Efficiency of Polish county hospitals

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Abstract

The situation of Polish hospitals is subject to changes resulting both from the changes in health policy and decisions regarding the entire economy. In last years financial situation of Polish hospitals is still worsening. Due to this fact it is now even more important to assess the efficiency of those units. The goal of the paper is to compare the performance of county hospitals in Poland over the period 2015-2018 using the Data Envelopment Analysis (DEA) method. We use super-efficiency model with two outputs: total number of discharged and dead patients and total person-days. 12 inputs were used including: number of beds, energy expenditure, medical and non-medical materials expenditure, employment of doctors and other personnel. The research study shows that the use of inputs is inefficient in most hospitals and, worse, inefficiency increases over time.

Keywords: efficiency, DEA, hospitals, super-efficiency

JEL Classification: I10, C14

1. Introduction

In recent years, the situation of Polish hospitals has been systematically deteriorating. This is caused by both health policy pursued by politicians and also political and economic decisions made by the government regarding the entire economy. Directors of county hospitals are in a very difficult situation for many reasons. One of them is the unstable law that makes it impossible to use strategic planning and strategic management. In addition, data for the healthcare system is not actually collected in Poland. There are also no studies on the efficiency of the health care system as a whole and its components. There is a lack of quantitative basis for making rational decisions by hospital directors, and this translates into the availability and quality of healthcare. In this situation, research study on efficiency of hospital functioning is of particular importance.

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The purpose of the paper is to compare the performance of county hospitals in Poland over the period 2015-2018 using the Data Envelopment Analysis (DEA) method. The super-efficiency DEA model with two outputs and 12 inputs is used.

2. Overview of the literature

The financial situation of county hospitals is deteriorating as shown by Nojszewska *et al.* (2019). In last years, the health sector in Poland was subject to different reforms. Hellich and Wierzowiecka (2017) describe transformation of Polish healthcare system from 1999 and discuss effects of those changes. Byszewski (2018) presents the recent reform, introduction of hospital network. Even though the cited paper refers mostly to public policy, the author states that the reform may contribute towards inefficiencies in the hospitals. Similar opinion can be found in (Kolwitz, 2018).

Healthcare sector is also influenced by the general economic reforms such as change in the minimum wage. Kujawska (2015) analysed the share of administration costs in total cost of a hospital. The cited paper was based on the case study, but the author still found out the wages amount for the majority of administrative costs. Now, with the rise of the minimum wage in the entire economy high share of such costs means higher burden for the hospital not only because of the employed personnel but also due to rising prices of outsourced services.

Due to all these reasons the environment in which county hospitals are performing is changing dynamically which provides new challenges for hospitals and in a way enforces them to implement some changes, like change of legal form or consolidation with other units. Susmarski (2016) presents such case of county hospital from pomorskie voivodship.

Data Envelopment Analysis (DEA) is frequently used to analyse efficiency and productivity changes of hospitals. Fuentes *et al.* (2019) use DEA to analyse the performance of Spanish hospitals, Chen *et al.* (2019b) focus on the impact of recession on efficiency. Ravaghi *et al.* (2019) conducted a literature analysis and reached the conclusion that DEA was used in circa 41% of studies concerning hospitals efficiency. Similarly, Kohl *et al.* (2019) provide a grouping of DEA-focusing studies into 4 categories, including: DEA application on hospital level data, management support and analysing the impact of policy changes. Chen *et al.* (2019a) used Malmquist index to examine the productivity growth of Taiwanese hospitals. Other examples of using this index include Li *et al.* (2019) and Chen *et al.* (2019b).

In Poland papers on hospitals situation usually focus on case studies as the access to individual data on larger groups of hospitals is in most cases either restricted or gathered data is not comparable between hospitals. For example Cygańska *et al.* (2018) focus on efficiency of different departments in one hospital. Łagowski (2016) and Grzesiak and Wyrozębska (2014) can be cited as exemptions. Kocisova *et al.* (2018), Jewczak and Żółtaczek (2011), and Kujawska (2013) analyse the hospitals performance at regional level (16 Polish voivodeships).

