

# Evaluation of Czech Hospitals Performance Using MCDM Methods

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**Abstract—** Regarding health care systems of the EU Member States, the funding and providing of health services are primarily in their competence. In the Czech Republic the health care system is a significant consumer of public expenditure. This system is based on the principle of solidarity. In general, citizens contribute to the health insurance fund according to their capabilities and receive health care according to their needs. State subsidies play an important role in order to ensure the functioning of health care system. Therefore, it is important to examine the performance of healthcare providers in order to regulate the amount of money provided by state.

In the paper the performance of selected segment of hospitals is compared using several Multiple Criteria Decision Making (MCDM) methods. The aim is to identify the best and the worst performing hospitals in analysed years based on selected set of financial indicators.

**Index Terms—** hospitals, MCDM, performance

## I. INTRODUCTION

THE financial health of hospital is often considered as crucial in terms of the healthcare financing system. In both Central and Eastern Europe, an economic transition has occurred in recent years, which has significantly changed the conditions of hospital operations [11]. Hospitals play an important role in the health care system of each country. Bed care in hospitals consumes significant amount of funding. Both quality and availability of provided services can be effectively guided by keeping the financial balance.

Reduction of financial resources may disrupt this balance and result in the decrease in the quality of services provided.

In the Czech Republic, the health care system consumes significant part of state budgeted (see Table I). Nevertheless, only small attention is paid to monitoring hospital performance. From this point of view, the looking for examples of good practice is an important task that can help to set more economical allocation of state resources – by lowering the amount of state expenses consumed by hospitals without, of course, lowering the level of patients' treatment.

Modelling financial situation is often done by using models that predict financial distress. There is a whole range of such models including e.g., basic Altman model [1] with later alterations, Zmijewski model [14] or IN index (see, e.g. [9]) designed for the specific market of Czech companies. Above mentioned models were originally built using business data from various industries - agriculture, manufacturing, construction, etc. Data from different economies and from different time periods have been used for their construction.

The universal model for the health and social care sector has not been clearly defined yet, therefore the models that have been developed for different fields of industry are usually used. Comparing the performance of hospitals based on models predicting financial distress was presented e.g., in Hajdíková and Váchová [4].

The aim of this paper is to compare selected set of Czech hospitals with respect to their performance using the financial health indicators and set of MCDM approaches.

TABLE I  
TOTAL HEALTH EXPENDITURE (IN MILLIONS OF CZK) IN YEARS 2010 – 2014

	2010	2011	2012	2013	2014
<b>Public expenditure</b>	243 281	242 410	246 918	246 562	254 683
<b>Private expenditure</b>	45 754	45 358	46 388	45 573	45 224*
<b>Total expenditure</b>	289 035	287 768	293 306	292 135	299 907
<b>% of GDP</b>	7,3	7,2	7,3	7,1	7,0

\*preliminary data

Source: Institute of Health Information and Statistics of the Czech Republic [6]

This work was supported in part by GAČR (Czech Science Foundation) under grant no. 15-00215S.

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## II. DATA DESCRIPTION AND METHODOLOGY

In the paper data from the time period 2012 – 2014 were used. The total number of hospitals in the Czech Republic does not differ significantly in given years. In 2014 the total number of hospitals was 189, but in 2012 and 2013 it was 188 [12].

Secondary data used for the analysis were collected from

financial statements of individual hospitals. These includes balance sheets and income statements. Moreover, the annual reports of hospitals were used as well. Documents are available on websites of selected hospitals and websites of the Ministry of Finance of the Czech Republic – the database of economic subjects ARES [8].

The complete data needed for analysis were obtained only for limited number of hospitals. Therefore, in the following sections, the analysis is performed on the set of 29 hospitals.

#### A. Financial Indicators

From the data about selected group of hospitals we calculated set of four indicators (I1 – I4) that were later used in computations. Overview of these indicators is presented in Table II. This set of four concrete indicators was identified and selected based on [3] and [2].

TABLE II  
INDICATORS USED IN MCDM METHODS

Indicator	Meaning	Description
I1	EBIT/operating income	The impact of the cost structure (ROS)
I2	(Net profit + depreciation) / total debt	EAT to total debts
I3	Operating income (sales) / total assets	Activity indicator
I4	Cost of employee benefits / operating income (sales)	Wage productivity

This group of indicators allows to include into performance evaluation varied sections of usually used financial analysis and it also reflects different legal forms and organizational forms of hospitals under consideration. The values of indicators I1 – I4 were used in the next section for identification of best performing hospital using selected MCDM methods.

