ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2020 Volume 8 Number 2 (December)
http://doi.org/10.9770/jesi.2020.8.2(8)

ENTREPRENEURSHIP AND SUSTAINABILITY CENTER

Publisher
http://jssidoi.org/esc/home

THE EFFICIENCY OF HOSPITALS: PLATFORM FOR SUSTAINABLE HEALTH CARE SYSTEM*

Beata Gavurova [1], Kristina Kocisova [2]

[1] *Center for Applied Economic Research, Faculty of Management and Economics, Tomas Bata University in Zlín, Mostní 5139, 76001 Zlín, Czech Republic*
[2] *Faculty of Economics, Technical University of Košice, Němcovej 32, 042 00 Košice, Slovak Republic*

E-mails:[1] gavurova@utb.cz ; [2] kristina.kocisova@tuke.sk

Received 19 March 2020; accepted 29 July 2020; published 30 December 2020

Abstract. Hospitals and other providers of health services are facing enormous pressure to reduce costs while providing better services for patients without lowering their quality. By utilising a two-stage dynamic Data Envelopment Analysis (DEA) approach, we explore whether there is a compromise between the production of services and the quality of services in the process of providing health care at the level of hospitals in Slovakia. While the first stage deals with the production efficiency of the hospitals, the second stage deals with the quality of service using patient-reported safety and satisfaction measures. The efficiency of hospitals in Slovakia is assessed, using hospital-level data from the database of INEKO for the years 2015 and 2018. In order to dynamically analyse the efficiency changes during the analysed period, the Malmquist index was used. The results revealed that overall technical efficiency increased over the analysed period. We can also see an increase within the service production division as well as service quality division. The results obtained represent a significant platform for the creators of health policy at the national level, and for the creators of the strategic regional health plans as a basis of continuous creation of mechanisms that are inevitable for providing a sustainable system of the Slovak health care at the regional level. The global threats of epidemics, such as COVID-19 pandemic, address the question of public health systems' sustainability, which enormously increases.

Keywords: Two-stage dynamic DEA; Service production division; Service quality division; Hospitals; Slovakia

Reference to this paper should be made as follows: Gavurova, B., Kocisova, K. 2020. The efficiency of hospitals: platform for sustainable health care system. *Entrepreneurship and Sustainability Issues*, 8(2), 133-146. http://doi.org/10.9770/jesi.2020.8.2(8)

JEL Classifications: C61, I11, R11, R58

* *This research was supported by the Internal Grant Agency of FaME Tomas Bata University in Zlin: RVO/2020: "Economic quantification of marketing processes that focus on value increase for a patient in a process of system creation to measure and control efficiency in health facilities in the Czech Republic".*

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2020 Volume 8 Number 2 (December)
http://doi.org/10.9770/jesi.2020.8.2(8)

1. Introduction

Sustainability of health care system is connected with a research of balance between supply and demand. Efficiency and effectiveness of the health care system represent a possible strategy in resolving the disparities between supply and demand of health care in a publicly funded health care system. It means the production of better health care that is funded by a set budget while preserving the quality of services. Monitoring and evaluation of effectiveness and financial efficiency of the health care system are long-term priorities of senior political representatives, and also of the general public and general population. The entire population, irrespective of age, race, sex and/or nationality is affected by the quality and available health care. Health care and health protection of citizens are enshrined in the constitutions around the world.

Consequently, this area reflects a human's quality of life. These aspects are related to the sustainability of health care systems, which is connected to intense technological development and subsequent increase in costs on health care as well as processes of demographic ageing (Megyesiova, Lieskovska, 2018, 2019). However, there are no concepts of health care systems' sustainability that would be known at the national or international level. It may be related to significant heterogeneity, complex health systems, and many other specificities, such as health policy, government strategies, processes of demographic ageing within a country, regional disparities in morbidity and mortality of the regions within a country, availability of health care, etc. (Bednarova et al. 2013; Bem et al. 2019). Thus, it is necessary to connect health care system sustainability with effectiveness, which may be regionally differentiated. Knowledge of these factors may help the creators of health policy to set appropriate supporting, stabilizing and regulatory mechanisms so, that the differences between regions and health facilities in quality and effectiveness of health care would be as low as possible (Predkiewicz et al. 2019). Also, the question of health system sustainability increases in the context of the COVID-19 pandemic, when the governments have started to search for solutions of providing health care system funding in such a crisis (Androniceanu, 2020).

The study's motivation is all of the above-mentioned coherent facts. It aims to research relationships between the production of services and the quality of services in the process of providing health care at the level of hospitals in Slovakia, and consequently, to evaluate the rate of differences between them.

2. Literature Review

Many international research studies deal with research on factors of health care systems' sustainability. These factors may have a different impact on a population and social systems in the individual countries (Syczygiel et al. 2014; Ucieklak-Jez et al. 2018); Du et al., 2020). For instance, Vandersteegen et al. (2015) researched the impacts of no-fault compensation on health care expenditures in their study, while the authors focused on the OECD countries. Also, this study states that it is essential to improve current medical practice systems, which are a significant factor that determines health care costs, as well as compensation systems in health care. Similarly, the role and influence of responsibility processes in health care are critical. De Meijer et al. (2013) research the factors of costs' division on health care and the impacts of their increase. The structure of their allocation influences the growth rate of health care costs in hospitals. The authors used the Dutch data of real health care costs, hospital registers and mortality databases to perform the research. In the conclusion of their study, the authors emphasize an expected and permanent increase of costs on health care in the hospital sector due to technological development.

Consequently, it should improve treatment, its financing costs and procedural complexity (human resources, infrastructure, etc.). Thus, the sustainability of public health systems becomes the main topic. In the studies of van Baal et al. (2012), Kuca et al. (2015), the authors examine health care system sustainability by means of the analysis of relationships between changes in the mortality rates and costs on health care per person. Also, the authors emphasize that the growth of health care costs per person may significantly depend on age. Karslsberg

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2020 Volume 8 Number 2 (December)
http://doi.org/10.9770/jesi.2020.8.2(8)

Schaffer et al. (2015) state and highlight that the evidence of cost efficiency is rarely used in the local health care expenditure plans. The study results stress the differences in objectives between Health technology assessment (HTA) bodies and local health service decision-makers. Grembowski et al. (2010) researched a relation of the changes in expenditures per capita of local health departments (LHD) to 1990–1997 changes in mortality rates for Black and White racial/ethnic groups in the U.S. The LHD costs were related to absolute reductions in mortality for infants, blacks, and white females. However, these costs did not close black-white mortality differences for these groups. Schofield et al. (2013) examined the impacts on income, taxes, government support payments and GDP due to lost labour force participation. In the conclusion of their study, the authors provide interesting facts: individuals bear the economic costs of lost income in addition to the burden of the condition itself. However, the state impacts include loss of productivity from reduced workforce participation, lost income, taxation revenue, and increasing government support payments - in addition to direct health care costs. These findings are significant for policy creators, who create prevention programs to eliminate morbidity and mortality of the most serious and expensive diseases, because their underestimation may have fatal impacts on finances of health and economic systems of a country. Even Brandle et al. (2016) connect health care system sustainability with an excess capacity of advanced medical technologies in the hospital sector, which influences health care costs' increase. This finding is significant, especially for decentralized structures of health care provision. Consequently, the importance of research efficiency of health care systems in the individual countries is evident and inevitable to setup sustainability strategies of health care systems in the individual countries. Zimon et al. (2016) see possible problem also in the logistic distribution in hospitals, which inhibit to higher health care efficiency.