Sometimes super-efficiency model is used in order to assess the performance (see for example Chitnis and Mishra (2019)) or pure-DEA approach is enhanced by some additional model. For example Rouyendegh *et al.* (2019) uses DEA combined with fuzzy Analytic Hierarchy Process (AHP) and Jacobs (2001) enhanced DEA with Stochastic Frontier Analysis (SFA).

3. Data and method of research study

Data Envelopment Analysis (DEA) was proposed by Charles *et al.* (1978). Cooper *et al.* (2011) provide the description of the method and discussion of additional changes. The approach allows to compare the performance of some objects, called Decision-Making Units (DMUs), which are assessed based on the inputs to outputs transformation. DEA is a non-parametric method, which means it does not require additional assumptions concerning specifics of the transformation process (as production functions). It provides results based only on the comparison of DMUs included in the provided dataset, under the assumption that those objects are homogenous. Simple DEA model allows only for identification of effective objects. Based on the reults obtained it is not possible to examine the efficiency in more depth, for example to compare or rank efficient objects based on their relative performance.

Questions mentioned above can be answered using so called super-efficiency models which may provide varied results for efficient DMUs (as compared with 1 in case of simple DEA model, Guzik 2009). DEA method uses relative approach and due to this fact the results are dependent on the sample, i.e. dataset used. Therefore it is impossible to assess the absolute changes in efficiency in time. In order to examine those changes Malmquist index, proposed by Caves *et al.* (1982) was used. It's defined as a geometric mean of two indexes of productivity change defined for two reference technologies (Färe *et al.*, 2011):

$$M(x_t, x_{t+1}, y_t, y_{t+1}) = \sqrt{\frac{D_t(x_{t+1}, y_{t+1})}{D_t(x_t, y_t)} \cdot \frac{D_{t+1}(x_{t+1}, y_{t+1})}{D_{t+1}(x_t, y_t)}}. \quad (1)$$

where: x_t – inputs in period t, y_t – outputs in period t, D_t – distance function with reference technology of period t.

In the paper we will denote values of Malmqust index as TFP.

Malmquist index can be decomposed in order to analyse two sources of productivity changes: change of efficiency (further denoted as EC) and change of technology (further denoted as TC). Decomposition formula is following (Färe *et al.*, 2011):

$$TFP = EC \cdot TC = \frac{D_{t+1}(x_{t+1}, y_{t+1})}{D_t(x_t, y_t)} \sqrt{\frac{D_t(x_{t+1}, y_{t+1})}{D_{t+1}(x_{t+1}, y_{t+1})} \cdot \frac{D_t(x_t, y_t)}{D_{t+1}(x_t, y_t)}}. \quad (2)$$

The interpretation of TFP, EC and TC is usual for the indices. Values greater than 1 mean the growth (improvement of, respectively: total productivity, efficiency and technology) while values lower than 1 mean decrease in respective areas.

We assume that hospitals in Poland satisfy homogeneity condition as they all perform in the same environment.

Data used come from the questionnaire completed by Polish county hospitals in summer 2019. The analysed period is 2015-2018. Due to a missing data only 76 hospitals were examined. 2 outputs were taken into account: - total number of discharged and dead patients; - total number of man-days. Considering only total number of man-days is not enough, as the aim of treatment is to efficiently treat the patient and discharge them. Unfortunately in the dataset provided by hospitals the numbers of discharged and dead patients were aggregated. We also used 12 inputs: - number of beds; - energy expenditure; - value of the contract with the National Health Fund; - medical materials expenditure; - energy; - non-medical materials expenditure; - outsourcing of medical services; - outsourcing of non-medical services; - employment of doctors; - employment of nurses; - employment of paramedics; - employment of administrative staff.

4. Results

The result of the super-efficiency study with the SE-CCR (super-efficiency CCR) model oriented on inputs under constant returns to scale indicates that almost half of county hospitals were inefficient. In 2015-2016, there were 39 effective hospitals in each group of 76 examined hospitals, and in 2017-2018 efficiency improved slightly, as 43 hospitals were also effective in each group of 76 examined hospitals. Although the share of efficient hospitals is above 0.5 it is still relatively small.

