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EVALUATION OF TECHNICAL EFFICIENCY IN FINANCIAL DIMENSION OF PRIVATE MEDICAL ENTITIES IN PODKARPACKIE VOIVODSHIP – DEA APPROACH

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Abstract The major aim of this paper is to assess technical efficiency of private medical entities. Technical efficiency refers to the capacity of a medical entity to obtain the maximum output for a particular set of inputs. The article presents results of research study on technical efficiency of 33 medical entities using the Data Envelopment Analysis method (DEA) which allows the use of multiple inputs/outputs without imposing any functional form on data or making assumptions of inefficiency. The research study was carried out in years 2011-2016 on medical entities from Podkarpackie voivodship. The analysis was conducted based on the CCR input-oriented model.

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Introduction

Efficiency is both fundamental and universal category used to evaluate performance – the application is not limited only to economics but it can be expand to other fields of human activity. Furthermore, it is constantly examined and investigated. Nonetheless, the understanding of efficiency as a concept remains ambiguous.

Studies into the subject-matter literature have revealed a wide spectrum of possibilities of how efficiency can be defined and interpreted and they reveal different concepts concerning its substance. The multidimensional aspect of the term translates into different approaches that can be found in the literature as to how economic efficiency is identified and how its measures are applied (Opolski et al., 2018).

One of the most important principles in any business is the principle of efficiency; where the best possible economic effects (outputs) are attained with as little economic sacrifices as possible (inputs). Efficiency can be defined as the demand that the desired goals are achieved with the minimum use of the available resources (Martić et al., 2009, p. 37).

For many years the word “efficiency” has already been used in connection with human activity: it is the effect of rationality inherent in managing limited resources. Economically, efficiency is about using available yet limited resources, a situation so typical to the world around us. The notion acquires a special meaning if we consider limited resources in the healthcare sector (Opolski et al., 2018).

That’s why, public and private medical entities, being part of the healthcare system, are facing an growing pressure to improve efficiency. Moreover, observing increasing demand for health services – as an outcome of changes of population ageing, determining the efficiency of medical entities is significant and very much relevant challenge to decision-makers in the healthcare sector. Nevertheless, the assessment of medical entities efficiency is not trivial.

Research on efficiency in the area of healthcare has growing interest of authors around the world (Maniadakis et al., 1999; Kontodimopoulos & Niakas, 2005; Maniadakis & Thanassoulis, 2000; Rebba & Rizzi, 2006; Hollingsworth, 2003; Hollingsworth & Parkin, 2001; Jacobs et al. 2013, Ozcan & Cotter, 1994) and for the same time in Poland (Rój, 2011; Żółtaczek, 2014; Wardzińska, 2012). The vast majority of research studies relates to publications from the area of public healthcare. Research in the area of private health care is much less coveredso it is possible research gap.

The aim of the study is to evaluate technical efficiency (in area of financial dimension) for the 33 private medical units from Podkarpackie voivodship. Assessment of efficiency can be done using parametric and non-parametric methods. Presented research study was done using non-parametric approach.

In area of non-parametric approaches, well known tool to evaluate efficiency of healthcare providers is Data Envelopment Analysis (DEA). The basic idea behind DEA is to determine a best practice frontier of efficient Decision Making Units (DMUs) that envelops all inefficient DMUs. An efficiency value can be assigned to every DMU by measuring the distance to the frontier (Kohl et al., 2019, p. 245).

The paper is divided into three sections. Firstly, it is mentioned the literature review of application DEA method in health sector regarding efficiency. Second section is dedicated to the used data and method. Last section indicate results, discussion and conclusion remarks as well.

Literature review

Effectiveness in health care is most often defined as: "[...] a measure of the costs that make up the care or the inputs used to achieve its specific level". What does the relation between inputs (e.g. costs in the form of labor, capital) and intermediate outcomes (e.g. number of cured patients, waiting time for treatment, etc.) mean the relation between the final outputs (e.g. the index of extended life years) (Owczarek & Suchecka, 2011 , pp. 79-80).

Decision Making Units use various production factors, such as labor or capital, and produce valuable products such as improved health or patient satisfaction. Table 1 provides a matrix of the different dimensions of performance that can be assessed within the health sector. Technical efficiency is related to the production of a certain number of health services (outputs) with the least possible amount of expenditures (inputs). Allocative efficiency considers patient preferences during distributing healthcare services ensuring that health benefits are maximized. Expressing the value of expenditure in monetary units leads to the assessment of effectiveness in the cost dimension. It consists in producing a given number of services at the lowest possible cost or maximizing the number of services provided at given costs. If a given DMU purchases certain resources at prices, not higher than the market prices, and achieves technical and allocative efficiency, it means that it operates cost-effectively.

