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STATISTICAL EVALUATION OF THE EFFICIENCY OF HOSPITALS

Summary of Doctoral Thesis

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INTRODUCTION

The health of the population is maintained and ensured through the organization and operation of health systems worldwide. Their basic function is to provide medical and health services to the population. Medical services that are provided by hospitals are the core of the health systems, because hospitals have the equipment and resources necessary to cover the most complex medical needs, with the mission of managing medical emergencies and health crises. Thus, the global performance of health systems and the health of the population is closely related to the efficiency and quality of medical services provided by hospitals.

The Romanian health system is known as having the lowest performances among the European Union (EU) countries. The existing discrepancies at the level of the Romanian health system and the network of public hospitals led to the problem of the present research: Romania has 379 public hospitals, with a higher number of hospital beds than the EU average, but less medical staff in hospitals. At the same time, hospital services are overused and expensive, exceeding by approximately 5% the average of hospital expenses in the EU, but the medical needs of the population are insufficiently met, Romania registering the highest mortality rate from treatable causes in the European Union.

The current scientific approach aims to carry out a comparative statistical evaluation of the efficiency of public hospitals in Romania, based on the resources involved and the volume indicators of medical activity in hospitals.

The objectives subordinated to this purpose cover 5 aspects:

(1) Description of the current state of the Romanian health sector, the classification of public hospitals, according to the level of competence and their financing system;

(2) The theoretical foundation of the research, by defining the concept of efficiency in the context of the health sector and placing it in the broader framework of the performance of the health sector, along with the quality of medical care;

(3) Theoretical and critical analysis of the main indicators that allow the assessment of the efficiency of hospitals at the country level for comparisons, rankings and recommendations to optimize the management of hospital resources, based on specialized literature;

(4) Classification of public hospitals in Romania in terms of efficiency, using appropriate statistical methods;

(5) Identifying the significant contextual variables (demographic and economic) that influence the (in)efficiency of public hospitals in Romania.

Using the research problem as starting point, the following research hypotheses were formulated:

- Public hospitals in Romania are inefficient. The observed inadvertences and the highest mortality rate from treatable causes in the EU lead to this hypothesis: the existing resources are not optimally managed.

- Public hospitals in Romania have a mixed inefficiency, managerial and scale inefficiency. It is expected that small and medium-sized hospitals not to operate at an optimal level of scale, that is, the volume of medical activity is not adapted to the level of resources; it is also expected that managerial inefficiency will be identified at the level of most of the analyzed hospitals.

- Inefficient public hospitals need to optimize their results. Results previously obtained for hospitals in the North-East development region, which is second in the country in number of hospital beds, indicated a possible average increase in their results by 9% (Caunic, 2020).

The thesis is structured in five chapters. The first four chapters include the theoretical foundations of the research, present the current state of knowledge in the field, the state of the Romanian health sector and of public hospitals. The last chapter describes the empirical study carried out at the level of public hospitals, using the data corresponding to the medical activity of the calendaristic year 2019.

In chapter I, the research theme is presented, with exposition of the theoretical concepts regarding efficiency and the efficiency of production, extrapolated to medical industry and correlated with another important notion that characterizes medical services, namely, quality. Efficiency produces quality and together, efficiency and quality produce performance. Medical services are defined, as final product of medical activity, envisaged as a production process. The focus is on hospital services, offering classifications, with the presentation and explanation of their financing scheme, based on the clustering of patients into diagnosis groups (Diagnosis Related Groups - DRG).

In chapter II of the thesis, the current state of the Romanian health system is described, based on the analyzes carried out by international bodies, such as the World Health Organization (WHO), the Organization for Economic Cooperation and Development (OECD), the European Observatory for Health Systems and Policies, The World Bank and also based on the latest statistical data, having Eurostat as a source.

Chapter III is a review of the main indicators applied in international studies to evaluate the efficiency of hospitals and of the methods used in these studies, and chapter IV focuses on the methods used in the research. The non-parametric efficiency estimation models, based on linear programming, which define the Data Envelopment Analysis (DEA) method, applied in the conducted empirical study, are presented. The advantages and disadvantages of the method, the models and the complementary techniques are also highlighted (the bootstrap technique, for biase corection, the Jackknife sensitivity analysis to test the robustness of the scores, the super-efficiency model for identifying outliers and the Slack-Based DEA model based, used to emphasize the increases that inefficient units should operate, at the output level, to reach the efficiency frontier. The chapter concludes with a review of the studies that have used DEA to assess efficiency of hospitals. Also, a brief subchapter is allocated to the Tobit regression model, frequently applied in the literature, in a second stage of the researches, to identify the influence of internal and external factors on the efficiency of hospitals. Tobit regression is also applied in the current work to determine the impact of contextual variables, beyond the control of hospitals, on their efficiency.

