EFFICIENCY ESTIMATION OF THE UKRAINIAN PUBLIC HIGHER EDUCATION INSTITUTIONS: INSIDE AND OUT

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

MA in Economic Analysis

Kyiv School of Economics

2018

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Kyiv School of Economics

Abstract


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This thesis intends to investigate the efficiency of the individual Ukrainian higher education institutions to set up a benchmark for further development. First, the analysis focuses on 14 Ukrainian medical universities to analyze an input – oriented technical efficiency. Next, under the current integration processes between European Union and Ukraine, the analysis of the efficiency of the Ukrainian education system with EU member – courtiers and 6 non- EU members allows determining the position of Ukrainian HEI among the developed countries. The Data Envelopment Analysis is one of the widespread to analyze the efficiency of education and healthcare systems due to the homogeneity in inputs and outputs. The heterogeneous bootstrapping procedure allows to obtain the reliable scores analyzing the Ukrainian universities and smoothed homogeneous were used for the cross-country estimation. The Zaporizhia State Medical University demonstrates the best results inside the country and could be used as a benchmark for Ukrainian medical universities. The comparison with the developed countries displays that Bulgaria, Turkey and Ukraine are the most prosperous countries that use the resources most efficiently way with the number of enrolled students as the output. Change in output for the next model indicates that Ukraine became the most efficient country under all assumptions. The Bulgaria, Turkey and United Kingdom are efficient under the different mix of assumptions.

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LIST OF ABBREVIATIONS

**HEI**. Higher Education Institution

**MoH**. Ministry of the Health of Ukraine

**DEA**. Data Envelopment Analysis

**CRS**. Constant Returns to Scale

**VRS**. Variable Returns to Scale

**NIRS.** Non-increasing returns to scale

**ISCED**. International Standard Classification of Education

*Chapter 1*

# INTRODUCTION

Education is a ground of nation' development and well-timed appraisal of the education system allows the government to ensure more effective resource allocation. The government spending for education as a share of GDP varies among the countries. According to the combined data from the Eurostat and the UNESCO Institute for Statistics demonstrates that Ukraine is on the top-five among the 31 EU countries with the highest share of government expenditures for tertiary education (Figure 1). Only four EU countries: Sweden (1.94%), Finland (2 %), Norway (2.2 %) and Denmark (2.35) spent more than Ukraine for the postsecondary education.

However, one of the most respected global ranking "The Times Higher Education World University Rankings 2018"[1][1], which covers more than 1000 Universities over the world, reflects the gloomy results for Ukraine. The World University Rankings chooses 13 indicators to rank the HEIs, which divided into the five groups: teaching, research, citations, international outlook (staff, students and research) and industry income. According to the ranking, only five Ukrainian universities are present in this ranking and none of them is present in top-1000. Meanwhile, the European institutions cover almost 100 top places among the top 1,000 universities in the world. The other ranking "Webometrics Ranking of World Universities" considering the The National Taras Shevchenko University of Kyiv occupies the 1,273 position among 20,000 HEIs in the 2018[2].

Quite a low level of education in Ukraine and galvanizes the process of students' migration. According to the independent non-profit analytic center

1 https://www.timeshighereducation.com/world-university-rankings/2018/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats
2 http://www.webometrics.info/en/Europe/Ukraine%20

CEDOS, growth in the number of Ukrainian students at foreign universities from 2009 to 2015 was 129%[3].

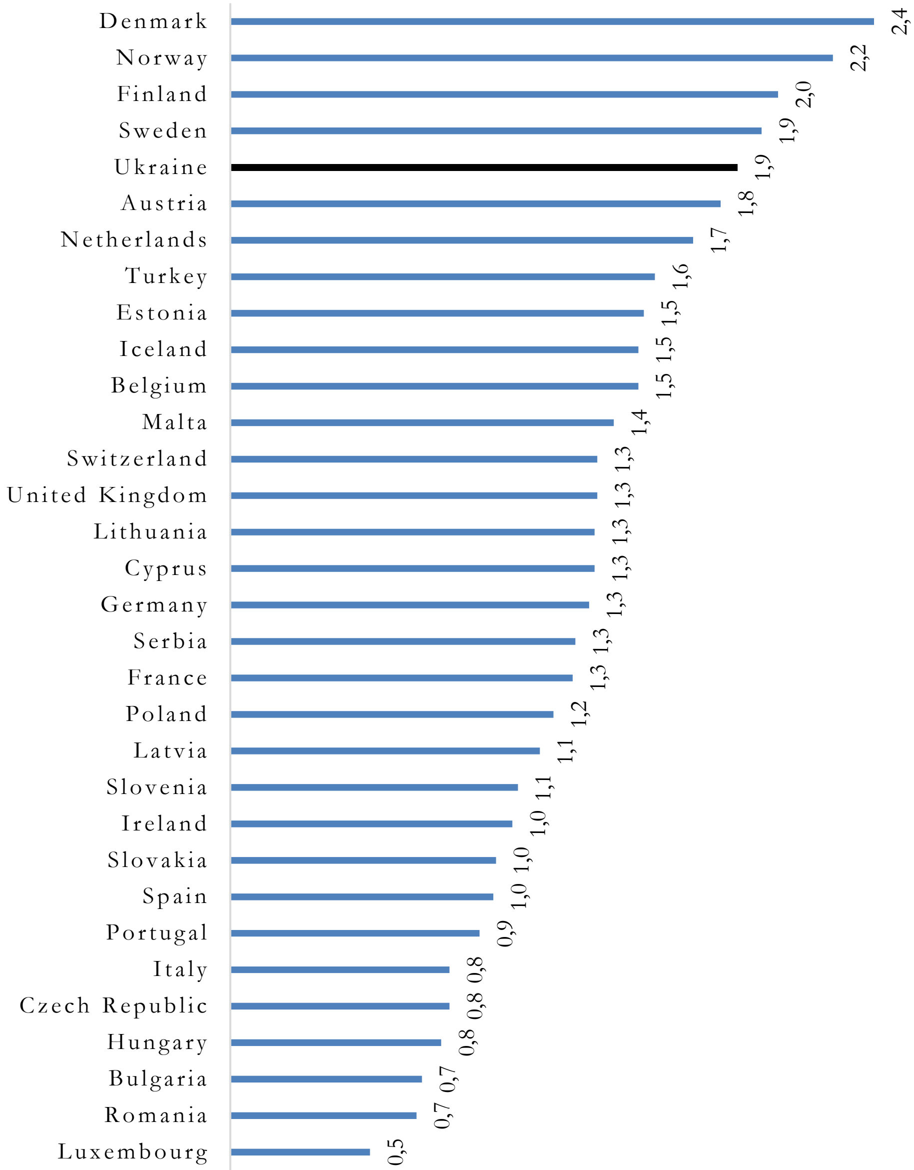


Figure 1. Public Expenditure on Tertiary Education in 2014, % of GDP

Poland, Germany, Russia, Canada, Italy, Czech Republic, the USA, Spain, Austria, France and Hungary are among the most desirable countries to study

