individual hospitals and other health care institutions. However, it is also important to take into consideration the role of the region and regional politics for increasing efficiency in health care.

In the Czech Republic, the issue of health care is also addressed from a regional point of view. The regions focus on increasing the efficiency of health care and set for themselves plans, strategies and development concepts which are mainly focused on four following areas: human resources in health care, quality of health care, processes in health care, udgeting of the health care systems.

Amongst the main goals of the regional health care politics of individual regions are: optimization of the health care institution's network, re-structuralization of the health care with a focus on availability and inter-linking, modernisation of health care institutions, creating a condition for the work of the qualified personnel, introducing the system of lean health care, increasing efficiency and streamlining health care institution's budgets, prevention etc.

All of these goals point to the one key goal: to maximize the quality and efficiency in providing health care in a given region (Krajský úřad Královéhradeckého kraje, 2015), (Zlínský kraj, 2013).

The efficiency of public health care delivery in a regional context is examined in their studies, for example, by Halkos and Tzeremes (2011: 73-82). They respect the effect on the efficiency of public healthcare provision of factors such as GDP per capita and population density are examined in Greek. They derived to the general conclusion that increased levels of GDP per capita does not ensure prefectures' public healthcare delivery efficiency, having an overall negative effect on prefectures' healthcare delivery performance. In additions they present that population density has a positive effect on prefectures' healthcare delivery efficiency indicating that urban hospitals are very much better resourced than the corresponding rural hospitals.

The main goal of this paper is to compare, by using the DEA analysis, hospitals within the individual regions of the Czech Republic and, based on the results, formulate recommendations for improving chosen indicators.

1 Statement of a problem

1.1 Health care in the Czech Republic

Until 1991, the health care in the Czech Republic was financed from government budgets and in 1992 the system was replaced with financing health care via means of health insurance. Since then the hospitals have become financed by receiving payments for procedures from the accounts of public health insurance companies. The hospitals presented their procedures in point system and the value of a point was determined by revenue and expenditure of health insurance companies. Unfortunately, this resulted in hunting for points, unnecessarily prolonging the treatment time in hospitals and indeed to a lack of finances for health care. From 1.1.1997, the Ministry of Health introduced new list of medical procedures, in which the value of the point was directly determined by fixed rates in CZK. In 2007, another major change was introduced and hospitals became financed by so-called flat-rate payments. When setting the amount of a flat-rate payment it was assumed that the vast majority of a hospital's expense is fixed and does not depend on the number of patients or the number of undertaken medical procedures. According to Gladkij et al. (2003), such expenses account for 75% of the total expenditure of a hospital. The amount of a flat-rate was then calculated from the actual cost of the previous year. However, the flat-rate system in financing hospitals brought with it several problems:

- The budget was being increased at a very slow rate on the basis of conciliation with health insurance companies;
- Because the amount of the flat-rate payment was determined on the basis of the financial management of the previous years, the hospitals which managed their finances better were given less and, on the other hand, the hospitals which did not save money were advantaged;
- The patients' right to decide was suppressed as good hospitals with good reputations and a higher quality of care could not receive more patients because their budget was exhausted sooner and, on the other hand, the hospitals without the reputation of good quality had enough money to receive patients without limits. (Gladkij et al., 2003), Kožený, et al., 2010)

A fundamental change in financing hospitals was introduced on 1.1.2012. 75% of hospital care is now financed by payments calculated through Diagnosis Related Groups – DRG. The DRG system classifies groups of patients on the basis of their diagnoses and the relative weight of a given group is set from the estimated values of an average cost. Even though this system, which has been being implemented world-wide since 1962, had been gradually tested in the Czech Republic since 1996, it was no sooner completely introduced in the Czech Republic than in the year of 2012.

