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Performance measurement using DEA in Slovakia's Health Care Sector

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Abstrakt
Rising health care budgets due to demographic change and hospital expenditure are pushing states towards providing health care services as efficiently as possible. Policy makers seek to find ways to measure efficiency of public health care services rendered. Data envelopment analysis (DEA) is a linear programming method which quantifies the relative efficiency of multiple homogeneous entities (DMUs) and globally accepted method when comparing individual service or product providers and nowadays the most commonly used one. Slovakia's researchers have just recently established their presence in this field. The study collects and examines the so far published research studies which used DEA as a method for performance / efficiency measurement when dealing with Slovakia's health care sector. The small but rising number of current studies is a testament to overall rising acceptance of the DEA in Slovakia's academic landscape, while sophisticated DEA methodologies (e.g. Malmquist index) still have to be acquired.

Kľúčové slová
health care system, technical efficiency, performance measurement, data envelopment analysis

Informácia
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1. Introduction

Rising health care budgets also due to demographic change and hospital expenditure, which in some countries accounts to more than 50 % of the total health care expenditure, are of concern to many policy makers. New health care deals and bills, policy changes and exchange of information regarding individual states in Europe and worldwide (for example within the OECD) have all the focus of providing more and higher quality health care as efficiently as possible. Due to non-existent or low competition within this segment of the tertiary sector, the concern is mostly located at the level of policy makers and policy

influencers. While some countries are trying to increase competition through activity-based funding schemes and implementation of higher provider choice, the development of efficiency measures and performance indicators have been considered a prime.

As a rather young democracy Slovakia's health care system is still developing. After the major health care reform throughout the years 2002 till 2006 a new way of thinking was set to be introduced into the system, including increasing competition and changing perception of patients towards health and health care as being goods which do not come for free.

Although significant improvements in life expectancy and infant mortality were made since the 1990s, health care outcome of life expectancy is still below EU-15 average (Eurostat, 2022) and avoidable mortality rates are significantly high (especially ischemic heart diseases, cerebrovascular diseases and colorectal cancer) (Šoltés and Gavurová, 2015 in: Smatana et al., 2016). Although overall amendable mortality was reduced by around 28 % from 2002 to 2013, these results are still under those achieved by other countries (Kovalčík and Tunega, 2015 in: Smatana et al., 2016).

The focus of these studies and undertakings profoundly signify the rising need for a measured and quantifiable view of the health care sector as such, but also of further inclination in looking into the performance of it's regional or functional segments.

This research is part of a larger dissertation delving into the area of long-term care as a segment of health and social care while focusing on quality aspects of care and their significance. While the finished dissertation deals with implementation of the further discussed DEA method within the field, it builds upon this research with the aim to map out the existing implementations of DEA in the health care sector in Slovakia using literature review methodology.

2. DEA as an Instrument of Performance Measurement

Data Envelopment Analysis (DEA) is a linear programming method within the Operations Research instrumentarium that quantifies the relative efficiency of multiple homogeneous entities (called Decision Making Units / DMUs) (Cooper et al., 2007). To measure performance it uses a set of linear combination of outputs over a linear combination of inputs. The DMU is the entity responsible for the conversion of inputs into outputs.

Originally developed by Charnes, Cooper, and Rhodes (1978), DEA has been used widely by researchers to compare individual DMUs with each other in a variety of fields. While arriving from manufacturing and planning, it spread to educational organizations (schools, universities), health care (hospitals, clinics), agricultural production, banking services and many more. It builds upon the work of Farrell (1957), who focused on single input over single output technical efficiency estimation. While using linear programming optimization, which is a mathematical method to reach the best outcome for a linear objective function subjected to equality and inequality constraints, it estimates efficiency and establishes ranking of DMUs using multiple inputs over multiple outputs.

In managerial decision making organizations do tend to get inspired by competitors or other actors in their field of business. DEA supports this by providing rankings and slacks as results of its implementations thus practically not only providing the DMUs with their rank within a benchmarking scheme but also pointing out which DMUs optimal processes to look at and which problematic inputs and outputs to tackle to improve its standing.

Hollingsworth (2008), Pelone et al. (2015) and Kohl et al. (2019) have all conducted large scale review studies regarding the measurement of efficiency and productivity and use of DEA within the health care sector aimed at comparing methodological frameworks, focus areas, inputs and outputs used, even producing some conclusions regarding their results. Hollingsworth (2008) examines the overall health care spectrum – as stated above, more than half of those studies is being conducted regarding hospitals, while nursing homes, physicians, and primary care have all scored individually below 10 % of the studies examined – Pelone et al. (2015) focuses strictly on primary care and Kohl et al. (2019) at hospitals alone.