[3] https://cedos.org.ua/uk/osvita/ukrainski-studenty-za-kordonom-skilky-ta-chomu

for Ukrainians. The EU HEIs are considered as one of the most attractive options for the potential students. There are over 1.4 million students from around the world came to Europe in 2012 to gain higher education. In addition, the scholarships and other financial support opportunities stimulate students to select the EU education.

There were almost 300 Universities in Ukraine where studying almost 1.4 mln. students in 2017[4]. Focusing on the students from abroad, which come to Ukraine to gain higher education number of insights, could be obtained. The Ministry of Education and Science of Ukraine highlights that India, Azerbaijan and Morocco account for more than 35% of inbound students. Among the top 10 most popular universities among international students, 7 HEIs are medical universities. This fact demonstrates the interest to the Ukrainian medical education system. There are the 14 medical HEIs, which operate under the Ministry of Health of Ukraine and compete for the attraction of external students. In addition, reforms in medical education in Ukraine is one the top priorities for medical reform in the country, therefore the estimation of the efficiency could be an important part for further improvements supporting current innovations. For example, the first international monitoring quality assessment of higher medical education was held in Ukraine in 2018[5], which should drives the standards of the medical education towards the international level. However, the acting health minister of Ukraine, Ulana Suprun, mentioned that only 3 percent of Ukrainian junior doctors passed the United States Medical Licensing Exam — the general education test every medical doctor has to pass in the United States to get the medical license[6]. Finally, combining the results from the quality and efficiency

4 http://www.ukrstat.gov.ua/
5 http://moz.gov.ua/article/reform-plan/reforma-medichnoi-osviti-scho-zminitsja-dlja-studentiv-ta-likariv-
6 https://www.kyivpost.com/lifestyle/ukrainian-universities-boast-quantity-quality-lacking.html

assessment provides the opportunity to understand broad picture about the medial higher education in Ukraine.

A difficult economic situation and decreasing the financing for education in real terms in Ukraine highlights the importance of the efficient resource allocation. The financial support for government higher institutions came from the Ministry of Education and Science of Ukraine, but a parallel education system exists. There are more than 10 other ministries, which are teaching more than 19%[7] all students. The extensive infrastructure of the education system also leads to the inequality among the universities and complicates a task of the efficiency estimation.

There are two points of interest in this research. The first task is to determine, which of the medical universities in Ukraine should be considered as a benchmark for the best practices implementation under the current reforms. The second question tries to figure out the further direction for successful education reform' developing under the EU integration path. The suggested hypotheses Ukraine is much less efficient in inputs usage relative to the EU countries. Therefore, the identification of the outstanding practices could be taken into account by the government to put the Ukrainian HEIs on the top of the worldwide rankings.

All facts as mentioned above stipulate interest of the efficiency estimation inside the county using the example of the medical HEIs and further comparison with the developed countries. As a general approach estimating the efficiency level is the comparison of inputs and outputs. In this study, we use the Data Envelope Analysis as one the widespread approach to estimate the efficiency in education system. Thus, DEA is applied to measure the efficiency of higher education all over the world. In recent years, many researchers have studied the efficiency of universities in different countries,

[7] http://www.ukrstat.gov.ua/

such as the UK, Australia, Turkey, India, Malaysia, Thailand, Czech and China.

The DEA has number of the advantages, which make the efficiency estimation possible. The lack of requirements for the specification form and usage of the multiple inputs and outputs make the DEA attractive among the efficiency estimation methodologies. This method estimates the relative efficiency using the peers' comparison to obtain the efficiency scores.

Finally, the contributions of this research are twofold. First, this master thesis contributes to the literature providing the efficiency analysis for medical Ukrainian universities. The popularity of the usage of the DEA in Ukraine could be noticed starting from 2000. The oldest research about the technical efficiency estimation is related to the Grain Production in Ukraine. Kurkalova, Lyubov A., and Helen H. Jensen (2000) use stochastic production frontier to estimate the technical efficiency on a representative sample of Ukrainian state and collective grain-producing farms. The other study by Vitaliy Zheka (2005) investigates the corporate efficiency. Author adopts the Data Envelopment Analysis too and use the Limited Dependent Variable Estimations for the research purposes.

As best of my knowledge, there is only one paper (Lissitsa, Coelli, Rao, 2005) describes the efficiency in education in Ukraine and estimates technical efficiency of 44 agricultural economics programs from 19 Ukrainian universities during the 2002/03 academic year. Authors used the two stage approach and find out "wide disparities in performance, ranging from 36% to 100% technical efficiency". At the next stage, they figure out that student demand, commercial activities and staff quality have a significant effect on the efficiency of a university or program.

Second, it is the difficult task to find the research about the cross – country comparison of the efficiency assessment of the Ukrainian higher education system with developed systems. The study by Gorodnichenko, Y. and Peter, K.S. (2005) intends to measure the returns to schooling in Russia and Ukraine from 1985 to 2002 and determine the reasons for the difference between countries. Although the authors figure out that the price effect is the major argument for the differences in returns to schooling, no other studies could be found, which put the focus on the cross – country comparison of the education system of Ukraine. Therefore, this master thesis will provide the scientific background for the further reforms in Ukraine.

The thesis is structured as follows. Chapter 2 describes the main findings related to the efficiency estimation in higher education and provides literature overview. The detailed methodology of the DEA is a core of Chapter 3. The data description and characterization of inputs and outputs indicators are present in Chapter 4. The estimation results and policy implications are the part of Chapter 5. The summary of the thesis is provided in the Chapter 6.