#### B. MCDM Methods

MCDM methods represent the way how to make choices in case that multiple criteria are present. In many real-life problems more than one criterion is observed and evaluation of such problems requires application of MCDM approaches. There are different categories of MCDM methods. In preference oriented problems either the best alternative is selected or all the alternatives are ranked from the best alternative to the worst one. Another approach considers assigning alternatives to predefined categories (see e.g., [10]).

In the paper we use four MCDM methods for preference oriented problem of creating the ranked list of hospitals. Namely, they are a simple sum of a sequence, a scoring method and a method of standardized variables [7]. Finally, we included into analysis also results of TOPSIS method.

##### Simple sum of Sequence

Using simple sum of sequence, the units (for example hospitals) are ordered for each criterion based only on a value that they reach for given criterion. The alternative with the best value in particular criterion is given the first

position, the second in order is assigned the second position, etc. In this way all alternatives are ordered based on values of each criterion. After that the values assigned to each alternative are summed up over all criteria. Based on the total sum, the result rank is created. The lower the sum, the better the position of alternative in aggregate order.

##### Scoring Method

In scoring method, the alternative that reaches the best value of particular criterion is assigned 100 points. Points for the rest of alternatives are assigned based on their comparison with the best alternative. Alternatives are evaluated for each criterion, and then the values for each alternative are summed up. The higher the sum, the better the result of given alternative.

##### Method of Standardized Variables

Method of standardized variables includes the computation of standardized variables that differs based on type of criteria. The formulas for standardized variables in case of benefit and cost criterion are given in (1) and (2), respectively.

For benefit criteria (the higher value of criterion is preferable):

$$v_{ij} = \frac{(x_{ij} - x_{aj})}{\sigma} \tag{1}$$

For cost criteria (the lower value of criterion is preferable):

$$v_{ij} = \frac{(x_{aj} - x_{ij})}{\sigma} \tag{2}$$

where  $v_{ij}$  is standardized variable of j-th criterion (indicator) for i-th alternative (hospital),  $x_{ij}$  is value of j-th criterion for i-th alternative,  $x_{aj}$  is arithmetic mean calculated from the values of j-th criterion and  $\sigma$  is standard deviation calculated from the values of j-th criterion. The values of standardized variables for each alternative are then summed up over all criteria and aggregate ranking is obtained based on the total sum.

##### TOPSIS

The Technique for Order Preference by familiarity to Ideal Solution (TOPSIS) is a method that ranks the alternatives based on their distance from ideal and basal alternatives [5].

The use of classical TOPSIS method to evaluate hospitals was presented in details in Váchová and Hajdřková [13]. In this paper only some results from above mentioned application of TOPSIS method are involved as part of analysis of hospital performance.

### III. RESULTS AND DISCUSSIONS

How the position of hospitals changed in the list of analysed objects in selected years is presented in Table III. Moreover, the last column of Table III shows the aggregate ranking of hospitals based on their positions in years 2012-2014. The aggregate ranking was again set by using the

method of simple sum of sequence.

Based on the above mentioned methods we were able to identify the best performing hospitals, as well as the worst performing ones. But the deeper analysis is definitely needed in order to understand what the cause of their positions in the ordered list of hospitals actually is. We have looked for some similarities in the group of hospitals at leading positions, as well as in the set of hospitals that occupied the bottom positions in the analysis.

The hospitals in the first three positions, which are characterized according to the established criteria by the efficiency leadership, have several common features. All hospitals are located in regional cities in the Czech Republic. In České Budějovice and Hradec Králové there are 93 thousand residents, in Ostrava 292 thousand residents. Ostrava and Hradec Králové are university cities with universities preparing new doctors - the examined hospitals are faculty hospitals. Hospitals are owned by the region and the Ministry of Health of the Czech Republic. All hospitals in these first three positions contain basic

departments - internal, pulmonary, pediatric, infectious, oncological, gynecological, surgical, orthopedic, urological, ocular and central health workplace. The similarity of these hospitals also occurs in some additional characteristics - these are e.g., the average number of beds, the average number of doctors and the average number of hospitalizations in the survey period (see Table IV).