DEA is considered the mostly used tool in these studies. Almost half of the studies (48 %) examined by Hollingsworth (2008) are pure DEA implementations and further 19 % use DEA in combination or some other form of regression analysis. Malmquist studies (dynamic DEA method comparing efficiency scores in time) account for another 8 % of studies. Kohl et al. (2019) establishes that while almost all studies in their selection used DEA, 48 % of these publications also used a newer method or were used to develop and test newer applications (e.g. to use the Malmquist Index in fuzzy environments or to compare traditional DEA with other applications to highlight the effects of individual drivers within the used measures).

3. Methodology of Literature Review

To provide an overview and analysis of the current state of research on a selected topic or question such as the implementation of DEA towards measuring performance in the Slovakian health care system, literature review as methodology was selected. It's goal as a method in general is to evaluate and compare previous research on a topic to provide an analysis of what is currently known, and also to reveal controversies, weaknesses, and gaps in current work, thus pointing to directions for future research.

As the specific organization of a literature review depends on the type and purpose of the review, as well as on the specific field or topic being reviewed, we first examine the spectrum of literature available within the area of research. We then explore past and current work on the topic. Rather than a chronological listing of previous work, we selected to organize the found studies thematically, by issues and segments of health care they tend to focus on. This thematic organization makes it easier to examine contrasting perspectives, theoretical approaches, methodologies, and findings, which are helpful towards the analysis of their strengths and weaknesses.

From this analysis it will be sought to offer general valuation of the implementation and usage of DEA as efficiency and performance measuring method within the Slovak health care setting. As a part of a dissertation research the aim is also to demonstrate the relationship of the undergoing research to previous work.

When regarding the field of DEA health care related studies focused on Slovakia, the focus can be found to mirror the global wide application of the model: there are studies which deal with the macroeconomic view of the efficiency of the health care system as such, while others provide insights into their application on regional basis or even comparing individual decision making units as hospitals and specialized centers. Within the literature review process, we will begin at the macro-level and process further towards regions and individual hospitals, arriving finally at specialized institutions. Regardless we will provide an overview table to summarize and contrast their respective sample sizes and used application models.

4. Results and Discussion

Within this literature review we collected overall five DEA studies with different focuses. This amount of health care relevant DEA research reflects the rather small number of researchers and teams focusing on this policy and managerial sector. The macro-economic analytical views of Slovakia have been done as part of overall cross country comparisons or stem from a local research projects (Jankovič and Mandžák (2019)) dealing with accession to the market and competition in the healthcare sector. Regional efficiency analysis is reflected in the research of Štefko et al. (2018) and further Kočišová et al. (2019) building upon the previously mentioned study. Individual hospitals and specialized centers are focus of just two studies so far by Hajduová et al. (2015) and Lacko et al. (2017). Studies which were excluded from this review are studies which used DEA just as an initial part of their overall structure or which do not focus solely on Slovakia but overall cross country comparison where Slovakia is not the focus country.

The following table (author's own research) provides an overall review of the studies under scrutiny:

Study Type	Author	Type and Number of DMUs	Number of Inputs	Number of Outputs
Country	Jankovič and Mandžák (2019)	30 countries x 11 years	1: • Health Care Expenditures	2: • Healthy Years of Life • Preventable Deaths
Regions	Stefko et al. (2018)	8 regions x 8 years	5: • Number of beds • Number of medical staff • Number of CT devices • Number of MR devices • Number of medical equipment overall	2: • Bed occupancy rate • Average nursing time in days
	Kocisova et al. (2019)	8 regions x 8 years	2: • Number of beds • Number of medical staff	2: • Bed occupancy rate • Average nursing time in days
Hospitals	Hajduova et al. (2015)	55 hospitals	6: • Number of doctors • Number of nurses • Number of other staff • Medical costs • Number of beds • Costs per bed	3: • Number of treatment days • Number of patients • Number of outpatient visits

Lacko et al. (2017)	4 facilities x 6 years	5: • Number of doctors • Number of nurses • Number of other staff • Number of beds • Costs per bed	2: • Number of hospitalizations • Number of outpatient visits

To provide a basis for the upcoming discussion of the review results, individual studies are being discussed.

Jankovič and Mandžák (2019) have estimated efficiency of public health care expenditures using DEA for Slovakia and compared it with other countries. By using per capita type of variables (health expenditures per capita, healthy years of life and preventable deaths per million people) they arrive at a dire ranking results (last position in ranking efficiency using the CCR output oriented model) yielding high potential for improvement. Slovakia would need to either reduce health care expenditure per capita and number of preventable deaths by more than half as it keeps the same level of healthy life years per capita to rank as efficient.