Annual health care expenses rose every year and almost quadrupled from 1994 to 2009. Since 2010 the increasing trend has ceased and the expenditure is now around 290 000 mil. CZK. In 1994 there was nil participation of private persons on expenditure in health care, in 2000 the participation rose to 8.6% and since 2008 the proportion of private expenditure in health care has exceeded 15% of the total expenditure. To compare, in 2001, 82.6% of total health care expenditure was covered by public health insurance (it was 83% in 1994) and the proportion of expenditure from public budgets decreased to 8.8% (it was 17% of the total cost in 1994). Based on then up-to-date information, public health insurance accounted for 79% of the total cost in 2013 and the expenditure from state and territorial budgets decreased to 5.7%. (Institute of Health Information and Statistics, 2014). According to the Institute of Health Information and Statistics of the CR (Institute of Health Information and Statistics, 2014), hospital costs account for the largest part of health insurance companies' expenditure. As shown in table 1 (see Tab. 1), it accounts for nearly half of all health insurance companies' expenditure as it fluctuates between 44 – 48%. For example, in 2013 hospital costs equalled to 46.9% of the total expenditure, the costs of institutes for long-term patients 3.9%, costs of general practitioners 6%, costs of stomatological establishments 4.5%, costs of out-patient establishments 27.1%, costs of spa and convalescent homes 0.7%, costs of medical transport services 0.7%, costs of medical emergency services 1%, costs of prescription drugs 15.6%, costs of medical aids 2.7%. The table also shows the expenditure of the health insurance companies in absolute terms, i.e. in mil. CZK.

Tab. 1: A comparison of the Proportions of Hospitals Costs in Health Care Costs Covered by Health Insurance Companies in the CR and Hospitals Health Care Costs Covered by Health Insurance Companies in the CR (in mil. CZK)

	2006	2007	2008	2009	2010	2011	2012	2013
A	44.4	45.2	46.1	45.3	47.7	47.3	46.7	46.9
B	74424	81917	89370	96548	102932	103982	104674	103998

Source of data: Institute of Health Information and Statistics, 2014

A - Proportions of the hospitals costs in health

B - Hospital costs in mil. CZK care costs covered by health insurance companies

At the end of 2013 (Institute of Health Information and Statistics, 2014), there were 29 218 health care establishments registered in the Czech Republic, which is the highest amount in the entire history of the health care system. The largest part of these are Independent out-patient establishments (24 979), the number of which has been slowly and gradually increasing in recent years. The net of health care establishments further consists of 188 hospitals, 239 specialised therapeutic institutes, 368 special health establishments, 24 979 independent out-patient establishments, 3 377 establishments for pharmaceutical services, 19 hygienic services and 48 other establishments.

According to the Institute of Health Information and Statistics of the CR (Institute of Health Information and Statistics, 2015), the situation in the Czech Republic is such that there are 188 accredited hospitals, the largest number (28 hospitals) of which is in the Prague City region, followed by Středočeský region – 25 hospitals and the smallest number of hospitals is Vysočina region – 6 hospitals and in Karlovarský region – 5 hospitals. Regarding to the kinds of hospitals in the regions, Prague City has the largest number of University hospitals – 4 hospitals. The largest number of hospitals providing acute care is in Středočeský region – 21 hospitals, followed by Jihomoravský region – 18 hospitals and Moravskoslezský region – 17 hospitals. The largest number of hospitals of subsequent care is in Ústecký region – 9 hospitals of subsequent care, followed by Prague City – 7 hospitals of subsequent care and by Středočeský region – 4 hospitals of subsequent care.

1.2 Measuring the efficiency of hospitals using the DEA method

Efficiency is a term widely used in economics, commonly referring to the best use of resources in production. Hollingsworth and Peacock describe two types of efficiency in health and health care: technical efficiency and allocated efficiency (Hollingsworth, 2008: 1107-1128). Technical efficiency means reducing the employment of excess inputs. Allocated efficiency means selecting inputs that incur minimum costs (Byrnes, Valdmanis, 1994).