Both the average super-efficiency of county hospitals in terms of the efficiency of the use of their inputs, as well as the differences between hospitals were not subject to visible trends (Table 1). The minimum values fluctuated by 8%, but the lowest and highest values were recorded in the first two years, and in the following years values they were close to the values from the first year of the analysis. The value of the first quartile initially increased slightly and remained stable in the last two years. Both values were less than 1, which indicates inefficiency of the hospitals in question. Similarly, the median value increased (except 2016), and the changes were in the range of 9%. The mean increased in 2016, in the following years it decreased and increased again almost to the value of the starting year. The value of the third quartile in subsequent years increased and decreased, and the diversity reached 5%. These three indicators were only slightly higher than 1. The highest value increased the most from year to year, and its diversity was 42%. As outliers increased, this indicates a relative increase in the distance between the most effective hospitals and their entire group.

Table 1. Distribution of super-efficiency index by year for county hospitals in 2015-2018

	2015	2016	2017	2018
Min	0.634	0.677	0.642	0.652
Q1	0.829	0.851	0.858	0.859
Q2	1.009	1.001	1.050	1.102
Mean	1.498	1.543	1.406	1.480
Q3	1.337	1.369	1.298	1.362
Max	16.196	17.499	18.260	22.950

Table 2. Malmquist's total productivity index, TFP, and its components: efficiency change index, EC, and technology change index, TC, for county hospitals in 2016/2015

	TFP	EC	TC
Min	0.790	0.849	0.810
Q1	0.943	0.993	0.953
Q2	0.973	1.000	0.985
Mean	0.999	1.004	0.995
Q3	1.023	1.011	1.003
Max	2.327	1.312	2.327

Table 2 shows that in 2016/2015 total productivity decreased in more than ½ hospitals. The TFP index assumed a value slightly higher than 1 only for the third quartile. The maximum value was only slightly higher than 2. The effectiveness decreased in ¼ of the hospitals as shown by the values of EC. The median value was 1, i.e. the second-quarter of hospitals did not change their efficiency. The value of third quartile increased compared to the median by only 1%, which also indicates the unchanging efficiency. The maximum value is slightly higher. The values of TC indicate that there was also no technical progress. For at least

½ hospitals, the index was less than 1, i.e. the technical situation of the hospitals worsened. Only the third quartile was equal to 1, and the maximum value was only slightly greater than this value.

Table 3. Malmquist's total productivity index, TFP, and its components: efficiency change index, EC, and technology change index, TC, for county hospitals in 2017/2016

	TFP	EC	TC
min	0.379	0.878	0.379
Q1	0.924	0.983	0.940
Q2	0.965	1.000	0.982
Mean	0.965	1.005	0.960
Q3	1.005	1.000	1.012
max	1.507	1.290	1.168

Table 3 shows that in 2017/2016 the values of the total productivity index and its components for county hospitals testify to their difficult situation. For more than ½ hospitals, total productivity decreased. The value of the third quartile is close to 1, meaning productivity almost does not change. Only the maximum value is slightly greater than 1. Changes in efficiency are similar as shown by the EC values. In ¼ of the hospitals it was decreasing. The median and third quartile were 1, meaning the effectiveness did not change in the middle half of the examined hospitals. The maximum value is slightly higher than 1, i.e. there is a small group of hospitals where the efficiency increased slightly.

Table 4. Malmquist's total productivity index, TFP, and its components: efficiency change index, EC, and technology change index, TC, for county hospitals in 2018/2017

	TFP	EC	TC
min	0.331	0.824	0.331
Q1	0.892	1.000	0.896
Q2	0.936	1.000	0.934
Mean	0.931	1.009	0.921
Q3	0.979	1.026	0.966
max	1.525	1.191	1.280

Table 4 shows that the situation also slightly worsened in 2018/2017. Total productivity decreased because for at least ¾ hospitals the index was less than 1. Only the maximum value was greater than 1. Against the background of TFP, efficiency changes look better because the EC index is less than 1 only for the minimum value. In at least ½ hospitals efficiency did not change. Only the maximum value is slightly higher than 1 which shows that there were individual hospitals in which efficiency improved. In ¾ hospitals, the technical progress index (TC) was less than 1, i.e. the situation of these hospitals worsened. Only the maximum value slightly exceeded 1.