Our study focuses on the research of hospitals' efficiency in Slovakia, and it aims to research a compromise between the production of services and the quality of services in the process of providing health care at the level of hospitals in Slovakia. The important impact has also health insurance company which achieved a special place among financial institutions, as mentioned by Liberko et al. (2012) Data Envelopment Analysis (DEA) was used in the study. In recent years, this method is also widely used in other research areas, and it contributes to the formation of new modules that reflect on the complexity of decision-making processes. Many research studies evaluate its appropriateness while showing many application possibilities as well as limitations.

Avkiran (1999) points out that DEA is a non-parametric linear programming technique that calculates a comparison ratio of outputs to inputs for each unit, which is reported as a relative efficiency score. The efficiency score is usually expressed as a number between zero and one or 0 and 100%. A decision unit with less than one can be considered as inefficient compared to other units. Luo (2003) states that DEA is a formulation of linear programming that defines a non-parametric relationship between multiple outputs and multiple inputs. It identifies the efficiency frontier, which consists of the most efficient decision-making units (DMU). Efficient DMUs are units for which no other DMU or linear combination of DMUs can generate at least the same number of given outputs. According to Zimková (2014), the non-parametric DEA method makes it possible to create the efficiency frontier and evaluate the efficiency of the DMU. Conventional DEA models are designed to maximise the relative efficiency of each decision unit, provided that the relative efficiency scores obtained in this way for each decision unit are also feasible for all other decision units in the data set. Therefore, both reference points are identified, the relatively efficient units that define the efficiency frontier, as well as the internal points that are below the efficiency frontier. Due to its deterministic nature, the DEA method hypothesises that the DMU causes all deviations from efficiency. Nevertheless, there are some elements, such as the legislative framework, the level of competition, the impact of the crisis, which the company cannot control and which also affects the efficiency of the unit under investigation. According to Palečková (2015), the DEA model can be designed either to minimise inputs or to maximise outputs. Input orientation focuses on reducing the number of inputs while maintaining at least current output levels, while output orientation aims to maximise output levels without increasing input utilisation. The DEA measures the relative efficiency of a homogeneous set of DMUs using multiple inputs to produce multiple outputs. The DEA also identifies the sources and degree of inefficiency for each input and output concerning inefficient DMUs. It provides a means for comparing the efficiency of multiple DMUs to each

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2020 Volume 8 Number 2 (December)
http://doi.org/10.9770/jesi.2020.8.2(8)

other based on multiple inputs or outputs. Saleh & Malkhalifeh (2013) state that DEA has been applied in many studies in various sectors of the economy. Conventional DEA models consider the system to be single-process. However, there are several so-called network approaches, which consider a system to be composed of different processes or phases, each of which has its inputs and outputs and intermediates between the various phases. Two-stage DEA models have higher discriminative power than conventional, single-process DEA. The main disadvantage is the need for more detailed data (i.e. at the process level) and the greater complexity of the resulting models, especially if some inputs or outputs are shared between processes. Ozcan (2014) pointed to the fact that in health care, services are produced by various departments that each contribute to the overall efficiency of the hospital. It is more so for those hospital systems where the individual hospitals and other networks such as physician practices, nursing homes, ambulatory surgery centres, and diagnostic centres may be part of the whole picture. Through the network DEA model, one can observe not only the efficiency of the health care facility but also its sub-unit efficiencies as its components. Network DEA models were first introduced by Fare & Grosskopf (2000), and their models have been extended by Tone & Tsutsui (2009) and others. The network DEA model extended by Lewis & Sexton (2004) presents a multi-stage structure as an extension of the two-stage DEA model. Also, Kao (2017) pointed to the fact that the system is usually composed of many subsystems operating interdependently. Conventional DEA only considers the inputs supplied to and the outputs produced from the system in measuring efficiency, ignoring its internal structure. As a result, the overall system may be efficient, even while all component divisions are not. More significantly, there are cases in which all the component divisions of a DMU have performances that are worse than those of another DMU, and yet the former still has the better system performance. With an eye on solving these problems, many ideas have been extended from the conventional DEA to build models to measure the efficiency of production systems with different network structures, which are referred to as network DEA. Consequently, for systems composed of interrelated divisions, managers need to know how the performances of the various divisions are evaluated and how they are aggregated to form the overall performance of the system. We are also able to analyse the relationship between the efficiency of a system and those of its component divisions when the systems being examined have different types of network structures. This relationship shows the extent to which the efficiency of a division impacts that of the system as a whole. The division with the most significant effect is the one to which more effort should be devoted so that the performance of the overall system can be raised more effectively. Grmanová (2013) says that gradually the need arose to compare the efficiency not only of the whole process but it was also necessary to find out the efficiency of partial processes, into which this whole process is decomposed. It was the reason for the creation of two-stage DEA models. A two-step DEA can be used to evaluate the efficiency of the whole process, but also to examine the effectiveness of sub-processes. The use of a two-stage DEA method makes it possible to examine the effectiveness of each of the two evaluated sub-processes and the product of the efficiency of the subjects in the different sub-processes or whether it is the same as the efficiency of the overall process. According to Chen et al. (2010), the DEA is a method for measuring the effectiveness of DMUs. The DEA has been extended to examine the effectiveness of two-stage processes, where all outputs from the first phase are transitional measures that make up the inputs to the second phase. The resulting two-stage DEA model not only provides an overall efficiency score for the entire process but also provides an efficiency score for each stage. Given the existence of transitional measures, the usual procedure for adjusting inputs or outputs to efficiency points, as in the DEA standard approach, does not necessarily lead to a borderline projection. Also, Mitropoulos (2019) prepared the two-stage DEA model to assess the efficiency of health service delivery. He supposes that within the first stage, we use resources to produce health services as intermediate outcomes. In the second stage, the health services are used to produce final outcomes within the service quality division. These research results emphasize a significance of the DEA model's use also in this analysis in order to achieve the study's aim.

3. Methodology, Variables and Data Collection

We apply a two-stage dynamic DEA model to assess the efficiency of service production division and service quality division. In the first stage, the service production division assesses the utilisation of resources (labour, physical capital) to produce health services as intermediate outputs. In the second stage, the health services obtained from the service production division are used as inputs to the service quality division to produce final outputs that express the patients´ experiences from hospitals. The conceptual model can be expressed by the following figure (Fig. 1).

In particular, the inputs of the service production division include the number of doctors per hospitalised patient, the number of nurses per hospitalised patient and number of beds per hospitalised patient to satisfy health care for patients. We decide to apply expression per hospitalised patient to eliminate size differences between hospitals. The outputs (intermediate outputs) from this division is expressed by the average length of hospital stay, surgical procedure rate, surgical planning and median waiting time for emergency admission.

The service quality division uses as inputs all the intermediate outputs from the service production division to produce quality and safety health services as expected by patients. The patients´ perceptions of hospitals' quality are assessed by using four satisfaction measures based on the respondents´ ratings of the health care in hospital, the staff access to patients in the hospital, the patient information in hospital, and the hotel services in the analysed hospital. As mentioned by Mitropoulos (2019) the patient safety is an essential issue in health care services. Adverse events, in the process of caregiving, may result from problems in practice, products, procedures or systems.