Table 1: Matrix of the different dimensions of efficiency

	Dimensions of efficiency		
	Technical efficiency	**Allocative efficiency**	**Cost efficiency**
Definition	The difference between the stated level of services provided by the entity and its actual service capabilities.	The ability of an entity to use the optimal set of inputs, taking into account their price and the production technology used.	The quotient of the smallest cost by the actual cost incurred by a given entity.
Goal	Effectiveness of the entity transforming inputs into effects.	Maximizing results for a given cost level or minimizing costs for a given service level.	Technological and allocative efficiency are general determinants of cost-effectiveness.

Source: based on: Rój, J. (2011), pp. 150-151.

Efficiency can be considered by using three approaches: indicators, parametric and non-parametric methods (Kosmaczewska, 2011, p. 132). However, the most popular method of estimating the multi-criteria efficiency of the health sector is the non-parametric DEA method. Wardzińska (2012) made a review of the literature on using parametric SFA and non-parametric DEA methodologies. Her results show much less interest in the SFA method than in the data envelopment analysis. Publications linked with the stochastic marginal analysis featured in all literature databases examined by the author six times less frequently. On average, the SFA method was mentioned in ca. 17% of the cases compared to the references to the DEA method. According to the studies conducted by Kisielewska (2005), DEA is the most popular in Poland (6 out of 8 studies). Tavares (2002) collected the literature on the DEA method for the years 1978–2001 and found over 3,200 publications in the reviewed research journals, which publish empirical results of studies and methodological aspects connected with the DEA (Tavares, 2002), which is simple and flexible in its structure and thus enables comparing various inputs and outputs without making additional assumptions as is the case of parametric methods (Kudła, 2006).

Stefko et. al, 2018 assumes that many authors prefer the application of DEA methods due to several advantages like simultaneous use of multiple inputs and it does not require a mathematical specification of the production function it is most appropriate to investigate the impact of exogenous variables suggests recommendations for an inefficient production unit.

The DEA method is widely used to measure the efficiency of both, public and private sector entities. It is used, among others, to assess the efficiency of cities, hospitals, libraries and universities (Nazarko et. al.; 2008, s. 94). Initially, the research was limited only to estimating the cost function or production. Recently, more creative ways have emerged in the area of using efficiency analysis. This include issues such as changing productivity over time and the impact of ownership and institutions on efficiency (Jacobs et al. 2013, s. 28).

The DEA method can be applied to various levels of health care, starting from the healthcare system as a whole (to compare countries) (Banneyan et al. 2007; Puig-Junoy 1998a,), through regions (Ozcan & Cotter 1994), hospitals (Linna & Häkkinen, 1998; Grosskopf & Valdmanis 1987; Fragkiadakis et. al, 2014), hospital wards (Puig-Junoy 1998b; Hollingsworth & Parkin 2001), to doctors (Chilingerian 1994).

Literature study point to the wide application of the DEA method in examining the efficiency of the healthcare sector. In Poland, the DEA method was implemented firstly in the second half of the 90s. In Polish scientific research Żółtaczek (2014), Łyszczarz (2014) and Rój (2011) evaluated the efficiency of healthcare systems (understood as a whole). Żółtaczek (2014) compared health care systems on the example of 26 EU countries assuming following inputs: the number of doctors per 100,000 inhabitants and the share of public expenditure on health care in the country's GDP and

output: expected life expectancy. In turn, Łyszczarz (2014) evaluated 23 health care systems of OECD countries by developing the following selection of variables in the model of technical efficiency of health care systems: inputs - the number of practicing physicians per 1000 inhabitants, the number of practicing nurses per 1000 inhabitants, the number of beds for short-term hospital care per 1,000 inhabitants, healthcare expenditure as a percentage of GDP (% of GDP). The outputs includes the following variables: life expectancy rate for women 0 years (years), life expectancy rate for men 0 years (years), life expectancy rate for women 65 years (age), indicator life expectancy of men aged 65 (years), an instrumental indicator based on premature mortality of women, an instrumental indicator based on premature mortality of men. Rój (2011) assessed the efficiency of healthcare systems in 18 EU countries, taking into account in inputs, among others: expenditure on healthcare per capita according to purchasing power parity, sulfur oxide emissions (in t) and carbon dioxide emissions (in t). The expected number of years of life at birth was adopted as output.