Chapter V is presents the empirical study regarding the efficiency of public hospitals in Romania. The chapter begins with a review of the Romanian literature on the efficiency of hospitals and the presentation of the results of the qualitative analysis on Romanian scientific works, that were published after 2008, which was a decisive moment for performance evaluation of hospitals management from two perspectives: legislative and informatic.

The statistical approach consisted in applying the basic DEA models, output-oriented, correcting the biased estimates using bootstrap technique, highlighting the outliers using the super-efficiency DEA model and verifying the robustness of the efficiency scores, through sensitivity analysis using Jackknife technique. Also, Slack-Based DEA model output-oriented was run to obtain more information about the increases that each inefficient hospital should operate at the output level, in order to reach 100% technical efficiency. Each analytical frame ends with discussions on the results. The Tobit regression analysis, from the second stage of the research, highlighted the contextual variables that have a significant influence on the inefficiency of health units, suggesting the inclusion of similar additional variables, but also of more specific factors, which belong to the health system, in future research, for a more accurate projection of the determinants of hospital inefficiency.

The thesis ends with a brief section dedicated to the impact of COVID-19 health crisis on the medical system from Romania, since the coronavirus pandemic was a great challenge for all nations and all health systems. Also, general conclusions are presented and research limits. Suggestions are offered regarding future research directions in this field, poorly investigated at the national level.

CHAPTER I. EFFICIENCY APPROACH IN THE HEALTH SYSTEM

Efficiency assessment of health systems and of healthcare facilities is a constant concern for all governments, due to the increase of demand and consumption of medical services and due to increase expenses of this sector. These aspects lead to the issue of ensuring the sustainability of health systems, which is possible by increasing the efficiency and quality of medical services provided to the population. Thus, the notions of economic efficiency and production efficiency have been assimilated in the medical industry, in order to be able to evaluate the performance of this sector.

In economic sciences, economic efficiency is used to denote the best functioning of a sector of activity, characterized by maximum production with minimum costs and maximum consumption surplus. In this context, the way resources are allocated becomes a priority. The concept of economic efficiency is linked to the name of the economist and sociologist Vilfredo Pareto (1906), who stated the theory of the economic optimum or Pareto's optimum, linking the paradigm of efficiency to the concept of well-being. Thus, economic and social welfare is maximized when the allocation of resources is optimal, and this occurs if it is impossible to redistribute a single resource to improve the condition of one individual, without affecting the state of another individual (Blaug, 2007, p. 187).

Economic efficiency compares the effects of economic activity (revenues) with the efforts required for its production (costs) and is expressed as a ratio between those two: efficiency = effect / effort (Ceban and Bădărau, 2016, p. 230). The result (output) / effort (input) ratio is, however, the equivalent of productivity. Or, in addition to productivity, efficiency also incorporates the idea of the production frontier and production possibilities. Efficiency is given by the distance between the observed output / observed input ratio and the optimal output / optimal input ratio, the latter describing the best production possibility (frontier) (Lovell, 1993). Production possibilities are those that indicate the optimal levels of production, consideringthe the scale of operations of each observed unit (the size of the observed units). As part of the economic efficiency, production efficiency involves the lowest possible cost per unit of production. Thus, any economic entity can increase its production efficiency if (Burz, 2013, p. 23): (a) minimizes its effort or costs; (b) maximizes its effects (the results); (c) optimizes its effect-to-effort ratio by a superior increase in effects compared to the efforts increase.

Farrel (1957) proposes a method for estimating production efficiency, based on the production function, considering that *„if economic planning targets certain industries, it is important to know to what level we can expect a certain industry to increase its output by the mere increase of efficiency, without absorbing other resources”* (Farrell, 1957, p. 11). Farrell describes the production efficiency as being formed by technical efficiency and allocative efficiency and shows a way to compute them.

The technical efficiency (ET) of a producer is ensured if the maximum possible amount of output is obtained from a given combination of inputs (Farrell, 1957, p. 254). By comparing the actual production with the optimal level that can be achieved, given the available resources, the measure of the technical efficiency of a producer is obtained. Alternatively, a producer's technical efficiency is ensured if a given (predetermined) quantity of output is obtained using the minimum possible quantity of input (Hollingsworth, 2008, p. 1108).

The allocative efficiency (EA) of an economic entity is given by the use of production factors in the best possible proportion, from the perspective of prices. If the observed units (firms) are perfectly efficient both technically and allocative, then:

overall efficiency or production efficiency is the product of ET x EA.