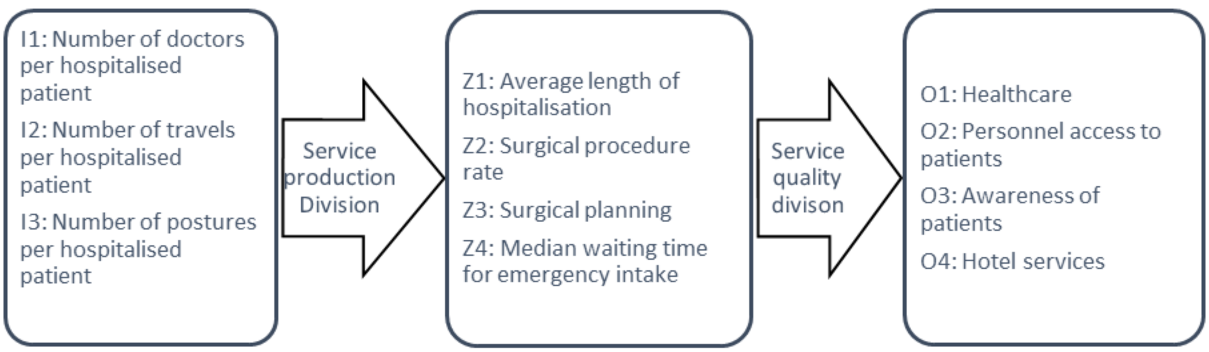

Fig. 1. The two-stage health service delivery process

Source: Prepared by authors

The analysis focuses on assessing the efficiency of the hospitals in Slovakia between 2015 and 2018. Our analysis is done for a sample of 40 hospitals. All variables used in this study are available on an annual basis from the web page www.kdesaliecit.sk prepared by the INEKO. Through this page, the INEKO want to provide objective data and want to draw the public attention to the discussion about the quality and efficiency of medical facilities. If people have more quality information, they can make better decisions and create more effective pressure to improve public services. They want to help the project with patients and their relatives, as well as the facilities themselves. The data come from health insurance companies, Ministry of Health of the Slovak Republic, the Office for Health Care Supervision, the National Centre for Health Information, self-governing regions, Transparency International Slovakia and their analyses. As mentioned by INEKO, some data may be distorted; for example, by the small number of samples and may not correspond to the reality of the device. The complete definition of the health care indicators that are included in the DEA model is available in Table 1.

Table 1. Definition and descriptive statistics of variables included in the DEA model

Indicator	Definition	Min / Max / Average / St.dev
Inputs		
Number of doctors per hospitalised patient	Practicing doctors that provide services for individual patents in hospital; density per 1 hospitalised patient	0.0042 / 0.0356 / 0.0071 / 0.0049
Number of nurses per hospitalised patient	Number of nurses working in hospital; density per 1 hospitalised patient	0.0114 / 0.0542 / 0.0174 / 0.0067
Number of beds per hospitalised patient	Inpatient beds available in hospital; density per 1 hospitalised patient	0.0217 / 0.3124 / 0.0385 / 0.0448
Intermediates		
Average length of hospital stay	Average number of days that patients spend in hospital measured by dividing the total number of days stayed by all inpatients during a year by the number of admissions or discharges	4.2672 / 8.6143 / 6.1100 / 0.9645
Surgical Procedure Rate	The share of operations in the total number of hospitalizations	0.3053 / 0.8280 / 0.6274 / 0.1231
Surgical Planning	It assesses whether only acute cases go to the hospital or whether patients choose it for planned emergency health care themselves.	0.0390 / 0.3211 / 0.1350 / 0.0655
Median waiting time for emergency admission	Median waiting time in minutes	12.15 / 22.40 / 16.77 / 2.59
Outputs		
Health care	Assessment of the patient about the provided health care and improvement of the health condition after discharge from the hospital, on a point scale from 0-5, recalculated to other hospitals	0.6611 / 0.7992 / 0.7251 / 0.0309
Staff access to patients	Assessment of the patient about the time spent by the doctor and the nurses, the availability of consultations with the doctor, on a point scale from 0-5, recalculated to other hospitals	0.6863 / 0.8355 / 0.7660 / 0.0309
Patient information	Assessment of patient information about a diagnosis, clarity of information and patient involvement in decision-making on a point scale of 0-5, recalculated to other hospitals	0.6484 / 0.8094 / 0.7276 / 0.0342
Hotel services	Patient rating on the quality of accommodation, quality of food and quality of cleaning in the hospital on a point scale from 0-5, recalculated to other hospitals	0.5514 / 0.7890 / 0.6481 / 0.0522

Source: Prepared by authors

As all our inputs and outputs are expressed in the form of ratios, it able us to use model under the assumption of constant returns to scale. As mentioned by Jacobs et al. (2006), this is very common in health care. For example, mortality rates, discharge rates, doctors per head of population, nurses per occupied bed, the proportion of expenditure on clinical supplies from total expenditure, proportion of theatre time for hip replacement operations from total theatre time are commonly used measures of input or output. The essential point to note is that the use of such data automatically implies an assumption of constant returns to scale because the creation of the ratio removes any information about the size of the organisation.

We assume a general two-step process, as shown in Fig. 1, for each of a number of n DMUs. We assume that each DMU_j (j=1,2...,n) has m inputs x_{ij} (i=1,2,...,m) in the first phase and D intermediate outputs z_{dj} (d=1,2,...,D) from this stage. These outputs D then become inputs to the second phase and therefore behave as temporary measures. The outputs from the second phase are y_{rj} (r=1,2,...,s). In our case, we assume that in the first phase, the goal will be to determine the minimum number of inputs x_{ij} (i=1,2,...,m) needed to produce intermediate outputs z_{dj} (d=1,2,...,D) from this stage. For this reason, an input-oriented model will be applied in the first phase. As mentioned by Charnes et al. (1978), the input-oriented model under the constant returns to scale assumption (CCR model) for measuring the relative efficiency of DMU can be expressed as follows:

$$EI_0 = \min \theta_0 \qquad (1)$$

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2020 Volume 8 Number 2 (December)
http://doi.org/10.9770/jesi.2020.8.2(8)

$$\text{s.t. } \sum_{j=1}^{n} z_{dj}\lambda_j \geq z_{r0} \qquad d = 1,2,\ldots,D$$
$$\sum_{j=1}^{n} x_{ij}\lambda_j \leq \theta_0 x_{i0} \qquad i = 1,2,\ldots,m$$
$$\lambda_j \geq 0 \qquad j = 1,2,\ldots,n \tag{2}$$

In the second phase, the goal will be to determine what maximum number of outputs y_{rj} (r=1,2,...,s) the production unit is able to generate from a given number of inputs (intermediate outputs from the first division) z_{dj} (d=1,2,...,D). In this case, an output-oriented model will be applied in the second phase.

$$EO_0 = \max \phi_0 \tag{3}$$

$$\text{s.t. } \sum_{j=1}^{n} y_{rj}\lambda_j \geq \phi_0 y_{rq} \qquad r = 1,2,\ldots,s$$
$$\sum_{j=1}^{n} z_{dj}\lambda_j \leq z_{d0} \qquad d = 1,2,\ldots,D$$
$$\lambda_j \geq 0 \qquad j = 1,2,\ldots,n \tag{4}$$

In the case under investigation, it is assumed that the value of the intermediated variables is the same, whether they are perceived as inputs or outputs. It is possible to apply two separate DEA analyses into two stages, as reported by Seiford & Zhu (1999). The criticism of such an approach is the internal conflict that arises between the two analyses. For example, it assumes that the first stage is efficient, and the second phase is not. When the second stage improves its performance, the change in inputs (intermediate variable) may cause the first stage to be inefficient. It suggests the need for a DEA approach that ensures coordination between the two stages. As mentioned by Liang et al. (2008), it is, therefore, appropriate to define the efficiency of the whole two-stage process as the geometric average of the efficiency of two phases $E_0 = EI_0$ x EO_0.