*C h a p t e r  2*

# LITERATURE REVIEW

Charnes, Cooper and Rhodes first developed the efficiency estimation through the nonlinear programming methods in 1978. Authors focus mainly on the nonprofit organizations to evaluate their performance. More general usage of the DEA methodology could be noticed looking at Herrera and Pang (2005), which examined the efficiency of public spending in the emerging economies through the two-stage approach. First, the efficiency as a distance between input - output combinations and efficient frontier using Free Disposable Hull (FDH) and Data Envelopment Analysis (DEA) was estimated. Secondly, authors verifying the statistical association between the efficiency scores and environmental variables using the Tobit estimation. The obtained results show the inverse relationship between the expenditures and efficiency scores: higher expenditures demonstrates lower efficiency rates.

Nowadays the DEA is widely used in different areas such as service (Hathroubi, Peypoch, Robinot, 2014), scientific production (Schubert, 2014) and education (Ruiz, Segura, Sirvent, 2015). The Liu et al. (2013) tried to investigate the different application of the DEA and figure out that banking, health care, agriculture and farm, transportation, and education are the most popular industries for such type of analysis. Authors investigate the efficiency on every stage of education in different countries. Burney and Johnes (2013) point their attention to the four levels of schooling (kindergartens, primary, intermediate and secondary) in Kuwait. Sutherland, Price, Joumard and Nicq (2007) analyzed the spending efficiency in primary and secondary education both within and among the OECD countries. The paper demonstrates a potential to improve efficiency among the countries and corroborate the fact of a wide range of efficiency within some countries. A strong correlation between two estimates of the efficiencies were obtained using the DEA and stochastic frontier analysis. Haelermans et al. (2012) focus only on the Dutch secondary schools. Bayraktar et al. (2013) measure the efficiency in Turkish public and private universities. The total performance of the university faculty was a point to research by De Witte et al. (2013).

The efficiency estimation became an essential tool for the higher education institutions due to the limited financing and growing pressure. Nazarko and Šaparauskas (2014) use the DEA to in the efficiency assessment of Polish universities of technology and highlights the importance of such research for further policy implications.

The DEA technique applies to efficiency assessment of HEIs in the different countries. For example, Abbot and Doucouliagos (2003) chose to put their research interest to the 36 government-owned universities in Australia through the DEA. The Johnes (2006) and Fleggs et al. (2003) investigate the performance of universities in England. The Greece HEIs are the focus of the research by Katharaki and Katharakis (2010). The Chilean universities were analyzed by Ramirez-Correa et al. (2012). Kantabutra and Tang (2010) look at the Thai public universities and develop two models to examine the teaching and the research efficiency.

The other group of paper, which use the DEA to estimate the efficiency, concentrates on narrow part of the higher education system and focuses on the university departments. The 19 academic departments of Indian university were analyzed through for teaching and research activities using DEA methodology with the sensitivity analysis to test the robustness of the scores. In addition, Martin (2003) also investigates both activities in the Zaragoza University's departments. The measurement of the efficiency in academic departments of an engineering college in Turkey was the point of interest of Köksal and Nalçaci (2006). The application of the DEA methodology could be found in the study by Agha et al. (2011), which investigates the academic departments' efficiency in the Islamic University in Gaza. Moreno and Tadepali (2002) analyzed the efficiency of academic departments at a public university and point out to the importance of this kind of research for university administrators. Kao and Hung (2008) analyzed the relative efficiency of the academic departments at National Cheng Kung University in Taiwan. Authors divide the departments of similar features via an efficiency decomposition and cluster analysis. The Liu and Xu (2017) investigate the effects of educational efficiency on national competitiveness for 53 countries with the focus on the East and Southeast Asia. They obtain the results using the Data Envelopment Analysis (DEA) and the Malmquist Index (MI). Firstly, the researchers analyzed the educational efficiency and effects of educational efficiency on national competitiveness was further evaluated. Finally, authors conclude that for the most competitive countries educational efficiency has the most significant impact. The Liu and Xu state that the educational efficiency becomes important when the level of national competitiveness reaches a particular stage.

Wolszczak-Derlacz and Parteka (2011) focus on the European public higher education institutions (HEI) using the two-stage approach. They analyzed 259 public HEIs from 7 European countries across the time period of 2001–2005 combining parametric and non-parametric approaches. Authors used different specifications for DEA: 3 inputs and 2 outputs; 2 inputs and 2 outputs. After the efficiency scores were obtained, they were connected with the HEI characteristics. The paper highlights that the size of the educational institution, the number and composition of faculties, sources of funding and gender staff composition are the most significant parameters for the efficiency evaluation.

The experience of the Czech Public Universities highlights the importance of the division the HEIs according to the specialization, because more costly specialties requires more inputs and as a result, they become less efficient. In this paper, Pavla Mikušová (2015) selected only public universities because they account 99.7% of the budget. In this study, the DEA (output - oriented) was used with the different input and output mix.

Abd Aziza, Janorb and Mahadi (2013) investigated the difference in the efficiency focus on the 22 departments of a public university in Malaysia. Authors used DEA with four combinations of the input and output indicators and constant return to scale because of the low correlation between the number of academic staff and CCR efficiency scores. Variety of efficiency scores among the departments demonstrates the sensitivity of the DEA the number of inputs and outputs.

Besides, the literature analyzes highlights the importance of the methodology used for the efficiency estimation. Johnes, G., and Tone, K. (2017) point to the sensitivity of the efficiency scores using the different measurement techniques. Authors consider DEA and two options of the slacks - based measures (SBM). The estimation of the efficiency scores varies among the methods; especially SBM-Min demonstrates the significant distinction from the other approaches.

Taking into account a negligible level of the efficiency estimation in Ukraine and widespread usage of the DEA methodology in the world, current analysis becomes especially crucial for the Ukrainian government and researchers to identify the country position.

*C h a p t e r 3*

# METHODOLOGY

The literature proposed different methods to obtain the efficiency estimates in various fields of study. There are two major approaches to estimating the efficiency with multiple inputs and outputs. The first group of methods is nonparametric approaches which calculate the efficiency without production function form' specification. The Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) are the most popular methodologies. These approaches use the peers' analyses and establish the benchmark for further comparison through solving the optimization technique. Under the non-parametric technique, the efficiency score is calculated "as a ratio of the distance from the origin of the outturn relative to the efficiency frontier" (Johnes, 2017).