Literature studies of Polish scientific research have also shown the use of the DEA method at a lower levels. The efficiency analysis at the level of subregions was carried out by Łyszczarz (2009), and at the level of provinces was carried out by Kujawska (2013) and Łyszczarz (2010).The most polish studies are focused at regions, especially voivodships (Kujawska, 2013; Łyszczarz, 2009). DEA method was also implemented to medical entities of public healthcare sector (Podgórska, 2018; Rój 2011). However, it can be observed in Poland limited number of efficiency studies at entities level both at public and private sector. Generally, there is a lack of implementing this method to private sector entities.

Data and method

In this paper was estimated technical efficiency (in financial term) of 33 private medical entities using DEA approach- a input-oriented model with fixed economies of scale. The production function was determined and the relative technical efficiency values were estimated. Data were collected from the National Register of Court for Podkarpackie voivodship for period 2011-2016. These private medical entities are also working under agreement with National Polish Fund. Financial data were gathered from the annual reports of private medical entities, access to the data of this kind of entities is limited. As an input (i) operational costs of medical entities were included, simultaneously as an output (o) operating profits were counted in.

In research study Data Envelopment Analysis method was adopted. The most popular methods of estimating multi-criteria efficiency in the case of the health care sector are: DEA and SFA method, with the quantitative predominance of DEA approach due to it simple and flexible structure, allowing for the comparison of various inputs and outputs, without additional assumptions, which are characterized by parametric methods.

At the end of the seventies of the last century, Charnes, Cooper and Rhodes (1978) recommended a non-parametric method Data Envelopment Analysis, commonly known as DEA. In their pioneer work, they have introduced the term Decision Making Unit (DMU for short), defining the decision maker for each unit in the study. The method, initially considered to be competitive with parametric proposals for the assessment of effectiveness, quickly gained recognition, especially in the case of assessing the effectiveness of service and non-profit entities.

DEA is a non-parametric approach presented in 1978 by Charnes et al. (1978), although its roots may be found as early as 1957 in Farrel's seminal work (Farrell 1957) or even to Debreu's, which introduced in the early fifties the "coefficient of resource utilisation" (Debreu, 1951).

The input-oriented objective function of the nonlinear CCR model for the tested DMU remains reduced to the following equation:

$$Q_o = \max \frac{\sum_{r=1}^{s} u_r \, y_{ro}}{\sum_{i=1}^{m} v_i \, x_{io}}$$

All were developed as modifications to the basic CCR model (short for the first letters of the names of the authors of the method, Charnes, Cooper and Rhodes), the input-oriented version of which is discussed below. This model is a nonlinear (quotient) programming problem, which can be reduced to a linear problem. Determining the level of efficiency of a given DMU consists in solving the related decision-making task. Therefore, there are as many tasks as there are objects (Domagała, 2007). The tested DMU is marked with the index o. The following designations have been adopted:

Q_0 – the efficiency indicator of the o-th object.

0 – index denoting the examined Decision Making Unit, $1 \leq o \leq n$, n – the number of DMUs, (j= 1, ..., n),

s – the number of produced outputs, (r = 1, ..., s),

m – the number of inputs, (i= 1, ..., m),

u_r – decision variable; weight of the r-th output,

v_i – decision variable; weight related to the i-th input,

y_{rj} – size of the r-th output of the j-th object,

x_{ij} – size of the i-th input of the j-th object.

According DEA approach, DMU is effective when the efficiency score is at 100% (or 1). Efficient entities whose technical efficiency (in financial dimension) amounted to 100% were identified. It means that in their case there is no more effective combination of expenditures to achieve the same outputs. Entities whose technical efficiency amounts to 100% are considered efficient and constitute a benchmark (in the context the inputs consumed to outputs achieved) in relation to entities operating inefficiently. In efficient DMU's can find what combination of inputs and outputs will give the optimal solution for selected number of units.

Results and discussion

The search for efficiency in the area of healthcare is an extremely important issue. Especially in the context of assessing the effectiveness of health systems in different countries, as well as the medical entities operating in them, public and private as well. The conclusions obtained as a result of conducted (global and national) studies provide valuable information for decision makers of the health care system. They also very often indicate the achievable effects and areas of savings, as well as the factors that have the greatest impact on the effectiveness of entities operating in the system.

The scores of technical efficiency (in financial dimension) for selected DMU's is presented in Table 2. The least efficient entities in the are those marked with numbers 15 and 22. Entities whose efficiency was equal to 100% in all the years under research study are marked with numbers 9 and 21. Inputs included: operational costs and outputs included: operational profit. As is the case with the CRS, it is possible to obtain information on the optimal operating costs for the medical private entities identified as inefficient.