As we want to compare efficiency between two years, we can calculate the Malmquist index to measure the productivity changes over time. The Malmquist index can be calculated for both divisions, and also the overall Malmquist index. The Malmquist productivity index evaluates a productivity change of a DMU between two periods as the product of "catch-up" and "frontier shift" terms. The catch-up (recovery or efficiency change) term reflects the degree that a DMU attains for improving its efficiency. In contrast, the frontier shift (innovation or technological change) term demonstrates the difference in the efficient frontier surrounding the DMU between the two periods. We obtain the following formula for the computation of the Malmquist index:

$$\textit{Malmquist Index} = \frac{\delta^2((x_0,y_0)^2)}{\delta^1((x_0,y_0)^1)} \times \left[\frac{\delta^1((x_0,y_0)^1)}{\delta^2((x_0,y_0)^1)} \times \frac{\delta^1((x_0,y_0)^2)}{\delta^2((x_0,y_0)^2)}\right]^{1/2} \tag{5}$$

If the "catch-up" effect value is greater than 1, it interprets the progress in the relative efficiency from period 1 to period 2. The "catch-up" effect value equal to 1 indicates no changes in the relative efficiency, and a value below 1 indicates a regress in relative efficiency. The "frontier-shift" higher than 1 indicates progress in the frontier technology around the evaluated production unit from period 1 to period 2, while "frontier-shift" lower than one indicate regress in the frontier technology. The Malmquist index higher than 1 indicates progress in the total factor productivity change of the evaluated production unit, from period 1 to period 2. The Malmquist index equal to 1 shows a status quo, and the Malmquist index lower than one means deterioration in the total factor productivity.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2020 Volume 8 Number 2 (December)
http://doi.org/10.9770/jesi.2020.8.2(8)

4. Results and Discussion

The efficiency score for service production division, service quality division and the overall hospital efficiency for the 40 Slovak hospitals are presented in Table 2. The average overall efficiency score for all analysed hospitals was 0.8254 in 2015. Twenty-two hospitals achieved a higher level of overall efficiency compared to the average in 2015; four of them were marked as efficient. On the other hand, eighteen hospitals achieved a lower level of overall efficiency compared to the average in 2015. In 2018 the average overall efficiency was 0.8052, where twenty hospitals achieved a higher level of overall efficiency compared to the average in 2018, five of them were marked as efficient, and fifteen hospitals achieved a lower level of overall efficiency compared to the average in 2018. When we look at the efficiencies of divisions, we can see that the average efficiency of service production division was 0.9160 in 2015 and 0.9102 in 2018. In 2015 twenty-five hospitals achieved a higher level of efficiency compared to the average in the service production division, between them fifteen were marked as efficient, and fifteen hospitals achieved a lower level of efficiency compared to the average in the service production division in 2015. In 2018 twenty-two hospitals achieved a higher level of efficiency compared to the average in the service production division, between them eighteen were marked as efficient, and eighteen hospitals achieved a lower level of efficiency compared to the average in the service production division in 2018. In the case of the service quality division, twenty-one hospitals achieved a higher level of efficiency compared to the average in service quality division, between them twelve were marked as efficient, and nineteen hospitals achieved a lower level of efficiency compared to the average in service quality division in 2015. In 2018 nineteen hospitals achieved a higher level of efficiency compared to the average in service quality division, between them twelve were marked as efficient, and twenty-one hospitals achieved a lower level of efficiency compared to the average in service quality division in 2018.

When we compare the level of average efficiency in service production division and service quality division in 2018, we can see that the level of efficiency in of service production division was higher than in the service quality division. The same tendency can be seen in the case of twenty-two hospitals. The opposite tendency can be seen in the case of thirteen hospitals. In the case of five hospitals, the level of efficiency is the same in both divisions. Comparing the results, we can say that hospitals tend to be more efficient within the service production division. To analyse the relationship between two divisions of hospitals, we have calculated the Pearson´s correlation coefficient, which was -0.1298 in 2015 and -0.1378 in 2018. These results indicate a small negative relationship between service production division and service quality division in both years. The results pointed to the fact that synergy existed between these divisions.

Table 2. Efficiency score in divisions and overall efficiency for selected Slovak hospitals in 2015 and 2018

No.	Hospital	Service production division		Service quality division		Overall efficiency	
		2015	2018	2015	2018	2015	2018
1.	F.D. Roosevelt University Hospital in Banská Bystrica	1.0000	0.7977	0.8043	0.8705	0.8043	0.6944
2.	The SNP Central Military Hospital in Ružomberok – teaching hospital	1.0000	1.0000	0.9366	0.8995	0.9366	0.8995
3.	The Martin University Hospital	0.9471	0.9284	0.9869	0.9113	0.9347	0.8460
4.	The University Hospital Nitra	1.0000	1.0000	0.8482	0.7297	0.8482	0.7297
5.	The Ružinov Hospital in Bratislava	0.8336	0.7519	0.8919	0.7439	0.7434	0.5593
6.	J. A. Reimana Teaching Hospital with Polyclinic in Prešov	0.7421	0.8359	0.7754	0.7228	0.5754	0.6042
7.	Teaching Hospital with Polyclinic in Nové Zámky	0.9136	1.0000	0.7758	0.7661	0.7088	0.7661
8.	Faculty Hospital and Polyclinic in Žilina	1.0000	1.0000	0.6815	0.8185	0.6815	0.8185
9.	L. Pasteur University Hospital in Košice	0.8095	0.7408	0.7560	0.8159	0.6120	0.6044
10.	Faculty Hospital in Trenčín	0.7367	1.0000	0.9778	0.7703	0.7204	0.7703
11.	Faculty Hospital in Trnava	0.8131	0.8922	1.0000	0.7912	0.8131	0.7059
12.	Košice-Šaca Hospital, 1st private hospital	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13.	Hospital in Stará Ľubovňa	1.0000	0.7895	1.0000	1.0000	1.0000	0.7895
14.	The Poprad Hospital	0.8817	1.0000	1.0000	0.9668	0.8817	0.9668
15.	Hospital with Polyclinic in Spišská Nová Ves	1.0000	0.8927	0.8789	0.9788	0.8789	0.8738
16.	Hospital of Dolnáorava with Polyclinic L.N.Jége in Dolný Kubín	0.9415	1.0000	1.0000	1.0000	0.9415	1.0000