The main difference between the DEA and FDH is an assumption about the shape of the efficiency frontier. Using the DEA, the returns to scale approach will be the major factor, which determine the shape of the efficiency frontier. There are three assumptions about the returns to scale using the DEA: Constant returns to scale (CRS), Variable returns to scale (VRS) and Non-increasing returns to scale (NIRS). For example, under the CRS assumption, the efficiency frontier perceived as a ray from the origin through the observation(s) with the highest efficiency score. The CRS is the most widespread approach among the researches and it assumes that an increment in input results in proportion increment in outputs. The efficiency frontier using the FDH approach looks in a stepwise fashion and relaxes the assumption about the convexity. Both methods could estimate the efficiency scores for output – oriented and input – oriented models depending on the purpose of the analyses. The output orientation models describes how much outputs could be expanded given the current levels of inputs. In input – oriented model, we obtain the scores, which displays how much inputs could be abbreviated without reducing the level of outputs (Figure 2). In addition, literature propose to make a choice between the input and output orientation considering the control over the variables by the DMU. In the current study, it's assumed that both the individual university and country could easily handle with inputs rather than outputs.

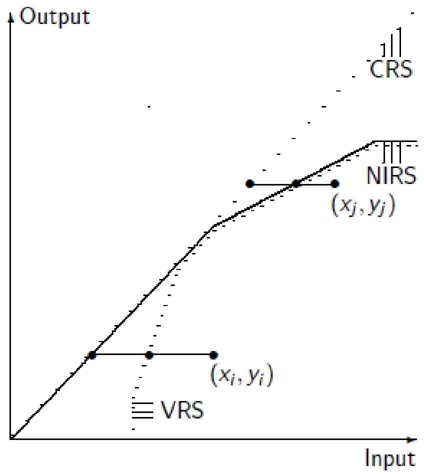


Figure 2. Input – based production processes (one input, one output) with different technologies CRS, VRS and NIRS. Reprinted from "Nonparametric Frontier Analysis using Stata" by O. Badunenko and P. Mozharovskyi, 2016, The Stata Journal 16, p.4.

In addition, the nonparametric techniques have two different types to provide efficiency analysis, radial and nonradial. Firstly, the radial Debreu-Farrell measure of the efficiency loss assumes that available inputs and outputs are feasible feasible (Debreu 1951; Farrell 1957). Secondly, the expansion/reduction all outputs/inputs is proportional until the frontier is reached. Meanwhile, the nonradial approach (Russell measure) suggests that some but not all outputs/inputs can be expanded/shrunk) while remaining. This research proposes the analysis of the efficiency using the radial approach to identify the position of the unit.

The second group consists of the parametric approaches that specifies the production function and perform the analysis through statistical methods.

For example, one of the most widespread approach is Stochastic frontier analysis (SFA), which decomposes the regression error term into statistical noise and measure of inefficiency. However, the SFA requires the functional form specification and sets the assumption about the inefficiency distribution. The obstacles that occurs using the SFA highlights the convenience of the DEA usage. However, the DEA also has some features, which should be taken into account. For example, the DEA method estimated the relative efficiency, not an absolute one and there are no "ideal efficiency" for the comparison. This problem makes the DEA sensitive to choice of peers and create a small sample bias. The other problems is also related to the sensitivity of the method in measurement error, statistical noise and outliers (Greene 1997; Coelli et al. 2003, and Murillo-Zamorano 2004). In addition, incorrected selected and omitted mix of inputs and outputs will provide the unreliable estimates.

In my master thesis, I will focus on the nonparametric DEA to estimate the efficiency of the universities in Ukraine and EU countries. The decision-making unit (DMU) for the first portion of analyses is an individual University and the second considers the Country as the DMU.

There are three major requirements for DMU which should be satisfied. Homogeneity of DMUs is one assumption for appropriate usage of the DEA approach. The first assumption suggests that the DMUs must perform through the similar activities and have the same purposes. Under the second, DMUs should utilize identical inputs to produce the same outputs. Finally, they should operate within the same surroundings (Dyson et al., 2001). Individual universities in this study are homogeneous units because they have similar resources and orients to the same results. In addition, all HEIs assigned to the same objectives. All medical Universities operate using the same inputs as academic staff, administrative staff to produce the similar outputs.

DEA is the optimization method mathematical programming and designed in the way to separate the efficient and inefficient units. The efficiency rate of the unit is considered as a ratio of weighted outputs and weighted inputs.

At first, it's hard to find the data, which will reflect the reality of the education system in Ukraine and to choose a good quality output, because of the high level of corruption in the education system and lack of the data. Therefore, it is more interesting to put emphasis on decreasing of the inputs to improve efficiency and focus on input-orientation DEA approach.

In addition, some studies analyze different types of efficiency such as teaching and research efficiency. However, the low level of publications of the Ukrainian researches in the international journals makes impossible the assessment of the research efficiency.

According to the model, we should maximize the efficiency rate of the DMU and the rate could be calculated solving the following linear fractional programming model (Pavla Mikusova, 2015):

$$\text{maximize} \quad z = \frac{\sum_i^r u_i y_{iq}}{\sum_j^m v_j x_{jq}} \tag{1}$$

$$\text{subject to} \quad \sum_i^r u_i y_{ik} \leq \sum_j^m v_j x_{jk}\, , k = 1,2, \ldots n \tag{2}$$

$$u_i \geq \varepsilon, i = \ 1,2, \ldots r \tag{3}$$

$$v_j \geq \varepsilon, i = \ 1,2, \ldots m \tag{4}$$

where

$z = value\ of\ efficiency\ of\ DMUq$

$\varepsilon = infinitesimal\ constant$

$x_{jk} = value\ of\ the\ j - th\ input\ for\ DMUk$

$y_{ik} = value\ of\ the\ i - th\ output\ for\ DMUk$

$v_j = weighnt\ of\ input$

$u_i = weight\ of\ output$

Infinitesimal constant $\varepsilon$ ensures all weights to be positive. This linear fractional programming problem provides an infinite number of solutions, because of the maximization of the output in the numerator and minimization of the inputs in the denominator. This problem leads to the transformation of the problem formulation to the linear programming and we can determine the constant in the following way:

$$\sum_j^m v_j x_{jq} = 1 \tag{5}$$

From the formula we can see that the sum of all inputs should be equal to 1 and in the output oriented the sum of all outputs should be equal to 1. Substituting the equation (5) into the (1) we obtain the following formula for the linear programming for DMU:

$$\text{maximize} \quad z = \sum_i^r u_i y_{iq} \tag{6}$$

subject to conditions (2), (3), (4) and (5).