The medical activity in hospitals can be conceptualized as a production process, in which various inputs are consumed (human resources, pharmaceutical products, medical and protective equipment, other consumable goods) for the medical prcesses through which the medical service is performed. The production costs (accommodation and meals provided for patients, medical and/or surgical treatment, investigations and medical care) dependent on the size of the production unit (hospital size) (Caussy and Than Sein, 2017, p. 389).

Thus, the medical service involves costs that are reimbursed by the Health Insurance Companies; it is, therefore, a service provided by trained and authorized professionals, in order to maintain, restore or improve the physical or mental well-being of individuals / the community, carried out in an organized framework, with legal recognition (accreditation) as a provider of medical services. The medical service providers report the results of their medical activities, carried out in a determined period of time, to governmental organizations with regulatory and financing role, for which they are paid according to the contract concluded with a health insurance institutions (House of Health Insurance). Thus, at the national level, there is a system of medical services or health services, whose operation and reimbursement has the necessary legal certification. For the present scientific approach we will refer to this understanding of medical services.

The evaluation of the efficiency of hospitals, as the main providers of medical services, is of interest to the decision-makers of health policies, being linked to the increase of socio-economic well-being, by maximizing the results of medical activity in hospitals. The results of the medical activity in hospitals are an indirect measure of the benefit registered in the health status of the population. The efficiency of hospitals is frequently assessed, from an economic point of view, based on financial indicators, such as personnel expenses and costs / patient and also using indicators of medical activity, such as *the number of treated patients* and *the length of stay*. A poor quality of care, however, affects the efficiency of healthcare providers, through higher costs per patient and multiple episodes of hospitalization for the same patient and/or prolonged lengths of stay, or through the occurrence of adverse events (unintended, unwanted health damage, injuries, illness, temporary or permanent disability or even death of the patient, associated with medical care). Any medical entity achieves high performance if, using existing resources, produces the maximum achievable amount of medical services (technical efficiency), which meet the quality standards. Achieving a high level of performance is conditional on the efficient use of all resources, in order to obtain the best results in the health status of the beneficiaries, with minimal risks for patient and satisfaction of the patient, following the interaction with the accessed medical service.

CHAPTER II. ASPECTS OF HOSPITAL EFFICIENCY

Hospitals are the main component of health systems and provide mainly curative services. According to World Health Organization (WHO), hospitals are „facilities that provide short-term or long-term medical care consisting in follow-up, diagnosis, treatment and recovery for persons suffering from an illness or suspected of illness or injury, as well as for pregnant women. The hospital can also offer outpatient services for patients who do not require hospitalization" (WHO, 1963, p. 10). In Romania, hospitals provide medical services through inpatient care (hospitalization with length higher than 12 hours) or through day hospitalization (hospitalization with maximum length of 12 hours/visit); also, hospitals can have in their structure departments that provide specialized outpatient services, outpatient paraclinical services / paraclinic radiology (diagnostic investigations) and home care (National Institute of Statistics, 2020, p. 6).

At the international level, a distinction is made between general hospitals (which include several specialties) and specialty hospitals (which provide services for a specific pathology), between non-university hospitals and university hospitals (with an educational mission, training for future medical personnel and also involved in medical research) and between secondary-level hospitals (providing less complex medical services) and tertiary hospitals, which provide medical services of high-complexity.

In Romania, in addition to the classification determined by ownership, territorial criterion, educational criterion and the specific of pathology treated, there is also the classification of public hospitals, performed by the Ministry of Health based on competence criteria, according to the material endowment, the human resource and the complexity of the services provided: thus, the hospitals they are classified in 5 categories of competence and, to a certain extent, the category of competence conditions the level funding for the hospitals. Categories I and II designate public hospitals of very high and high competence, capable of providing complex medical assistance for complicated cases, including regional and county emergency hospitals, but also monospeciality hospitals. Categories III and IV include hospitals with less equipment, which treat conditions of lower complexity, and the V^{th} category includes medical facilities that offer palliative services.

The descriptive analysis we carried out for the year 2019 indicates that the network of public hospitals in Romania was formed from hospitals of IV category up to 43%, with basic level of competence, treating conditions with a low degree of severity / complexity. The low level of competence of most hospitals leads to a decrease in their addressability and patients choosing hospitals with a higher degree of competence. Thus, an imbalance is created by overutilizing the services provided by hospitals with high competence, while the resources held by smaller hospitals tend to remain idle or underutilized, and their efficiency decreases. The irrational allocation and use of resources thus affects the production efficiency of medical services provided to the population.