Stefko et al. (2018) have used the method to evaluate health care technical efficiency in individual regions and quantify the basic regional disparities and discrepancies with focus solely on 56 hospitals. Input-wise they they regard relevant categories as labor by selecting total number of medical staff (including the number of physicians and nurses) without selecting out these or regarding specialized personnel as a distinct input. Overall patient capacity of hospitals is represented with total number of beds. In their argument each added bed means an extra cost to the hospital for its purchase and future operation, while also a source of marginal profit. Their specialized treatment capacity and capability is characterized by number of tomography (CT) and magnetic resonance (MR) devices as separate inputs. These reflect not only technological availability but rather specialized diagnosis utilization within the hospital setting. All inputs used within the study prove to be in accordance with generally accepted norms when utilizing DEA in a hospital segment. Output variables used are bed occupancy rate and average nursing time in days and directly reflect the use of resources in a hospital. Lower bed occupancy rates are considered a sign of inefficient resource use and may lead also to an argument of a low quality as described earlier. Average length of nursing time or stay is calculated as ratio of total number of treatment days to the number of hospitalized patients. By reducing the length of stay hospitals reduce overall costs. The models selected are standard BCC and CCR models while the results delivered by those are further compared with each other.

Kocisova et al. (2019) as being also part of the previous research team built upon this in their study by evaluating the impact of external environmental variables. Their DEA model used just two inputs (number of beds and number of overall medical staff) and two outputs (use of bed capacity and average nursing time). Regarding the DEA results, they conclude that regions with higher number of capacity (beds) use these less efficiently than those with lower capacity. Similarly the overcapacity of medical personnel leads to lower efficiency indices in its utilization. We may pose the argument that managerial decisions while using scarcer resource lead to their more efficient utilization. Surpluses of capacities at some regions but also a lower efficiency in their usage have been noted. Higher length of stay (thus increase in nursing days output within the model) may however lead to more critical patient's cases being accepted and implementation of more difficult treatment procedures which may lead to increase in financial resources

needed. The authors also note the overall trend to reduce the inpatient hospitalizations and a shift towards outpatient services and savings of beds. These trends may lead to even lower bed and staff use however may lead to increase in re-admissions and therefore higher financial pressure in the long run.

Prior to these two studies Hajduova et al. (2015) used DEA to evaluate and compare sets of general and specialized hospitals (37 DMUs) with university hospitals (13 DMUs) and private hospitals (5 DMUs). Selected inputs as number of doctors, nurses, other staff, material costs, number of beds (capacity) and costs per bed cover the integral aspects of the capital and labour inputs within health care. Three outputs: total number of treatment days, number of patients admitted and number of outpatient visits provide a solid ground in measuring direct outputs of hospital services. While the paper proved short on comparing the individual sets of hospitals, it provided an interesting overall trend as general and specialized hospitals in Slovakia were found to be increasing their efficiency. The reasons were a decrease in material costs and costs per bed, which allowed most hospitals to retain or increase their efficiency.

A single study was so far published in Slovakia regarding the long-term care health care segment. Lacko et al. (2017) have focused on selected specialized heath centers in Slovakia – namely specialized in geriatric care. While collecting and comparing the data just from four DMUs, they managed to obtain data from six years each thus arriving at data from 24 individual states of these DMUs, which allowed them to use a high amount of inputs and outputs. The authors opted for labor descriptive inputs such as number of doctors, nurses and other staff of these centers, as well as capital descriptive inputs like costs per bed and number of beds (all average per year). As output variables number of hospitalizations and number of outpatients were selected. The sum of used inputs and outputs is within the mentioned maximum of possible inputs and outputs for these unit set. Due to the nature of the model the results rendered to be very center-specific. If a center proved to have problems within number of regular outpatients (output) or costs per bed (input), it proved to be the case for almost (or throughout) all years, as none of the centers changed drastically structurally (regarding inputs or outputs) during the research period. Because of this, individual centres were easily ranked in comparison to each other. Most relevant and significant slacks were identified in areas of number of outpatient visits / regular patients (thus capacity usage) but also costs per bed and number of beds (capital-bound inputs). Lowering the number of physicians / doctors was regarded as significant by some model situations however also described as critical due to “decreasing it could result in problematic fulfillment of the norms issued by the Ministry of Public Health about required staff ward safety” (Lacko et al., 2017, p. 155). Increasing number of patients are also realistically blocked by norm numbers set by the insurance companies covering the health care contract with these institutions, as the over-head number of patients would have to be financially covered by the long-term care facilities themselves, not mentioning that this care would demand increasing the numbers and capacity of doctors, nurses and other staff.