17.	Vranov nad Topľou Hospital	0.8832	0.8790	1.0000	1.0000	0.8832	0.8790
18.	Hospital A. Leňa in Humenné	0.9607	0.7916	0.9410	0.8407	0.9040	0.6654
19.	General Hospital with Polyclinic in Lučenec	1.0000	0.9147	0.9617	0.9084	0.9617	0.8309
20.	Hospital of arm. Gen. L. Svoboda Svidník	0.6074	0.8060	0.9677	1.0000	0.5878	0.8060
21.	The Štefan Kukura Hospital and Polyclinic in Michalovce	1.0000	1.0000	0.9620	1.0000	0.9620	1.0000
22.	The Hospital of Alexander Winter in Piešťany	0.8702	0.8283	0.8308	1.0000	0.7230	0.8283
23.	General Hospital in Komárno	1.0000	1.0000	0.8571	0.8604	0.8571	0.8604
24.	Hospital with Polyclinic in Trebišov	0.9454	0.8731	1.0000	0.8772	0.9454	0.7659
25.	Hospital and Polyclinic in Dunajská Streda	0.6771	0.6365	1.0000	1.0000	0.6771	0.6365
26.	Liptovská Hospital and Polyclinic, MD Ivana Stodolu in Liptovský Mikuláš	0.9365	0.9878	1.0000	0.9686	0.9365	0.9567
27.	Faculty Hospital and Polyclinic Skalica	0.8844	1.0000	0.8984	0.9261	0.7945	0.9261
28.	General Hospital with Polyclinic Levoča	0.9670	0.9058	0.9865	0.8095	0.9539	0.7332
29.	St. Jacob's Hospital with Polyclinic in Bardejov	1.0000	1.0000	0.8636	0.7668	0.8636	0.7668
30.	St. Barbara's Hospital with Polyclinic in Rožňava	1.0000	1.0000	0.6744	0.7482	0.6744	0.7482
31.	The and Hospital Polyclinic in Brezno	0.9542	0.9267	0.8903	0.8377	0.8495	0.7762
32.	Hospital in Snina	0.7828	1.0000	1.0000	1.0000	0.7828	1.0000
33.	Kysuce Hospital and Polyclinic, Čadca	1.0000	1.0000	1.0000	0.8319	1.0000	0.8319
34.	Hospital and Polyclinic Považská Bystrica	0.9553	0.8926	0.7458	0.8696	0.7125	0.7762
35.	Hospital and Polyclinic of St. Luke in Galanta	1.0000	1.0000	0.8235	0.8428	0.8235	0.8428
36.	Hospital Zvolen	0.9675	0.8679	0.8733	1.0000	0.8449	0.8679
37.	Hospital and Polyclinic in Myjava	0.8217	0.7776	0.7701	0.8198	0.6328	0.6375
38.	Hospital and Polyclinic in Revúca	0.8714	1.0000	1.0000	1.0000	0.8714	1.0000
39.	Hospital and Polyclinic in Prievidza	0.9375	1.0000	0.7397	0.7531	0.6934	0.7531
40.	Hospital Partizánske	1.0000	0.6906	1.0000	1.0000	1.0000	0.6906
	Average	0.9160	0.9102	0.9025	0.8861	0.8254	0.8052
	Max	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	Min	0.6074	0.6365	0.6744	0.7228	0.5754	0.5593
	St.dev	0.1009	0.1033	0.1025	0.0974	0.1245	0.1200

Source: Prepared by authors

The next part of the paper analyses changes in the efficiencies using the Malmquist index. The overall Malmquist index (MI) can be decomposed in frontier shift (F.S.) effect and catch-up (C.U.) effect. The frontier shift effect represents an improvement in efficiency due to the innovation, while the catch-up effect represents an improvement in efficiency due to improved operations and management of the hospital and also optimisation in terms of size. While the MI, F.S., and CU above 1 indicate the improvement between periods, the values below 1 indicate worsening in the efficiency. The total improvement, respectively, the deterioration can be calculated as the difference between the index value and the number 1. In percentage form, the difference is multiplied by 100.

Table 3. Malmquist index and its components in the Slovak hospitals

		Service production division			Service quality division			Overall efficiency			
No.	Hospital	CU	FS	MI	CU	FS	MI	CU	FS	MI	Rank
1.	F.D. Roosevelt University Hospital in Banská Bystrica	0.6428	1.5200	0.9770	1.0921	1.1807	1.2895	0.7020	1.7946	1.2598	16
2.	The SNP Central Military Hospital in Ružomberok – teaching hospital	1.0985	1.2694	1.3944	0.9447	1.1249	1.0627	1.0378	1.4279	1.4819	5
3.	The Martin University Hospital	1.0284	1.3075	1.3447	0.9481	1.1210	1.0628	0.9750	1.4657	1.4291	6
4.	The University Hospital Nitra	1.0091	1.1519	1.1624	0.8664	1.1576	1.0030	0.8743	1.3335	1.1658	21
5.	The Ružinov Hospital in Bratislava	0.5358	1.0271	0.5503	0.8744	1.1040	0.9653	0.4685	1.1340	0.5313	39
6.	J. A. Reimana Teaching Hospital with Polyclinic in Prešov	1.1814	1.1557	1.3653	0.9172	1.1008	1.0096	1.0835	1.2722	1.3785	10
7.	Teaching Hospital with Polyclinic in Nové Zámky	1.1084	0.9906	1.0980	1.0123	0.9974	1.0097	1.1221	0.9881	1.1087	25
8.	Faculty Hospital and Polyclinic in Žilina	0.9361	1.0291	0.9633	1.2223	0.9427	1.1522	1.1442	0.9701	1.1099	24
9.	L. Pasteur University Hospital in Košice	0.9752	1.5497	1.5113	1.0799	1.0779	1.1640	1.0531	1.6704	1.7592	2
10.	Faculty Hospital in Trenčín	1.6226	0.9791	1.5887	0.7947	1.1132	0.8846	1.2894	1.0900	1.4054	7
11.	Faculty Hospital in Trnava	1.0368	1.1527	1.1952	0.7604	1.0095	0.7677	0.7885	1.1637	0.9175	32
12.	Košice-Šaca Hospital, 1st private hospital	1.0012	1.2465	1.2481	0.9713	1.0846	1.0534	0.9725	1.3519	1.3147	12
13.	Hospital in Stará Ľubovňa	0.7486	1.0915	0.8171	1.0507	1.1151	1.1716	0.7865	1.2171	0.9573	30
14.	The Poprad Hospital	1.2171	1.3215	1.6084	0.8724	1.0656	0.9296	1.0618	1.4082	1.4952	4