As for the financing of hospitals, in 2005 Romania implemented the financing system based on diagnosis groups - Diagnosis Related Group (DRG), developed in the USA and promoted internationally precisely to control the costs of medical care in hospitals. This system is based on the principle of clinical and economic similarity of patients,clustering the patients in diagnostic groups, according to their condition and according to expected costs. On discharge, patients are fitted in the appropriate DRG group (through a grouper software). Each DRG group has a relative value (VR) that expresses the complexity of the cases from that group and an associated cost. The average of the VRs of all patients discharged in a given period results, in the case-mix index of the hospital (CMI). This indicator is very important for hospital management, because it expresses the complexity of the cases treated monthly and annually, as well as the necessary resources, and it is used in the formula for computing the amount that each hospital will contract with the Health Insurance House for the annual financing of services of inpatient care.

Although Romania has implemented the DRG system with the aim of increasing hospitals efficiency, the expenses of Romanian hospitals exceed the EU average by 5%, and the money does not get to the patient, since Romania occupies one of the last positions in the EU, in terms of hospital expenses / inhabitant.

The current state of the Romanian health system, as it is highlighted in the reports of the international organizations WHO and OECD and as it shown by the analyses carried out on the latest data available on Eurostat, is as follows:

- too many hospital beds - 7 hospital beds per 1000 inhabitants, compared to the EU average of 5 hospital beds per 1000 inhabitants;
- hospital services are the most used medical services in the system and consume most of the financial resources allocated to health sector (44% of health expenditures);
- poor quality of medical care in hospitals, demonstrated by the highest mortality rate from treatable causes in the EU;
- the shortage of human resources, due to the emigration of medical personnel for better remuneration and working conditions → insufficient staff in hospitals and unequal territorial distribution of medical personnel;
- the primary sector is underfunded and underdeveloped, unable to take on the pressure that exists on hospitals and support what, in Western health systems, is called *integrated medical service*, ensuring continuity of medical care beyond hospital.

CHAPTER III. INDICATORS FOR HOSPITAL EFFICIENCY EVALUATION

The literature and the official reports of international agencies such as WHO and OECD frequently use the generic term of „health system performance indicators" or „hospital performance indicators" to denote efficiency or quality in health sector. In the evaluations conducted at the macro-level (health systems), performance is assessed on the basis of efficiency indicators, with an emphasis on maximizing results and reducing costs. As the analysis goes to the micro-level of the medical service providers, the focus shifts to the quality of medical services, considering that a high-quality level of medical assistance implicitly determines a high level of efficiency and guarantees the performance of the medical entity. Thus, most countries have developed their own methodology to assess health sector performance, using a mix of efficiency and quality indicators.

Klazinga et al. (2011) have identified the most frequently used indicators in evaluation of hospitals performance, as measures of quality and efficiency: a). number of death in less than 30 days after discharge; b). readmission rate; c). surgical complications rate; d). nosocomial infection rate; f). bedsores; g). number of specific treatments; h). waiting times; i). systematic measurement of patient experiences (satisfaction); j). systematic measurement of medical staff experiences.

In the literature, the average lenght of stay, the bed occupancy rate and the infections associated with medical care (nosocomial infections) are highlighted as indicators of the efficiency and quality of the hospital medical services.

Average length of stay influences costs per hospital bed and beds utilization. The bed occupancy rate is directly related to the risk of nosocomial infections, when it exceeds 85%; on the other hand, a low bed occupancy rate indicates underutilization of the service and financial losses. The scenario of the efficient hospital is as follows: the number of admitted patients is high, compliance with the therapeutic protocols ensures the effective management of the patients pathology, by recommending the most appropriate investigations and treatments, which facilitate the quick resolution of each medical case and the free-up of hospital beds to receive other patients. After the rigorous disinfections, imposed by the sanitary regulations, in order to prevent nosocomial infections, a new case is admitted to each bed. At indicators level, this ideal scenario of the efficient hospital with quality services translates into: high number of admitted patients, high bed occupancy rate, but whithout exceeding the risk percentage of 85%, high bed turnover associated with low average length of stay and low rate of nosocomial infections. Under these conditions and cosnidering the number of the treated cases, the average cost per inpatient should reach the minimum values / case.

To measure the efficiency of hospitals, the most recent reviews of the literature highlight the fact that the methods based on estimating the production frontier are the most advanced methods currently used: Data Envelopment Analysis (DEA), as a non-parametric method, and Stochastic Frontier Analysis (SFA), as a parametric method (O'Neill et al., 2008, p. 158; 163; Kohl et al., 2018, p. 245). A considerable number of scientific studies treat the efficiency of hospitals in the context of the production function, conducting analyses on the basis of inputs and outputs (Adhikari et al., 2015, p. 143).