5. **Conclusion**

The aforementioned studies mirror the overall global approach to using DEA in health care as a performance measurement method. The selection of their inputs and outputs is in accordance with global standards. They focus on different levels of the health care sector – either the overall performance of the country in comparison with other countries, comparison of individual regions within Slovakia providing insight into policy making issues regarding administrative structure or focus on individual hospitals and

their technical efficiency. Thus, we may regard the spread and use of the Data Envelopment Analysis as extensive in Slovakia regarding their area of scope. On the other hand, while the method has been around since the 1980's, Slovakia's researchers are just catching up when regarding the number of involved studies undertaken so far. This may be regarded as partially due to the country's size and history as a young democracy which slowly establishes also a stronger academic basis in regards to policy making measurement and control mechanisms.

When regarding the use of the DEA models, which have undergone a significant development (e.g. Malmquist Index, Super Efficiency Models) since their invention, all of the studies have so far used the basic CCR and BCC models. Only the researchers of Lacko et al. (2017) have opted for a specialized application of the bootstrap resampling leading towards biased-corrected DEA scores. In other cases further use of the efficiency scores is presented by conventional statistical methods (regression analysis used by Kocisova et al. (2019)). Other authors (Jankovič and Mandžák (2019)) even outright call for further studies using more sophisticated analysis methods (e.g. Malmquist index). The omittance of Malmquist method especially when regarding that multiple of the studies have used – most probably due to the smaller sample size – several years of individual datasets for the same DEA application is a question on its own. Another question which remains to be answered is the application of the results of these studies towards their respective analytically examined DMUs and their stakeholders. Thankfully many of the studies do propose applicable results and comment their implications towards policy makers or hospital managers.

Overall – based on the rising frequency of DEA applications within the health care sector in Slovakia in the last couple of years – it is to be concluded that the importance and applicability but also the sophistication of the DEA method is on the rise within the Slovak academic community and further performance measurement studies are to be expected.

References

1. Charnes, A. Cooper, W.W. Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *Eur J Oper Res. 1978;2(6)*, pp. 429–44.
2. Cooper, W.W. Seiford, L.M. Tone, K. (2007). Data Envelopment Analysis, A comprehensive Text with Models, Applications, References and DEA-Solver software. 2nd edition. *New York: Springer*, 512 p.
3. Eurostat (2022). Eurostat Health Database. [Online] Available at: http://ec.europa.eu/eurostat/web/health/overview (accessed 8 May 2022).
4. Farrel, MJ. (1957). The Measurement of Productive Efficiency. *J R Stat Soc Ser A (General). 1957;120(3)*, pp. 253–90.
5. Hajduova, Z. Herbrik, G. Beslerova, S. (2015). Application of DEA in the Environment of Slovak Hospitals. *Investment Management and Financial Innovations, 12(4-si)*, pp. 148-153.
6. Hollingsworth, B. (2008). The Measurement of Efficiency and Productivity of Health Care Delivery. *Health Economics 17*, pp. 1107–1128.
7. Jankovič, P. Mandžák, P. (2019). Can Money Buy Health? Data Envelopment Analysis of Healthcare Expenditure. *Ekonomické rozhľady / Economic Review, Year 48, 4/2019*, pp. 415-428.

8. Kocisova, K. Gavurova, B. Behun, M. (2019). The Importance of Implementing Environmental Variables in the Process of Assessment of Healthcare Efficiency through DEA. *Ekonomický časopis, 67, 2019, No. 4*, pp. 367 – 387.
9. Kohl, S. Schoenfelder, J. Fügener, A. Brunner, J.O. (2018). The Use of Data Envelopment Analysis (DEA) in Healthcare with a Focus on Hospitals. *Health Care Management Science (2019) 22*, pp. 245–286
10. Lacko, R. Hajduová, Z., Gábor, V. (2017). Data Envelopment Analysis of Selected Specialized Health Centres and Possibilities of its Application in the Terms of Slovak Republic Health Care System. *Journal of Health Management 19(1)*, pp. 144–158.
11. Pelone, F. Kringos, D.S. Romaniello, A. Archibugi, M. Salsiri, C. Ricciardi, W. (2015). Primary Care Efficiency Measurement using Data Envelopment Analysis: A Systematic Review. *J Med Syst 39(1)*, pp. 1–14.
12. Smatana, M. Pažitný, P. Kandilaki, D. Laktišová, M. Sedláková, D. Palušková, M. van Ginneken, E. Spranger, A. (2016). Slovakia: Health system review. *Health Systems in Transition, 2016; 18(6)*, pp. 1–210.
13. Stefko, R. Gavurova, B., Kocisova, K. (2018). Healthcare Efficiency Assessment using DEA Analysis in the Slovak Republic. *Health Economics Review (2018) 8:6.*