Data Envelopment Analysis (DEA) is one of the frequently used methods to measure the efficiency of hospitals. The DEA method is one of the methods of linear programming developed by Charnes, Cooper and Rhodes (1978: 429-444) that computes efficiency scores for decision making units (DMUs) relative to their peer units. DEA is used to develop an efficiency frontier for the DMUs which operate with optimal performance patterns. These optimally performing DMUs, which are considered as technically efficient, lie on the efficiency frontier and have an efficiency score of 1. DEA has been used by researchers as Ozcan, Harris, Chilingerian, Rosenman to evaluate the efficiency of various organizational forms in the health care industry including hospitals, physicians and health maintenance organizations. Efficiency in DEA is defined as the ratio of the weighted sum of outputs of a trust to its weighted sum of inputs (Jacobs, 2001: 103-115). There are several methods for measuring efficiency, besides the basic DEA models, certain exist. The aim of this analysis is examine DMU into two categories – efficient and inefficient. DMU is efficient if the observed data correspond to testing DMU on the imaginary efficient frontier. Intent of frontier estimation is to deduce the production function in form of efficient frontier. (Staníčková, Melecký, 2016: 176-187). Basic DEA models, primary CCR input/output oriented models (with multiple inputs and outputs), assume constant returns to scale (CRS). In 1984, Banker, Charnes and Cooper suggested a modification of CCR model, which considers variable returns to scale (VRS) (decreasing, increasing or constant) – BCC input/output oriented models (with multiple inputs and outputs). VRS enable to better identify more efficient units. The assumption of VRS provides a more realistic expression of economic reality and factual relations, events and activities existing in countries. (Staníčková, Melecký, 2012: 168-173).

There are some researches focused on hospital efficiency in different regions published in 2016. Campos, et al. (2016: 33-40) studied efficiency of hospitals in 17 regions in Spain with DEA analysis. The results show that there are three groups of regions, first a group composed by six hospitals that are globally efficient, a second group composed by eight hospitals that are globally inefficient and a third group composed by three hospitals that are efficient in some terms and their efficiency can be improved. Wang, et al.

(Toloo, Nalchigar, 2009: 597-604) collected data from a sample of 32 county-level Maternal and Child Health Hospitals in rural areas of China in 16 regions in 2014. Efficiency scores were decomposed into technical, scale and congestion components, and the potential output increases and/or input reductions were also estimated in this model, which would make relatively inefficient hospitals more efficient. Nuti, Ruggieri and Podetti (2016: 1-11) published similar research results. The aim of the research was to investigate how university hospitals perform compared with general hospitals in 10 Italian regions. Regarding these results, performance was not affected by being in the university hospitals rather than the general hospitals group.

2 Methods

The DEA method is commonly used to evaluate the relative efficiency of a number of DMUs. The basic DEA model in Charnes, Cooper and Rhodes (1978: 429-444), called the CCR model, has led to several extensions, most notably the BCC model of Banker et al. (Banker, Charnes, et al., 2004: 345-362) assumes that there are n DMUs, (DMU_j: j = 1, 2, … ,n) which consume m inputs (x_i: i = 1, 2, …, m) to produce s outputs (y_r: r = 1, 2, … ,s). The BCC input oriented (BCC-I) model evaluates the efficiency of DMU_o, DMU under consideration, by solving the following linear program:

Equation:

$$\begin{aligned} &\max \sum_{r=1}^{s} u_r y_{rj} - u_0 && \sum_{r=1}^{s} u_r y_{rj} - u_{0'} - \sum_{i=1}^{m} w_i x_{ij} \le 0, j = 1,2,...n \\ &s.t. \sum_{i=1}^{m} w_i x_{io} = 1 && u_{0,} \, free \\ & && w_i \ge \varepsilon, i = 1,2,....,m \\ & && u_r \ge \varepsilon, r = 1,2,....,s \end{aligned} \tag{1}$$

here x_{ij} and y_{rj} (all nonnegative) are the inputs and outputs of the jth DMU, w_i and u_r are the input and output weights (also referred to as multipliers). x_{io} and y_{ro} are the inputs and outputs of DMU_o. Also, ε is non-Archimedean infinitesimal value for forestalling weights to be equal to zero. In account of the fact that the basic DEA models identify more than one DMU as efficient units, finding the most efficient DMU is an issue.