As mentioned above, the DEA approach is sensitive to the set of DMU, which was selected and represents only subset of the true production set. Consequently, the obtained technical efficiency scores are too optimistic and it became challenging to make an appropriate statistical inference. To alleviate this issue the bootstrapping technique could serve as a solution, which enables to estimate the bias and the confidence interval of the original estimate. The bootstrapping technique depends on some assumptions. Analyzing the input-based efficiency measurement, the major assumption depends on whether the estimated input-based measures of technical efficiency are independent of the mix of inputs (Badunenko, Mozharovskyi 2016). The independence could be tested through given the assumption of returns to scale of the global technology (Wilson 2003). The received results explain what type of the bootstrapping procedure should be used. If the measures of technical efficiency are independent of the mix than smoothed homogeneous bootstrap required. Otherwise, performing the heterogeneous bootstrap the statistical inference became possible.

The assumptions about the return to scale will be tested econometrically using Simar and Wilson (2002) approach. The null hypothesis states that global technology is globally CRS. If we reject the null hypothesis under the first test than the technology is globally VRS. If null hypothesis is satisfied, then the average distance between VRS and CRS frontiers is small. However, we can investigate further and perform the second test. The null hypothesis assumes that technology is globally NIRS versus VRS. In addition, the above-mentioned testing approach helps to test scale efficiency for each data point.

At first, it's hard to find the data, which would reflect the reality of the education system in Ukraine and to choose a good quality output, because of the high level of corruption in the education system and the lack of the data. Therefore, it is more interesting to put emphasis on decreasing the inputs to improve efficiency and focus on input-orientation DEA approach.

In addition, some studies analyze different types of efficiency such as teaching and research efficiency. However, the low level of publications of the Ukrainian researches in the international journals makes it almost impossible to assess the research efficiency, therefore the main focus of this study is on the teaching efficiency.

Different combinations of the input with the fixed mix of the outputs were used to estimate the efficiency. All models were developed using the input-oriented approach using the statistical software package Nonparametric Frontier Analysis in Stata (Badunenko, Mozharovskyi 2016).

The two models were used to highlight the differences with dissimilar outputs (Table 1). At first, the efficiency scores with the enrolled students were considered for both "inside" and "out" types. The number of graduates was chosen to confirm the fact that a high level of graduation could not always be considered as a measure of efficiency. In case of the cross – country comparison the one monetary term displays the public expenditure for tertiary education understand how much the country could save. The students to teacher ratio displays the number of students who attend a school or university divided by the number of teachers in the institution. In addition, the students to teacher ratio was chosen to alleviate the difference in size of the universities and to obtain the comparable results.

Table 1. Models of efficiency estimation of Ukrainian Universities and developed countries

| **Model 1** | | **Model 2** | |
|---|---|---|---|
| Input | Output | Input | Output |
| Total number of staff | Number of enrolled students | Total number of staff | Number of graduates |
| Expenses for utilities | | Expenses for utilities | |
| **Model 3** | | **Model 4** | |
| Input | | Output | |
| Public educational expenditure | Number of enrolled students | Public educational expenditure | Number of graduates |
| Teachers to students ratio | | Teachers to students ratio | |

*C h a p t e r 4*

# DATA DESCRIPTION

The variables selection plays one of the crucial role for DEA. The literature suggests a wide range of the potential indicators, but the choice is still has quite subjective intuition due to the lack of one best practice for this process. The study by the Berbegal Mirabent, J. and Solé Parellada, F. (2012) investigates 45 empirical papers published in 2000 and 2010. Authors analyze the different indicators for universities' efficiency estimation and categorize them. There following groups were formed: financial measures (funding sources and operating expenditures), human capital, infrastructures, teaching measures (enrolments, students' success and teaching offer and activity), research measures, knowledge transfer activities (research and technology transfer incomes) and overall measures (external rankings and internal surveys). For instance, Abott and Doucoullagos (2003), Avkiran (2001), Tyagi et al. (2009) and Worthington and Lee (2008) use the academic staff for teaching and research efficiency. Number of number of graduates is one of the most controversial indicator, because it could reflect the success of the teaching performance from the one side. However, the quantity of graduates could not be considered as the quality of the education. Nevertheless, Garcia Aracil and Palomares (2008), Abott and Doucoullagos (2003) used this indicator in their research.

The duality of the research purposes implicates the two separate streams for data collection. For the cross – country analysis the data from the EUROSTAT and UNESCO Institute for Statistics were used. The dataset consists of 35 observations in 2014. The dataset from EUROSTAT proposes data for 28 EU countries and 6 n on-EU countries: Liechtenstein, Norway, Serbia, Switzerland, Turkey and the Former Yugoslav Republic of Macedonia. The year choice was due to the existence of the data for all countries simultaneously. However, some replacements were made due to the absence of data. For example, the public expenditures per student for the Former Yugoslav Republic of Macedonia were obtained through the State Statistical Office of Republic of Macedonia. The same procedure was conducted in Ireland, Greece and Liechtenstein. For the meaningful analysis, all monetary values were used using the same currency (Euro). All variables in the analyses are corresponding to the 5-8 (tertiary education) level of the International Standard Classification of Education (ISCED) 2011, developed by UNESCO. The ISCED 5-8 includes:

- short-cycle tertiary education
- bachelor's or equivalent level
- master's or equivalent level
- doctoral or equivalent level.

Based on the objective and mission of the university, literature review on input and output factors used in other studies and data availability, the following indicators were chosen for individual universities and cross – country analyses were used to estimate efficiency (Table 2).

Table 2. Description of the Variables

| Inside | Description | Out | Description |
|---|---|---|---|
| $\boldsymbol{N_{stf}}$ | Total number of staff | $Exp_{pub}$ | Public educational expenditure by education level |
| $\boldsymbol{Exp_{sal}}$ | Expenses for salary | $N_{enr}$ | Total number of students enrolled in tertiary education |
| $\boldsymbol{Exp_{util}}$ | Expenses for utilities | $R$ | Ratio of students to teachers and academic staff by education level |
| $\boldsymbol{N_{grad}}$ | Number of graduates | $N_{grad}$ | Number of graduates |
| $\boldsymbol{N_{enr}}$ | Number of enrolled students | | |

Ukrainian higher education consists of two parts with different levels of accreditation. Colleges, technical schools are the part of higher education with I-II level of accreditation. Universities, academies and institutions appertain to III-IV level of accreditation. In my master thesis, we consider only educational institutions with the III-IV level of accreditation for the meaningful comparison.