Hustopeče hospital and Tišnov hospital in the last two positions are located within 30 km range from the regional city of Brno. There are 6000 inhabitants in Hustopeče and the hospital is owned by the South Moravian Region. This hospital has two departments - internal nursing care and basic outpatient care, with total number of 120 beds. Tišnov Hospital is located in a town with 9000 inhabitants, it has 95 beds and it is a hospital for the treatment of long-term patients. Other basic departments are outpatient. Tomas Bata Hospital in Zlín was placed on the third from the end position. Zlín is a regional town with 75000 inhabitants. In this hospital there are all basic departments and auxiliary facilities. The hospital is owned by the county. Overall, it

TABLE III  
RANKING OF HOSPITALS IN SELECTED YEARS, TOGETHER WITH TOTAL RANKING

Hospital	2012	2013	2014	Rank
ALMEDA a.s Neratovice	1	1	19	5
Oblastní nemocnice Kolín, a.s.	6	13	2	5
Jindřichův Hradec	22	17	20	21
České Budějovice	2	4	1	1
nemocnice Český Krumlov	10	6	12	7
Prachatice	7	4	8	4
Strakonice	15	19	17	17
Tábor	11	9	10	9
Domažlická nemocnice, a.s.	18	21	14	19
Klatovská nemocnice, a.s	24	15	4	13
Nemocnice následné péče LDN Horažďovice, s.r.o.	19	8	13	12
Nemocnice Sušice o.p.s.	8	23	29	22
Rokycanská nemocnice, a.s.	9	6	21	10
Stodská nemocnice, a.s	14	10	24	15
Nemocnice Kadaň s.r.o	17	28	16	24
Česká Lípa	26	24	15	26
Hradec Králové	4	3	11	3
Jesenická nemocnice	13	18	7	11
Fakultní nemocnice Ostrava	5	2	6	2
nemocnice Boskovice	3	20	5	7
Nemocnice Milosrdných bratří Brno, p.o	20	14	26	22
Tišnov p.o	27	24	27	28
Městská nemocnice Hustopeče	28	29	28	29
Krajská nemocnice T.BATI, a.s.	29	26	18	27
Kroměřížská nemocnice a.s.	23	26	3	18
Vsetínská nemocnice, a.s.	25	22	8	20
nemocnice Havlíčkův Brod, p.o	21	16	25	25
nemocnice Jihlava p.o.	15	12	23	16
nemocnice Pelhřimov, p.o	12	10	21	13

has very similar characteristics with hospitals in the first three positions.

Results shows that hospitals at leading positions are situated in areas of higher population density. These are hospitals with a basic and wider range of departments, providing the necessary number of beds, doctors, and the possibility of hospitalizing a larger number of patients. All the better performing hospitals are owned by regions in the Czech Republic with the possibility of their financial support.

TABLE IV  
BEST PERFORMING HOSPITALS WITH AVERAGE  
VALUES OF NON-FINANCIAL INDICATORS

Hospital	Beds	Doctors	Hospitalizations
České Budějovice	1450	508	54200
Ostrava	1100	510	46400
Hradec Králové	1370	590	41800

The question arises about whether and how the position of hospitals would change when some non-financial indicators are included in the analysis and whether all indicators should have the same weights. Another question remains whether hospitals can be grouped into segments with the same set of parameters.

#### IV. CONCLUSIONS AND FUTURE RESEARCH

Looking for what is the actual cause of better performance of hospitals in such a specific sector as health care system is not an easy task. In the paper we presented process of evaluation of segment of hospitals in the Czech Republic using the set of MCDM methods on financial indicators. The advantage of these methods is their computational simplicity. But with involvement of some non-financial indicators, their applicability may become potentially problematic. Given this problem, the question of looking for more advanced methods for identification of cause of performance appears.

Limitation of the performed analysis stems undoubtedly also from the data matrix. So far we were able to collect complete data only about segment of total number of hospitals in the Czech Republic. Therefore, our work will now focus on steps to complete the database and provide comparison of performance of larger set of hospitals.

In further research, we aim to perform a cluster analysis to divide hospitals by the same characteristics. In addition, we aim to compare the situation of Czech health care system performance with performance of hospitals in other comparable states in Central Europe (namely, Republic of Poland and Slovak Republic).

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