Table 2: The scores of technical efficiency (in financial dimension) for selected DMU's

DMU/Year	2011	2012	2013	2014	2015	2016	2017	Average
1	96.5	97.5	97.7	96.6	95.8	96.4	95.9	**97**
2	94.4	95.8	89.8	94.6	95.9	97.8	96.2	**95**
3	91.1	97.7	99.9	98.9	91.4	97.3	93.1	**96**
4	89.8	97.8	89.2	96.2	94.4	87.1	95.1	**93**
5	97.6	97.9	99.1	98.2	97.4	96.2	94.5	**97**
6	96.0	95.4	97.1	94.4	95.3	97.1	96.1	**96**
7	96.5	84.2	89.1	98.1	97.1	87.1	97.3	**93**
8	88.2	88.4	93.0	88.6	90.0	91.0	96.2	**91**
9	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100**
10	89.6	94.6	96.9	94.2	94.0	94.0	94.1	**94**
11	88.7	92.1	93.4	95.0	92.0	82.0	76.2	**88**
12	91.4	92.7	99.4	99.0	96.0	97.0	92.0	**95**
13	86.2	87.5	75.1	95.2	92.0	92.0	95.2	**89**
14	92.2	98.0	99.5	94.0	97.0	96.0	96.2	**96**
15	83.0	85.5	89.2	90.7	87.0	87.0	73.2	**85**
16	93.7	96.6	96.0	92.0	93.0	92.0	76.2	**91**
17	84.4	90.8	89.3	96.8	90.0	90.0	86.3	**90**
18	82.7	82.3	90.8	96.2	87.0	87.0	74.4	**86**
19	94.6	93.4	95.1	93.7	94.0	94.0	96.3	**94**
20	95.6	92.1	98.0	97.2	92.1	97.1	94.3	**95**

21	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100**
22	95.6	93.4	95.1	93.7	94.0	94.0	96.27	**81**
23	93.9	96.6	97.0	92.6	91.5	96.0	92.1	**94**
24	84.4	90.8	89.3	96.8	73.0	83.0	93.0	**87**
25	80.8	82.3	90.8	96.2	93.0	82.3	84.5	**87**
26	95.4	93.4	95.1	97.8	92.3	93.0	76.5	**92**
27	92.7	92.4	97.4	93.7	98.0	95.2	93.0	**95**
28	94.6	95.5	87.4	89.4	94.5	93.0	93.4	**93**
29	92.3	83.4	67.8	78.9	91.4	91.2	95.2	**86**
30	82.5	93.4	85.4	93.7	93.0	94.5	97.9	**91**
31	78.9	79.5	98.3	87.6	96.7	93.0	93.0	**90**
32	74.4	85.0	96.7	94.3	93.0	97.8	94.5	**91**
33	84.6	89.7	95.5	98.1	83.0	85.1	91.0	**90**
Average	**90.4**	**92.0**	**93.1**	**94.6**	**92.9**	**92.6**	**91.3**	

Source: Own calculation

Conclusion

The aging of society, progressing from year to year, the development of medical technologies or the growing demands of the society regarding the quality of services, as well as their availability, are among the many challenges faced by currently operating entities conducting medical activity. In the case of health systems analysis, one of the strategic research categories is to provide an opinion on a given system whether it effectively achieves the set goals.

The aging society makes demands on the organization of the health care system. On the other hand, the organizations operating in it are forced to look for new development opportunities, especially to increasing expectations with regard to the quality of services provided and the efficiency of using financial resources. Although, modern medicine is becoming more and more effective, it is also becoming more and more expensive.

The governments of countries are mainly interested in the effective allocation of public funds, in line with the preferences of the society. Payers, in turn, need information on the effectiveness of service providers in order to negotiate and conclude contracts for the provision of services. Healthcare providers focus their attention on verifying the areas requiring intervention and looking for new opportunities for action to increase efficiency. The public, in turn, is interested in reliable information on the activities of medical entities, as well as the entire health system. Obtained research study will give the chance to medical entities to benchmark obtained results. Inefficient medical entity can benchmark and get the answer how to improve it inputs in order to obtain the same outputs like entities determined as efficient.

To sum up, in this paper the technical efficiency was examined in financial dimension using sample of medical private entities as a crucial diagnostic and informative-comparative measure. Limitations of conducted research study linked to lack of data. Financial data are the most available because of indexing them in District Court. In order to obtain deeper analysis, expanded research study involved survey will be required. Further research into detailed measures of partial efficiency are required to obtain in-depth analysis of the entities under evaluation. To obtain further, in-depth analysis and to extend the previous research other dimensions of efficiency should be involved in the future - allocative or cost-effective. Moreover, quality of services should be included as a qualitative dimension. Based on the method used, the ranking should be treated as an impulse for further analyses in order to better understand the phenomena occurring within the entities.

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