Amin and Toloo (2007: 71-77) proposed an integrated model for finding most CCR-efficient DMU, as follows:

$$\begin{aligned} &M^* = \min M && \sum_{j=1}^{n} d_j = n - 1 \\ &s.t. M - d_j \ge 0, j = 1,2,....,n && 0 \le \beta_j \le 1, d_j \in \{0,1\}, j = 1,2,....,n \\ &\sum_{i=1}^{m} w_i x_{ij} \le 1, j = 1,2,.... && w_i \ge \varepsilon, i = 1,2,....., m \\ &\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} w_i x_{ij} + d_j - \beta_j = 0, j = 1,2,....n && u_r \ge \varepsilon, r = 1,2,....,s \end{aligned} \tag{2}$$

where d_j as a binary variable represents the deviation variable of DMU_j. DMU_j is most CCR-efficient if and only if $d_j = 0$. The constraint $\sum_{j=1}^{n} d_j = n - 1$ forces among all the DMUs for only single most CCR-efficient unit (Toloo, Nalchigar, 2009: 597-604).

The CCR model is designed with the assumption of constant returns to scale. This means that there is no assumption that any positive or negative economies of scale exist. It is assumed is that a small airport should be able to operate as efficiently as a large one – that is, constant returns to scale. In order to address this, Banker, Charnes, and Cooper

(1984: 1078-1092) developed the BCC model. The BCC model is closely related to the standard CCR model as is evident in the dual of the BCC model:

$$\begin{aligned} &\min(\theta,\lambda)=\theta && Y\lambda = y_0 + s^+ \\ &\theta\chi_0 - x\lambda = s^- && e\lambda = 1 \\ & && \lambda \geq 0, s^+ \geq 0, s^- \geq 0 \end{aligned} \tag{3}$$

3 Results and discussion

This study covers hospitals of all the 14 regions in the Czech Republic, we used data from annual reports published by Institute of Health Information and Statistics of the CR in 2013. In that year there were 188 hospitals. The hospitals are multi-product firms, treating a variety of patients with a variety of inputs. There is no established consensus as to how one should most accurately measure the output of hospital production. (Biørn, 2003: 271-283).

The following inputs and output criteria were chosen for the DEA analysis of the regions: the number of hospitalized patients in the year 2013 as the output, the following three indicators, all for the year 2013, as inputs: operating costs in mil. CZK, number of beds, number of physicians

We took into account theses hospital costs: drugs, medical devices, blood and blood products, food, energy consumption, services, personnel costs and depreciation. All the inputs and output are in the table 2.

Tab. 2: Inputs and output Data for DEA Model

	Output	Inputs		
Region	Number of hospitalised patients	Operating costs in mil. CZK	Number of beds	Number of physicians
Hospitals of Prague City	341 743	30475.411	9091	1865.59
Hospitals of Středočeský region	205 590	7383.61	5634	998.59
Hospitals of Jihočeský region	128 779	5624.304	3171	565.28
Hospitals of Plzeňský region	115 843	6427.262	3320	608.76
Hospitals of Karlovarský region	54 017	1844.7	1372	245.58
Hospitals of Ústecký region	174 974	6736.289	4873	711.04
Hospitals of Liberecký region	88 601	4216.842	2454	431.63
Hospitals of Královéhradecký region	106 805	7324.744	3286	575.97
Hospitals of Pardubický region	89 155	3359.104	2500	481.72
Hospitals of Vysočina region	101 038	3686.512	2495	437.99
Hospitals of Jihomoravský region	260 621	15987.992	7156	1552.46
Hospitals of Olomoucký region	128 597	7233.99	3019	680.39
Hospitals of Zlínský region	113 895	4173.26	2598	499.56
Hospitals of Moravskoslezský region	246 868	13213.768	5838	1184.85

Source: own

Online software for the calculation of Data Envelopment Analysis was used, which is available on DEAOS websites.