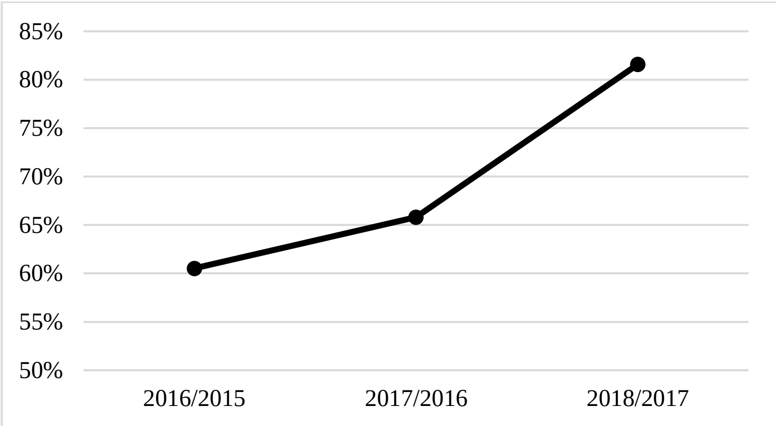

Figure 1. Share of hospitals for which EC<TC

EC index has lower values than TC index in most of the hospitals. As shown in Fig. 1 this share was constantly rising from 60.53% in 2015/2016 to 81.58% in 2017/2018. That leads to the conclusion that more and more hospitals technology changes were less favourable than efficiency ones.

Table 5. Average annual rates of changes in the total productivity index of Malmquist, TFP, and its components: efficiency change index, EC, and technology change index, TC, for county hospitals in 2015-2018

	TFP	EC	TC
2016	0.989	1.002	0.987
2017	0.954	1.003	0.951
2018	0.918	1.007	0.912
Mean	0.953	1.004	0.950

Table 5 shows the average results for individual years. Malmquist's total productivity index (TFP) in the entire period was less than 1. The mean for years 2015-2018 was 0.953, and TFP values ranged from 0.918 to 0.989. The individual values were decreasing. This means that hospital productivity is reduced by approximately 4.7% per year. The average change in efficiency (EC) was close to 1, and this value was taken by the index in individual years. This means that the effectiveness of using factors did not change in a visible way throughout the entire analysed period. There can be seen an increase but very slight in comparison to changes of TFP and TC. The average index of technology changes (TC) is 0.950 and in all subsequent years values of this index were less than 1 and TC values ranged from 0.912 to 0.987. It follows that TC decreased by approximately 5% from year to year. The individual values of this index were falling down each year. This indicates deteriorating possibilities of using new and innovative methods of treating patients in examined hospitals. It leads to the conclusion that total productivity changes on average are unfavourable and the average differences in total productivity as well as technical progress are increasing.

5. Conclusions

The use of the superefficiency DEA model and the Malmquist index and its components enabled the calculation of the over-efficiency of 76 county hospitals in Poland in 2015-2018 as well as the determination of changes in their effectiveness. The show that the use of factors in most hospitals is inefficient and only partially improves in individual years. The Malmquist index and its components have revealed that changes in TFP time, efficiency and technical progress are unfavourable, as in most hospitals the situation is getting worse, and only in some of them a slight improvement was noted. The average annual rates of change in the overall productivity index of Malmquist and its components prove that the situation of hospitals is difficult, because TFP and TC take values less than 1, and EC equals 1. This means that hospitals are retreating in the technical development of using their resources.

It is necessary to collect data and conduct intensive research on the effectiveness of hospitals in order to make decisions that will help hospitals improve their situation.

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