15.	Hospital with Polyclinic in Spišská Nová Ves	0.7216	1.1897	0.8584	1.1269	1.2071	1.3603	0.8131	1.4361	1.1677	20
16.	Hospital of Dolnáorava with Polyclinic L.N.Jége in Dolný Kubín	1.1350	1.0567	1.1993	1.0039	0.9363	0.9400	1.1394	0.9894	1.1273	22
17.	Vranov nad Topľou Hospital	0.9569	0.9987	0.9557	0.9458	1.1728	1.1092	0.9050	1.1713	1.0600	26
18.	Hospital A. Leňa in Humenné	0.8223	0.9978	0.8205	0.9233	1.0261	0.9473	0.7592	1.0238	0.7772	35
19.	General Hospital with Polyclinic in Lučenec	0.8243	1.1822	0.9745	0.9614	1.1855	1.1398	0.7925	1.4015	1.1107	23
20.	Hospital of arm. Gen. L. Svoboda Svidník	1.1023	0.9689	1.0679	1.7533	0.7009	1.2289	1.9326	0.6791	1.3124	13
21.	The Štefan Kukura Hospital and Polyclinic in Michalovce	0.9957	0.9808	0.9766	1.1388	0.9409	1.0715	1.1339	0.9229	1.0465	27
22.	The Hospital of Alexander Winter in Piešťany	0.9817	1.2641	1.2410	1.3474	1.0472	1.4111	1.3228	1.3238	1.7511	3
23.	General Hospital in Komárno	1.0770	1.0203	1.0988	1.0613	1.0270	1.0900	1.1430	1.0479	1.1976	19
24.	Hospital with Polyclinic in Trebišov	0.9207	1.2267	1.1294	0.8628	1.2977	1.1196	0.7943	1.5919	1.2645	15
25.	Hospital and Polyclinic in Dunajská Streda	0.6598	0.9893	0.6528	0.9986	0.9940	0.9926	0.6589	0.9833	0.6479	37
26.	Liptovská Hospital and Polyclinic, MD Ivana Stodolu in Liptovský Mikuláš	1.0488	1.0408	1.0916	0.9361	0.8139	0.7619	0.9818	0.8471	0.8317	34
27.	Faculty Hospital and Polyclinic Skalica	1.7015	1.0625	1.8077	1.0322	0.9442	0.9746	1.7562	1.0032	1.7617	1
28.	General Hospital with Polyclinic Levoča	0.8825	1.1694	1.0320	0.8318	1.2140	1.0098	0.7340	1.4196	1.0421	28
29.	St. Jacob's Hospital with Polyclinic in Bardejov	1.0147	1.1314	1.1480	0.9043	1.1864	1.0728	0.9175	1.3423	1.2316	18
30.	St. Barbara's Hospital with Polyclinic in Rožňava	1.0190	1.0456	1.0655	1.1080	1.0898	1.2075	1.1291	1.1395	1.2866	14
31.	The and Hospital Polyclinic in Brezno	0.9553	1.1056	1.0562	0.9519	0.9144	0.8704	0.9093	1.0109	0.9193	31
32.	Hospital in Snina	1.6709	1.0235	1.7101	0.9575	0.8101	0.7756	1.5998	0.8291	1.3264	11
33.	Kysuce Hospital and Polyclinic, Čadca	1.0083	1.0517	1.0605	0.8094	0.7240	0.5860	0.8161	0.7615	0.6214	38
34.	Hospital and Polyclinic Považská Bystrica	0.9345	0.9982	0.9328	1.1376	0.9252	1.0525	1.0630	0.9235	0.9817	29
35.	Hospital and Polyclinic of St. Luke in Galanta	1.0743	1.2121	1.3022	1.0478	1.0297	1.0789	1.1257	1.2481	1.4050	8
36.	Hospital Zvolen	0.8618	0.9410	0.8110	1.1904	0.7236	0.8613	1.0259	0.6809	0.6985	36
37.	Hospital and Polyclinic in Myjava	0.9133	1.1778	1.0757	1.1026	1.0572	1.1656	1.0070	1.2452	1.2539	17
38.	Hospital and Polyclinic in Revúca	1.1927	1.0269	1.2248	0.8586	0.8290	0.7118	1.0241	0.8513	0.8718	33
39.	Hospital and Polyclinic in Prievidza	1.1817	1.0814	1.2779	1.0435	1.0395	1.0847	1.2332	1.1241	1.3861	9
40.	Hospital Partizánske	0.4489	1.0674	0.4792	0.8833	1.0210	0.9019	0.3965	1.0898	0.4321	40
	Average	1.0062	1.1201	1.1219	1.0081	1.0263	1.0263	1.0118	1.1594	1.1457	
	Max	1.7015	1.5497	1.8077	1.7533	1.2977	1.4111	1.9326	1.7946	1.7617	
	Min	0.4489	0.9410	0.4792	0.7604	0.7009	0.5860	0.3965	0.6791	0.4321	
	SD	0.2568	0.1399	0.2867	0.1741	0.1421	0.1707	0.2975	0.2625	0.3186	

Source: Prepared by authors

Table 3 shows the Malmquist index (MI) of each hospital for the overall hospital efficiency, and also for service production division and service quality division. The hospitals are ranked in descending order according to the overall MI. The top-ranking hospital was Faculty Hospital and Polyclinic Skalica (No. 27) with a productivity gain of 76%, while Hospital Partizánske (No. 40) was the lowermost hospital with a productivity loss of 57%. The average productivity growth between two years was 14.57%, and only twelve hospitals exhibited productivity degrees between analysed years. From these hospitals, only four exhibited productivity degrees simultaneously in both divisions. The progress in the overall total factor productivity index was caused by the 1.18% growth in the relative technical efficiency (catch up effect) and positive innovation effect (15.94%) which led to the shift of production possibility frontier. The overall progress was positively influenced by the progress of 12.19% in the case of the service production division and by the progress of 2.63% in service quality division. The progress in the total factor productivity index in case of service production division was caused by the 0.62% growth in the relative technical efficiency and positive innovation effect (12.01%). In the case of service quality division, the progress was caused by the growth in the relative technical efficiency by 0.81% and the positive innovation effect (2.63%). The frontier shift effect representing the impact of innovation was positive in most of the hospitals in both divisions. The catch-up effect was positive in case of both sub-divisions, which represents an improvement in technical efficiency due to improved operations and management of hospitals and optimisation of their optimal size.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2020 Volume 8 Number 2 (December)
http://doi.org/10.9770/jesi.2020.8.2(8)