There are 14 medical HEIs under the Ministry of Health of Ukraine, which were given through the direct request to MoH. The 6 indicators about the HEI in 2017, which allows us to estimate the efficiency. Nethertheless, the Ukrainian Universities are homogeneous in inputs and outs, the difference among the DMUs could be noticed (Table 3). One of the key aspect, which determine the distinction between the HEIs is the size of the University. This parameter displays by the number of enrolled and graduated students.

Table 3. Descriptive statistics for individual Ukrainian University variables

| | $N_{enr}$ | $N_{stf}$ | $Exp_{util}$ | $N_{grad}$ |
|---|---|---|---|---|
| min | 6.0 | 72.5 | 36.6 | 16.0 |
| max | 816.0 | 1302.5 | 12947.7 | 711.0 |
| mean | 309.8 | 561.9 | 1711.6 | 259.3 |
| range | 810.0 | 1230.0 | 12911.1 | 695.0 |
| sd | 196.1 | 365.3 | 3406.5 | 178.9 |

The descriptive statistics of the variables for 35 countries demonstrates a wide range in the number of the enrolled students (Table 4). This fact could be explained by the difference in population and attractiveness of the country not only for studying. The maximum number of enrolled students were engaged in Turkey. The Germany and France occupy next positions and both countries are among the leaders in public expenditures for tertiary education. Meanwhile, the students do not prefer to study in Liechtenstein and Luxembourg due to high living cost.  The most comfortable country in context of student to teacher ratio is Luxembourg and Switzerland.

Table 4. Descriptive statistics for cross – country variables

| | $\boldsymbol{N_{enr}}$ | $\boldsymbol{Exp_{pub}}$ | $\boldsymbol{N_{grad}}$ | $\boldsymbol{R}$ |
|---|---|---|---|---|
| min | 830.0 | 118.1 | 271.0 | 8.2 |
| max | 6062886.0 | 38447.0 | 772362.0 | 71.8 |
| mean | 818227.8 | 6217.5 | 179238.4 | 17.9 |
| range | 6062056.0 | 38328.9 | 772091.0 | 63.6 |
| sd | 1225620.0 | 8937.3 | 241223.0 | 11.3 |

*C h a p t e r 5*

# ESTIMATIONS RESULTS

Two different models for 14 medical universities were estimated. The models are different in terms of the outputs: number of enrolled students for Model 1 and number of graduates for Model 2. At first, tests of independence for Model 1 indicate that assuming all possible returns to scale, the technical efficiency measures are not independent of the mix of inputs. Therefore, the heterogeneous bootstrapping will be further applied. The highest value of the bias-variance ratio for Farrell input-based technical efficiency measure validates the suggestion about the heterogeneous bootstrapping procedure usage (Table 5).

Table 5. Bias – Variance Ratio for Different Types of Bootstrapping for Model 1

| | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Smoothed Homogeneous | 14 | 3.41 | 2.74 | 1.84 | 12.40 |
| Smoothed Heterogenous | 14 | 7.01 | 4.29 | 4.10 | 17.08 |
| Subsampling | 14 | 1.39 | 0.30 | 0.92 | 1.86 |

The test about the return to scale became possible after applying the heterogeneous bootstrapping. The null hypothesis, which displays that the technology should be globally CRS, therefore there is no sense to perform the second test. Finally, this dataset requires the heterogeneous bootstrapping procedure under the assumption of constant return to scale.

The Table 6 represents the efficiency scores using the Model 1 with the enrolled students as an output measure. Bogomolets National Medical

University and Vinnitsa National Medical University indicates the highest efficiencies under the VRS and NIRS assumptions. Zaporizhia State Medical University demonstrates the highest score under all assumptions about the return to scale. Finally, the results about the RTS in the model point to the CRS, which provides the appropriate statistical inference. In this context, the only one efficient university could be found - Zaporizhia State Medical University. The mean efficiency under the CRS assumption is 0.65, which means that an average the HEIs should decrease their inputs by 35%. The National University of Pharmacy get the lowest grades among medical universities in Ukraine and demonstrates the huge sensitivity to the RTS: the efficiency scores under the CRS and NIRS assumption is 0.1, while the VRS assumptions shows the DMU as one of the most efficient.

Table 6. Technical efficiency scores for Model 1

| | | CRS1 | VRS1 | NIRS1 |
|---|---|---|---|---|
| 1 | Bogomolets National Medical University | 0.73 | **1.00** | **1.00** |
| 2 | Odessa National Medical University | 0.57 | 0.57 | 0.57 |
| 3 | Dniepropetrovsk State Medical Academy | 0.39 | 0.39 | 0.39 |
| 4 | Donetsk National Medical University | 0.55 | 0.69 | 0.55 |
| 5 | Vinnitsa National Medical University | 0.81 | **1.00** | **1.00** |
| 6 | Danylo Halytsky Lviv National Medical University | 0.48 | 0.54 | 0.54 |
| 7 | Lugansk State Medical University | 0.72 | **1.00** | 0.72 |
| 8 | Ivano-Frankivsk National Medical University | 0.72 | 0.76 | 0.72 |
| 9 | I. Horbachevsky Ternopil State Medical University | 0.89 | 0.96 | 0.89 |
| 10 | Bukovinian State Medical University | 0.87 | 0.95 | 0.87 |
| 11 | National University of Pharmacy | 0.10 | **1.00** | 0.10 |
| 12 | Zaporizhia State Medical University | **1.00** | **1.00** | **1.00** |
| 13 | Ukrainian Medical Stomatological Academy | 0.57 | 0.60 | 0.57 |
| 14 | Kharkiv National Medical University | 0.75 | 0.81 | 0.81 |

The Model 2 estimates the technical efficiency using the same inputs, but the number of graduates served as the output. This model also demonstrates the dependence of the mix of inputs and suggests the heterogeneous bootstrapping procedure. The Table 7 supports the idea about the heterogeneous bootstrapping demonstrating the highest ratio.