Taking into consideration the entire sample of researched hospitals we can describe them as follows. Table 3 depicts the minimum, maximum, mean and standard deviations of each researched input and output.

Tab. 3: Description of researched hospital sample

Name	Minimum	Maximum	Mean	Standard Derivation
Operating costs in mil. CZK	1844.7	30475.411	8406.2706	7131.1681
Number of physicians	245.58	1865.59	774.2436	447.9883
Number of beds	1372	9091	4057.6429	2088.0845
Number of hospitalized patients	54017	341743	154037.5714	78466.5434

Source: own

In our analysis we used input-based measures of efficiency. The choice of the specific DEA model depends on which of the given characteristics can be influenced and which cannot. Due to the fact that the number of hospitalized patients can hardly be influenced, the input oriented model was chosen. The results of the efficiency DEA analysis are presented in Table 6. In the CCR – I model, such weights are sought so that coefficient of technical efficiency was within the interval of $\leq 0,1 \geq$. A unit with a coefficient of technical efficiency equal 1 is efficient, a coefficient lower than 1 shows that a unit is not efficient and determines the extent to which inputs need to be decreased to ensure the unit becomes efficient. From the interpretation point of view, a hospital with an efficiency value of 100 % can be considered as efficient, therefore the hospitals in four regions can considered to be efficient. The table 4 depicts efficiency of individual regions.

Tab. 4: DEA results - input oriented (CCR-I) model

Region	Efficiency	Ranking
Hospitals of Karlovarský region (KVR)	100 %	1
Hospitals of Ústecký region (UR)	100 %	1
Hospitals of Zlínský region (ZR)	100 %	1
Hospitals of Vysočina region (VR)	100 %	1
Hospitals of Jihočeský region (JCR)	98 %	2
Hospitals of Olomoucký region (OR)	97.2 %	3
Hospitals of Moravskoslezský region (MR)	96.5 %	4
Hospitals of Středočeský region (SR)	95.1 %	5
Hospitals of Pardubický region (PDR)	90.6 %	6
Hospitals of Liberecký region (LR)	88 %	7
Hospitals of Prague City (PGR)	85.7 %	8
Hospitals of Jihomoravský region (JMR)	83.1 %	9
Hospitals of Plzeňský region (PZR)	82.5 %	10
Hospitals of Královéhradecký region (KHR)	79.4 %	11

Source: own

One of the main benefits of the DEA analysis is that it allows for comparing the individual units and that the number of inputs can be altered in order for the less efficient units to reach the position of the most efficient unit in the researched sample. Table 5 shows the target values for all regions which did not reach 100% efficiency. These are values that would ensure, if reached, that the given region would get to the same position as the most efficient regions, which are the hospitals of Karlovarský, Ústecký, Vysočina and Zlínský

regions. As was mentioned earlier, the output presented by the number of hospitalized patients can hardly be influenced, the possible improvements are therefore directed towards inputs. In general, in this particular model, while reducing the costs, it is also necessary to reduce the number of physicians and the number of beds.