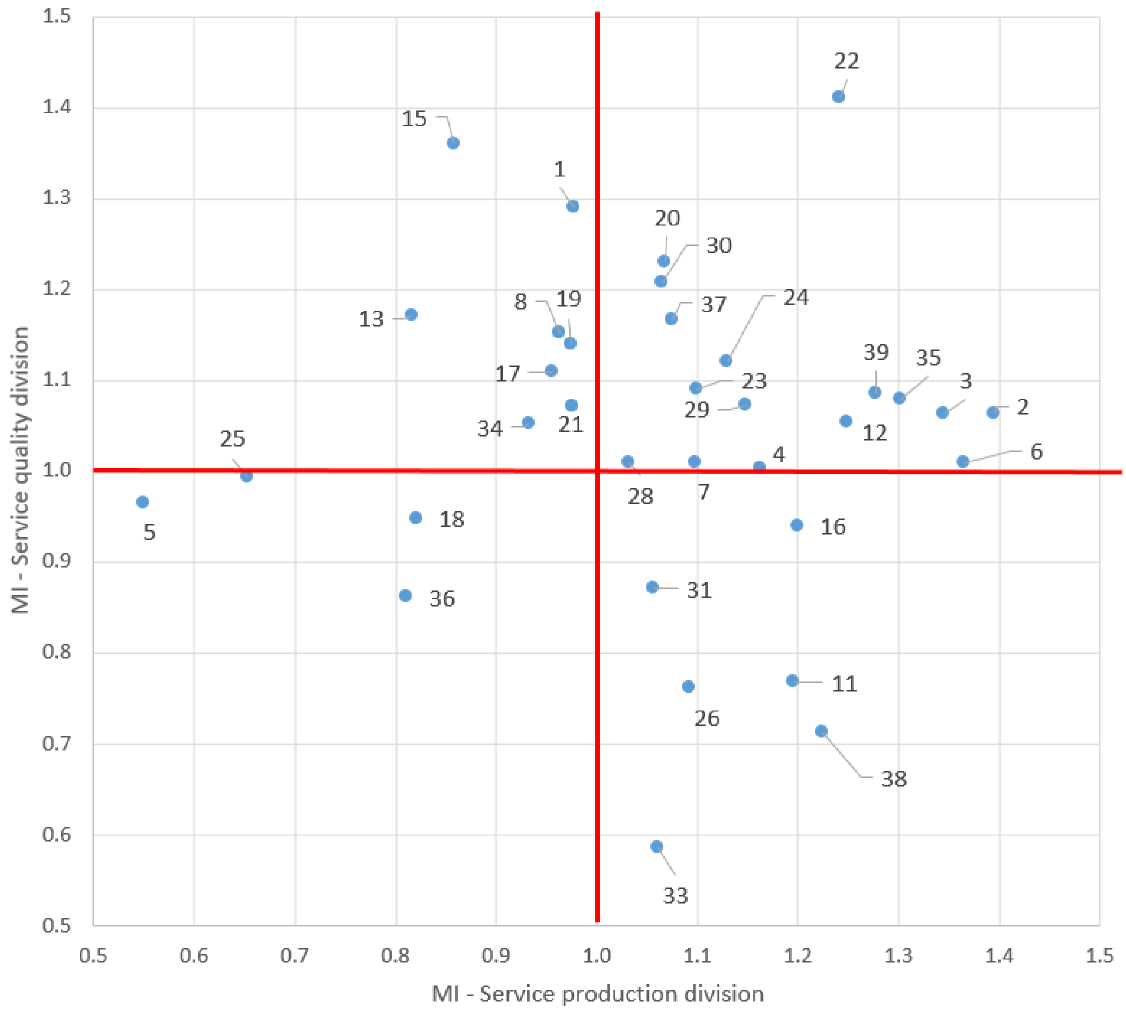

Fig. 2. Malmquist index in divisions

Source: Prepared by authors

From the hospitals that exhibited productivity progress, we can see from Fig. 2 that seventeen hospitals achieved progress in both divisions, and only five hospitals achieved degrees in both divisions. In the case of other hospitals, they were able to achieve progress at least in one division. We can see that ten hospitals achieved progress in service production division and degrees in service quality division, while the situation was opposite in the case of eight hospitals. The Pearson correlation coefficient of the divisional Malmquist indexes has also revealed a small negative relationship (-0.1185) between service production division and service quality division.

Conclusion

Human health is a significant dimension in the evaluation of the population's quality of life. Also, it is a biological characteristic, and it has a significant societal value. Priority of each country is to create the best and functioning health care system that would protect, monitor and especially improve population's health status by means of active and efficient health policy (Marešová et al., 2016). Health care market is characterized by many specificities, while the fundamental economic principles are also applied here. These principles create a space for potential conflicts, as well. It is connected to efforts that satisfy health care demand. However, the budget is limited. Demographic prognoses and informatization growth demand for health care, while covered by limited financial resources. Sustainability of health care systems is a priority in a short-term and also long-term horizon. The creators of health policy and other stakeholders need to face increasing pressures which result in the implementation of more systematic and effective ways of health care systems' measurement and evaluation in order to improve public health as well as health care, responsibility, management and effective use of resources in health care. Measuring the effectiveness of health systems is a cardinal issue in most of the countries.

The Slovak health care system provides a wide space for inefficiency decrease. The study's subject was all of the facts mentioned above. Its main aim is to examine relationships between the production of services and the quality of services in the process of providing health care at the level of hospitals in Slovakia and subsequently, evaluate the rate of differences between them. The Malmquist index evaluated the total efficiency of each researched hospital. Similarly, efficiency in its two researched divisions, service production division and service quality division, used the same index.

As a consequence of this fact, it is possible to create a scale of hospitals according to their hospital efficiency. The analyses results show significant differences in efficiency among individual hospitals. It will influence a different availability of health care among regions, as well as on a different rate of patients' satisfaction. Also, this rate will influence differences in health care demand within regions, and subsequently, it will influence a deepening of the regional disparities in health. The study's results provide a valuable platform for the creation of national and regional strategic health plans, whose aim is to eliminate disparities in health in the individual regions. Thus, these plans may create mechanisms for providing a sustainable health care system in Slovakia. The question of public health systems' sustainability enormously increases even in the context of the global threats of epidemics, such as COVID-19 pandemic.

References

Androniceanu, A. (2020). Major structural changes in the E.U. policies due to the problems and risks caused by COVID-19. Administratie si Management Public, 34, 137–149. https://doi.org/10.24818/amp/2020.34-08

Avkiran, N. K. (1999). An application reference for data envelopment analysis in branch banking: Helping the novice researcher. International Journal of Bank Marketing, 17(5), 206–220. https://doi.org/10.1108/02652329910292675

Bednárová, L., Pacana, A., Chovancova, J. (2013). Environmental information as a key to solve a problem with polluted territories, Ecology, economics, education and legislation: conference proceedings, volume II: 13th international multidisciplinary scientific geoconference SGEM 2013, 135–140.

Bem, A., Siedlecki, R., Predkiewicz, P., Gazzola, P., Ryszawska, B., Ucieklak-Jez, P. (2019). Hospitals' Financial Health in Rural and Urban Areas in Poland: Does It Ensure Sustainability? Sustainability, 11(7), 1932. https://doi.org/10.3390/su11071932

Braendle, T., Colombier, C. (2016). What drives public health care expenditure growth? Evidence from Swiss cantons, 1970–2012. Health Policy, 120(9), 1051–1060. https://doi.org/10.1016/j.healthpol.2016.07.009

De Meijer, C., O'Donnell, O., Koopmanschapa, M., van Doorslaer, E. (2012). Health expenditure growth: Looking beyond the average through decomposition of the full distribution, Journal of Health Economics, 32(1), 88–105. https://doi.org/10.1016/j.jhealeco.2012.10.009

Du, J., Peng, S., Song, W., Peng, J. (2020). Relationship between Enterprise Technological Diversification and Technology Innovation Performance: Moderating Role of Internal Resources and External Environment Dynamics, Transformations in Business & Economics, 19, (2(50)), 52-73.

Fare, R., & Grosskopf, S. (2000). Network DEA. Socio-Economic Planning Sciences, 34(1), 35–49.

Grembowski, D., Bekemeier, B., Conrad, D., Kreuter, W. (2010). Are local health department expenditures related to racial disparities in mortality? Social Science & Medicine, 71(12), 2057–2065. https://doi.org/10.1016/j.socscimed.2010.09.004

Grmanová, E. (2013). Aplikácia dvojstupňovej DEA metódy pri hodnotení efektívnosti poisťovní a bánk. Trends Economics and Management, 16, 7.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 2(6), 429–444.