Table 7. Bias – Variance Ratio for Different Types of Bootstrapping for Model 2

| | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Smoothed Homogeneous | 14 | 3.56 | 2.58 | 1.87 | 11.81 |
| Smoothed Heterogenous | 14 | 11.40 | 15.82 | 4.26 | 64.41 |
| Subsampling | 14 | 1.34 | 0.28 | 0.91 | 1.76 |

According to the Table 8, more universities are efficient under the VRS assumption (six universities obtain the score equal to 1). Bukovinian State Medical University and Zaporizhia State Medical University are fully efficient under the CRS assumption. In addition, the I. Horbachevsky Ternopil State Medical University demonstrates one of the highest score and could be considered as an example of successful management. The National University of Pharmacy demonstrates almost similar results as in Mode 1. The high sensitivity about the RTS assumption is also present in Model 2. On the average, the efficiency scores in Model 2 are slightly higher than in Model 1, which shows that in terms of graduates the universities performs a bit more efficient. The Donetsk National Medical University and Lugansk State Medical University obtain the lowest score among the HEIs (approximately 0.2), which means than the universities administrations should reduce the all inputs approximately by 80%. The Model 2 demonstrates that the VRS assumption provides more optimistic results for almost all universities.

Table 8. Technical efficiency scores for Model 2

| | | CRS2 | VRS2 | NIRS2 |
|---|---|---|---|---|
| 1 | Bogomolets National Medical University | 0.83 | **1.00** | **1.00** |
| 2 | Odessa National Medical University | 0.60 | 0.60 | 0.60 |
| 3 | Dniepropetrovsk State Medical Academy | 0.55 | 0.60 | 0.60 |
| 4 | Donetsk National Medical University | 0.19 | 0.69 | 0.19 |
| 5 | Vinnitsa National Medical University | 0.79 | **1.00** | **1.00** |
| 6 | Danylo Halytsky Lviv National Medical University | 0.55 | 0.62 | 0.62 |
| 7 | Lugansk State Medical University | 0.20 | 0.60 | 0.20 |
| 8 | Ivano-Frankivsk National Medical University | 0.83 | 0.84 | 0.83 |
| 9 | I. Horbachevsky Ternopil State Medical University | 0.99 | **1.00** | 0.99 |
| 10 | Bukovinian State Medical University | **1.00** | **1.00** | **1.00** |
| 11 | National University of Pharmacy | 0.41 | **1.00** | 0.41 |
| 12 | Zaporizhia State Medical University | **1.00** | **1.00** | **1.00** |
| 13 | Ukrainian Medical Stomatological Academy | 0.80 | 0.80 | 0.80 |
| 14 | Kharkiv National Medical University | 0.75 | 0.78 | 0.78 |

In the cross – country context, Greece, Turkey and Ukraine demonstrates the highest efficiency scores under all assumptions of return to scale using the Model 3 (Table 9). The greatest number of countries obtain higher scores under the variable return to scale assumption: Bulgaria, Germany, Greece, Luxembourg, Turkey and Ukraine.

Table 9. Technical efficiency scores for Model 3

| | | CRS3 | VRS3 | NIRS3 |
|---|---|---|---|---|
| 1 | Austria | 0.12 | 0.59 | 0.12 |
| 2 | Belgium | 0.12 | 0.39 | 0.12 |
| 3 | Bulgaria | 0.98 | **1.00** | 0.98 |
| 4 | Croatia | 0.28 | 0.45 | 0.28 |
| 5 | Cyprus | 0.12 | 0.60 | 0.12 |
| 6 | Czech Republic | 0.43 | 0.51 | 0.43 |
| 7 | Denmark | 0.08 | 0.60 | 0.08 |
| 8 | Estonia | 0.20 | 0.67 | 0.20 |
| 9 | Finland | 0.11 | 0.60 | 0.11 |
| 10 | Macedonia | 0.08 | 0.46 | 0.08 |
| 11 | France | 0.44 | 0.62 | 0.44 |
| 12 | Germany | 0.83 | **1.00** | 0.83 |
| 13 | Greece | **1.00** | **1.00** | **1.00** |
| 14 | Hungary | 0.53 | 0.70 | 0.53 |
| 15 | Ireland | 0.14 | 0.45 | 0.14 |
| 16 | Italy | 0.33 | 0.56 | 0.33 |
| 17 | Latvia | 0.29 | 0.64 | 0.29 |
| 18 | Liechtenstein | 0.00 | 0.75 | 0.00 |
| 19 | Lithuania | 0.34 | 0.64 | 0.34 |
| 20 | Luxembourg | 0.03 | **1.00** | 0.03 |
| 21 | Malta | 0.09 | **1.00** | 0.09 |
| 22 | Netherlands | 0.15 | 0.59 | 0.15 |
| 23 | Norway | 0.09 | 0.84 | 0.09 |
| 24 | Poland | 0.56 | 0.69 | 0.56 |
| 25 | Portugal | 0.32 | 0.62 | 0.32 |
| 26 | Romania | 0.73 | 0.73 | 0.73 |
| 27 | Serbia | 0.55 | 0.66 | 0.55 |
| 28 | Slovakia | 0.34 | 0.65 | 0.34 |
| 29 | Slovenia | 0.24 | 0.59 | 0.24 |
| 30 | Spain | 0.51 | 0.83 | 0.51 |
| 31 | Sweden | 0.13 | 0.82 | 0.13 |
| 32 | Switzerland | 0.11 | 0.96 | 0.11 |
| 33 | Turkey | **1.00** | **1.00** | **1.00** |
| 34 | Ukraine | **1.00** | **1.00** | **1.00** |
| 35 | United Kingdom | 0.47 | 0.67 | 0.47 |

Next, the test of independence indicates the independence from the mix of inputs and the homogeneous bootstrapping would provide the most reliable estimations. The least efficient countries are Denmark, Liechtenstein and Luxembourg, which should put more attention to the resource allocation. The average efficiency among the countries is 0.36 for CRS and NIRS assumptions. However, the VRS shows almost twice-higher efficiency (0.71). The 9% of the countries are efficient under the CRS assumption and 20% of the countries are efficient under the VRS. This fact demonstrates the importance of the assumptions about the RTS. Aziza A. et al. (2013) state that CRS assumes that an increment in inputs results in proportion increment in outputs, while VRS assumes that an increment in inputs results in a disproportionate increment in outputs (Cooper & Seiford, 2001). The current estimation results show that the model is sensitive to the convexity condition.