Tab. 5: Improvements for the hospitals in the regions

	Inputs			Output
Region	**Operating costs in mil. CZK**	**Number of physicians**	**Number of beds**	**Number of hospitalised patients**
Hospitals of Prague City	30475.411 to 12521.905	1865.59 to 1498.93	9091 to 7795.323	341743 to 341743
Hospitals of Středočeský region	7383.61 to 7020.973	998.59 to 934.68	5634 to 5221.865	205590 to 205590
Hospitals of Jihočeský region	5624.304 to 4781.296	565.28 to 553.96	3171 to 3107.525	128779 to 128779
Hospitals of Plzeňský region	6427.262 to 4279.781	608.76 to 502.00	3320 to 2737.78	115843 to 115843
Hospitals of Karlovarský region	1844.7 to 1844.7	245.58 to 245.58	1372 to 1372	54017 to 54017
Hospitals of Ústecký region	6736.289 to 6736.289	711.04 to 711.04	4873 to 4873	174974 to 174974
Hospitals of Liberecký region	4216.842 to 3297.38	431.63 to 379.77	2454 to 2159.19	88601 to 88601
Hospitals of Královéhradecký region	7324.744 to 3977.301	575.97 to 457.38	3286 to 2609.437	106805 to 106805
Hospitals of Pardubický region	3359.104 to 3044.675	481.72 to 405.33	2500 to 2264.485	89155 to 89155
Hospitals of Vysočina region	3686.512 to 3686.512	437.99 to 437.99	2495 to 2495	101038 to 101038
Hospitals of Jihomoravský region	15987.992 to 9549.49	1552.46 to 1143.12	7156 to 5944.891	260621 to 260621
Hospitals of Olomoucký region	7233.99 to 4711.96	680.39 to 564.04	3019 to 2933.36	128597 to 128597
Hospitals of Zlínský region	4173.26 to 4173.26	499.56 to 499.56	2598 to 2598	113895 to 113895
Hospitals of Moravskoslezský region	13213.768 to 9045.563	1184.85 to 1082.79	5838 to 5631.178	246868 to 246868

Source: own

Conclusion

The aim of this paper was to find out whether the set health politics in individual regions of the Czech Republic is efficient, which regions are more efficient in utilizing their potential and financial resources in their hospitals and, on the other side, which regions are

less efficient. Using the DEA analysis, the following inputs were analysed - operating costs, the number of physicians and the number of beds together with one output – the number of hospitalized patients. The analysis revealed four of hospitals of the regions are efficient (Karlovarský, Ústecký, Vysočina and Zlínský). The level of efficiency in other regions varies between 79,4 % and the above-mentioned 100%. The hospitals of Královéhradecký region shows he worst result. Looking at the structure and the number of hospitals in the regions, we cannot see any significant correlation so we cannot say that efficiency is correlated to the number or structure of hospitals in any given region.

The results of this research were compared with the results of studies by Halkos and Tzeremes (2011: 73-82). We can conclude that the results were confirmed. According to the results of the research, the higher the level of GDP per capita does not ensure higher efficiency in the provision of health care (see Table 6). Considering the GDP per capita marker, all the regions rank as average or under average, the Karlovarský region is even the region with statistically the lowest GDP per capita in the Czech Republic. Contrary to studies of Halkos and Tzeremes (2011: 73-82) a positive influence of population density on health care efficiency was not unequivocally confirmed. The Ústecký and Zlínský regions belong among the more densely populated regions, while the Karlovarský and Vysočina regions belong amongst the less populated regions. A specific situation occurs in Prague City. Even though this region represents the most populated region with the highest GDP per capita, it belongs among the least efficient region from a health care point of view. This is logically explained by the fact that the highly specialised and highly expensive care for all citizens of the Czech Republic is located and offered here.

Tab. 6: GDP per capita and Population density in individual regions in 2013

Rank	Region	GDP per capita (CZK thousand)	Rank	Region	person/km^2
1	PGR	816.4	1	PGR	2505.7
2	JMR	381.0	2	MR	225.0
3	PZR	359.6	3	JMR	162.6
4	SR	345.2	4	UR	154.7
5	KR	338.5	5	ZR	148.3
6	JCR	330.8	6	LR	138.6
7	ZR	329.4	7	OR	120.8
8	VR	327.2	8	SR	118.2
9	MR	326.0	9	KHR	116.0
10	PDR	312.9	10	PDR	114.2
11	LR	303.2	11	KVR	90.6
12	UR	298.0	12	PZR	75.8
13	OR	296.9	13	VR	75.1
14	KVR	277.3	14	JCR	63.3

Source: Czech Statistical Office, 2014

Karlovarský region (KVR), Ústecký region (UR), Zlínský region (ZR), Vysočina region (VR), Jihočeský region (JCR), Olomoucký region (OR), Moravskoslezský region (MR), Středočeský region (SR), Pardubický region (PDR), Liberecký region (LR), Prague City (PGR), Jihomoravský region (JMR), Plzeňský region (PZR), Královéhradecký region (KHR)

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