Chen, Y., Cook, W. D., & Zhu, J. (2010). Deriving the DEA frontier for two-stage processes. European Journal of Operational Research, 202(1), 138–142. https://doi.org/10.1016/j.ejor.2009.05.012

Jacobs, R., Smith, P. C., & Street, A. (2006). Measuring Efficiency in Health Care: Analytic Techniques and Health Policy. https://books.google.sk/books?hl=sk&lr=&id=SdE0CV6XazkC&oi=fnd&pg=PA1&dq=%22Measuring+Efficiency+in+Health+Care%22&ots=kOEfjeWX9r&sig=_kypqe2mOSrYN7V9PFrUDDNDYvg&redir_esc=y#v=onepage&q=%22Measuring%20Efficiency%20in%20Health%20Care%22&f=false

Kao, C. (2017). Network data envelopment analysis. Springer, 10, 26–33.

Karlsberg Schaffer, S., Sussex, J., Devlin, N., Walker, A., (2015). Local health care expenditure plans and their opportunity costs. Health Policy, 119(9), 1237–1244. https://doi.org/10.1016/j.healthpol.2015.07.007

Kuca, K., Mohelska, H., Maresova, P., Valis, M. (2015). Alzheimer's disease and its treatment costs: Case study in the Czech Republic. Neuropsychiatric Disease and Treatment, 2349. https://doi.org/10.2147/ndt.s87503

Lewis, H. F., & Sexton, T. R. (2004). Network DEA: Efficiency analysis of organizations with complex internal structure. Computers & Operations Research, 31(9), 1365–1410. https://doi.org/10.1016/S0305-0548(03)00095-9

Liang, L., Cook, W. D., & Zhu, J. (2008). DEA models for two-stage processes: Game approach and efficiency decomposition. Naval Research Logistics (NRL), 55(7), 643–653. https://doi.org/10.1002/nav.20308

Liberko, I., Bednárová., L., Šíra, E. (2012) Selected approach for evaluation of best commerce insurance company on Slovak republic market, Nová ekonomika: vedecký časopis, 5(2), 71-79.

Luo, X. (2003). Evaluating the profitability and marketability efficiency of large banks: An application of data envelopment analysis. Journal of Business Research, 56(8), 627–635. https://doi.org/10.1016/S0148-2963(01)00293-4

Marešová, P., Klímová, B., Vališ, M., Kuča, K., Mohelská, H. (2016). Treatment costs of Parkinson's disease in Central Europe. E+M Ekonomie a Management, 19(3), 31-39. https://doi.org/10.15240/tul/001/2016-3-003

Megyesiova, S., Lieskovska, V. Analysis of the Sustainable Development Indicators in the OECD Countries. Sustainability, 2018, 10, 4554, https://doi.org/10.3390/su10124554

Megyesiova, S., Lieskovska, V. (2019). Premature Mortality for Chronic Diseases in the E.U. Member States. Int. J. Environ. Res. Public Health, 2019, 16, 4021. https://doi.org/10.3390/ijerph16204021

Mitropoulos, P. (2019). Production and quality performance of healthcare services in E.U. countries during the economic crisis. Operational Research, 1–17. https://doi.org/10.1007/s12351-019-00483-3

Ozcan, Y. A. (2014). Advanced DEA Models. In Y. A. Ozcan (Ed.). Health Care Benchmarking and Performance Evaluation: An Assessment using Data Envelopment Analysis (DEA), pp. 121–137. Springer US. https://doi.org/10.1007/978-1-4899-7472-3_8

Palečková, I. (2015). Banking efficiency in the Czech Republic and Slovakia using the DEA Window Analysis. In Working Papers (No. 0012; Working Papers). Silesian University, School of Business Administration. https://ideas.repec.org/p/opa/wpaper/0012.html

Predkiewicz, P., Bem, A., Ucieklak-Jez, P. et al. (2019). Public or Private? Which Source of Financing Helps to Achieve Higher Health System Efficiency? 4th Wroclaw International Conference in Finance held at the Location: Wroclaw Univ Econ, Wroclaw, 26-27. 9.2018, Contemporary Trends and Challenges in Finance, Springer Proceedings in Business and Economics, 2019, pp. 191-199.

Saleh, H., Malkhalifeh, R. M. (2013). Performance Evaluation in Bank Branch with Two-Stage DEA Model. 1(11), 17–33.

Seiford, L. M., Zhu, J. (1999). Profitability and Marketability of the Top 55 U.S. Commercial Banks. Management Science, 45(9), 1270–1288. https://doi.org/10.1287/mnsc.45.9.1270

Schofield, D., Shrestha, R., Percival, R., Passey, M., Callander, E., Kelly, S. (2013). The personal and national costs of CVD: Impacts on income, taxes, government support payments and GDP due to lost labour force participation. International Journal of Cardiology, 166(1), 68-71. https://doi.org/10.1016/j.ijcard.2011.09.066

Syczygiel, N., Rutkowska-Podolowska, M., Michalski, G. (2014). Information and Communication Technologies in Healthcare: Still Innovation or Reality? Innovative and Entrepreneurial Value-creating Approach in Healthcare Management. CERS 2014: 5th Central European Conference in Regional Science, International Conference Proceedings, 2015, pp. 1020–1029.

Tone, K., & Tsutsui, M. (2009). Network DEA: A slacks-based measure approach. European Journal of Operational Research, 197(1), 243–252. https://doi.org/10.1016/j.ejor.2008.05.027

Ucieklak-Jez, P., Bem, A., Siedlecki, R. et al. (2018). Concentration of Hospital Infrastructural Resources as a Source of Inequalities in Access to Health Care Benefits in Poland. In: Finance and Sustainability Conference Location: Wroclaw, 2017, Finance and Sustainability Book Series: Springer Proceedings in Business and Economics, 2018, pp. 1–10.

Vandersteegen, T., Cleemput, I., Vereeck, L. (2015). Health Policy, 119(3), 367-374. https://doi.org/10.1016/j.healthpol.2014.09.010

Van Baal, P. H., Wong, A. (2012). Time to death and the forecasting of macro-level health care expenditures: Some further considerations. Journal of Health Economics, 31(6), 976887. https://doi.org/10.1016/j.jhealeco.2012.08.003

Zimková, E. (2014). Technical Efficiency and Super-efficiency of the Banking Sector in Slovakia. Procedia Economics and Finance, 12, 780–787. https://doi.org/10.1016/S2212-5671(14)00405-5

Zimon, D., Gajewska, T., Bednarova, L. (2016). An Influence of Quality Management System for Improvement of Logistics Distribution, Quality-Accessto to Success, 17(155), 68–70.

Acknowledgements

This research was supported by the Internal Grant Agency of FaME Tomas Bata University in Zlin: RVO/2020: "Economic quantification of marketing processes that focus on value increase for a patient in a process of system creation to measure and control efficiency in health facilities in the Czech Republic".

Prof. Beata GAVUROVA, Ph.D. is an expert in finance, financial analysis and financial risk management. She focuses in her research work on issues of measurement and performance management in various sectors, process management and process optimization, strategic and performance benchmarking. Her dominant research area is the development and testing in the management and performance measurement, the evaluation of methodologies and the preparation of an application platform for innovative management and performance measurement with the support of ICT. She led several national projects, has participated in many international projects targeting the innovative applications of ICT in the private and public sector. **ORCID ID**: https://orcid.org/0000-0002-0606-879X

Assoc. Prof. Kristina KOCISOVA, PhD. is the Associated Professor at Faculty of Economics, Technical University of Kosice. Her research interests: application of Data Envelopment Analysis to measure efficiency in different sectors of the national economy, analysis of different aspects of the banking sector. **ORCID ID**: https://orcid.org/0000-0003-0784-441X