The Model 4 describes the efficiency among the countries using the number of graduates as an output and demonstrates a huge range in the efficiency scores among the countries. There are only 6% of the countries, which are efficient under the CRS assumption. However, Table 10 shows that 17% and 11% of the countries perform fully efficiently under the VRS and NIRS assumption respectively. The main differences from the first model could be noticed in Bulgaria, Turkey, Ukraine and United Kingdom (Table 10). However, the efficiency of Ukraine in terms of graduates does not catch the quality of education, which could be concluded from the absence of the Ukrainian university in the top 1000 of the leading rankings. The Model 4 shows that Turkey lost first position under the CRS assumption. The test of independence demonstrates the same result as in Model 3 and homogeneous bootstrapping was used. Macedonia demonstrates the worst results as well as Liechtenstein and Luxembourg. The average efficiency or the last model is a bit higher (0.38), but a great potential for further developed is present for most of the countries.

Table 10. Technical efficiency scores for Model 4

| | | CRS4 | VRS4 | NIRS4 |
|---|---|---|---|---|
| 1. | Austria | 0.10 | 0.58 | 0.10 |
| 2. | Belgium | 0.10 | 0.39 | 0.10 |
| 3. | Bulgaria | **1.00** | **1.00** | **1.00** |
| 4. | Croatia | 0.35 | 0.45 | 0.35 |
| 5. | Cyprus | 0.16 | 0.60 | 0.16 |
| 6. | Czech Republic | 0.43 | 0.49 | 0.43 |
| 7. | Denmark | 0.09 | 0.60 | 0.09 |
| 8. | Estonia | 0.16 | 0.64 | 0.16 |
| 9. | Finland | 0.07 | 0.59 | 0.07 |
| 10. | Macedonia | 0.07 | 0.46 | 0.07 |
| 11. | France | 0.77 | 0.92 | 0.92 |
| 12. | Germany | 0.82 | 0.90 | 0.82 |
| 13. | Greece | 0.58 | 0.59 | 0.59 |
| 14. | Hungary | 0.46 | 0.65 | 0.46 |
| 15. | Ireland | 0.17 | 0.45 | 0.17 |
| 16. | Italy | 0.37 | 0.53 | 0.37 |
| 17. | Latvia | 0.31 | 0.60 | 0.31 |
| 18. | Liechtenstein | 0.00 | 0.75 | 0.00 |
| 19. | Lithuania | 0.33 | 0.62 | 0.33 |
| 20. | Luxembourg | 0.04 | **1.00** | 0.04 |
| 21. | Malta | 0.16 | **1.00** | 0.16 |
| 22. | Netherlands | 0.17 | 0.58 | 0.17 |
| 23. | Norway | 0.09 | 0.83 | 0.09 |
| 24. | Poland | 0.68 | 0.71 | 0.68 |
| 25. | Portugal | 0.25 | 0.61 | 0.25 |
| 26. | Romania | 0.77 | 0.78 | 0.78 |
| 27. | Serbia | 0.59 | 0.64 | 0.59 |
| 28. | Slovakia | 0.46 | 0.69 | 0.46 |
| 29. | Slovenia | 0.23 | 0.57 | 0.23 |
| 30. | Spain | 0.64 | 0.80 | 0.64 |
| 31. | Sweden | 0.13 | 0.80 | 0.13 |
| 32. | Switzerland | 0.18 | 0.97 | 0.18 |
| 33. | Turkey | 0.67 | **1.00** | **1.00** |
| 34. | Ukraine | **1.00** | **1.00** | **1.00** |
| 35. | United Kingdom | 0.86 | **1.00** | **1.00** |

*Chapter 6*

# CONCLUSIONS

The low position of the Ukrainian universities brings up the question of the efficient resource allocation and required the determination of the point of the Ukrainian HEIs among the other countries. The active cooperation with the EU, drives the necessity of the comparison of Ukrainian education system with the systems of developed economies, which could provide interesting insights. The non-parametric DEA approach to determine the technical efficiency due to flexibility in use and lack of the data for more deep estimation. Using the multiple inputs and outputs and putting the attention to the input – oriented approach we identify the most efficient medical universities in Ukraine and determine the countries, which could be considered as a benchmark.

The data collection process is different for "inside" and "out" estimation. The data about the inputs and outputs in Ukrainian medical HEIs was obtained upon the direct request to the MoH for the latest available year (2017). The total number of staff, number of enrolled students, number of graduates and expenses for utilities are the indicators obtained from the MoH for efficiency estimation.

For cross – country comparison, the data were obtained from the EUROSTAT for EU and 6 non - EU countries and from the UNESCO Institute of Statistics for Ukraine. The several replacements were made to obtain the full dataset using the official statistics. As a result, the efficiency were estimated for 35 countries in 2014 year.

Analyzing the Ukrainian HEIs, the Zaporizhia State Medical University became the most efficient university among the other under the all assumptions and models. Next, the Bogomolets National Medical University and Vinnitsa National Medical University are the HEIs, which could be used as a benchmark under the VRS and NIRS assumptions. The Bukovinian State Medical University became efficient with graduates considered as the output. The lowest scores for National University of Pharmacy testify about the poor inputs resource usage. However, this University became efficient in case with graduates.

The Turkey and Ukraine demonstrate the highest efficiency scores almost under all assumptions about the returns to scale. The Model 3, with the number of enrolled students as the output, emphasizes the Greece as one of the most successful country, which uses the inputs in the most efficient way. The second model with the number of graduates indicates that Bulgaria is also efficient.

The limited research in the field of education proposes the great potential for further investigation. For example, the larger dataset of the Ukrainian HEIs allows for other methods such as FDH and SFA. Application of the other approaches and comparison the efficiency scores between the methodologies displays the inferences that are more reliable. The cross-country comparison with the developed countries, which have different approaches in education, could provide the information about the successful paths of development. In addition, the lack of the analyses among the individual university departments open opportunities for further research.

Estimated efficiency scores propose the number of policy implications for the variety of the stakeholders. The presidents of the medical Universities have an opportunity to choose the most efficient competitor and implement best practices to reduce extra expenditures. The Ministry of Health could use the results of the research to develop the strategy for further development and keep only Universities with the most efficient management.

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