In Romania, the methodology for hospitals evaluation is regulated by the National Authority for Health Quality Management (ANMCS) through quality standards, for the accreditation of healthcare facilities, but the analysis reports are not made public. The local authorities and the Ministry of Health (MOH) perform annual evaluation of the management of subordinated hospitals, through the performance indicators regulated by Ministerial Order 1490/2008, updated by the Ministerial Order 1384/2010. These evaluations seem to be rather a formality, as they do not lead to changes in the management of low-performing hospitals, nor to structural changes. The only entity that penalizes hospitals for poor quality / poor efficiency remains the ANMCS, by conditioning the accreditation, in the absence of 100% fulfillment of the standards.

CHAPTER IV. METHODS FOR EFFICIENCY ESTIMATION

To achieve the goal of the current scientific approach – the comparative evaluation of the efficiency of public hospitals, based on the available resources and the volume indicators of the medical activity, in the first analytical stage we used the basic models of the non-parametric Data Envelopment Analysis (DEA) method, to compute the efficiency scores of the hospitals included in the analysis. The results were tested for stability/robustness through sensitivity analyses, in order to highlight the stability of the efficiency scores and of the efficiency frontier in the presence of outliers. The outliers were identified using the super-efficiency model, and their impact on efficiency frontier stability was analyzed using Jackknife technique. In addition to the results obtained with the basic (radial) DEA models, the Slack-based DEA model was also applied to identify the output deficits and the output quantities necessary to the inefficient units, to increase their efficiency.

In a second analytical stage, we sought to identify the contextual variables that influence the inefficiency of hospitals, applying the Tobit regression model for censored dependent variables, considering that the method used to obtain the efficiency scores and the range in which they are contained (limited) make the efficiency variable to act as a censored dependent variable.

The DEA method was developed in 1978 by Charnes, Cooper and Rhodes (DEA-CCR model), continuing the works of Farrell (1957) on production efficiency, assessed through the analysis of the production frontier. The linear programming, on which this method is based, adds the advantages to the methods, indicating the optimal technology for maximum efficiency, for each evaluated unit. Charnes, Cooper and Rhodes (1978) extended Farrell's work, which considered the scenario of a firm with two inputs and one output, to a production scenario with multiple inputs and multiple outputs. The efficiency frontier is constructed as the best production line emphasizing the efficient production, separated from the inefficient lines of production: inefficient units will be placed in the area below the frontier, forming the production possibility set.

The first advantage of the DEA is that it does not require the use of price information. Commonly, the evaluation of efficiency is performed from the value for money perspective, based on cost data, which are not always available. DEA offers the possibility to estimate the overall technical efficiency of an entity, without including financial information.

The second advantage of DEA is that it can accommodate simultaneously, in a single model, multiple inputs and multiple outputs, without imposing the specification of a functional form between them. This is more than econometric models can do: they can use a single output or aggregate indicators.

A first condition for applying the method is that the evaluated organizations must be relatively homogeneous. The generic term of „Decision Making Unit" (DMU) was introduced, to denominate the units included in DEA analyses, thus covering a wide range of entities subject to comparative analysis (Cooper et al., 2006, p. xx). The second condition for applying the method is that the sample must contain a number of DMUs greater than or equal to 2 x (number of inputs + number of outputs) (Golany & Roll, 1989, p. 239) or 2 x (number inputs x number of outputs) (Dyson, 2001, p. 248).

DEA constructs the efficiency frontier as follows: the observed data are enveloped by a linear surface (finds the production possibility set) and then the optimal level of output is established, conditional on the quantity and mix of inputs introduced in the production process (constructs the production frontier or efficiency frontier). DEA approximates the efficiency frontier, composing a piece-wise linear envelopment: the efficient units are on this frontier, and the inefficient units are enveloped by the linear surface, without touching the frontier. The optimal level of outputs represents the production frontier, defined as the maximum amount of outputs that can be produced using the set of inputs (resources) available (Banker et al, 1984, p. 1079).

The efficiency score of each DMU is calculated based on its distance from the production frontier. For each analyzed unit, the DEA model establishes weights that maximize its efficiency, in relation to the other observed units, while fulfilling the condition that the efficiency score cannot be > 1. The efficiency of a DMU can be equal to 1, in which case it is considered efficient or can be < 1, in which case it is considered inefficient. For inefficient DMUs, the DEA model identifies the corresponding efficient units (having the same weights and the efficiency score = 1), which will compose the reference set for the inefficient unit (Boussofiane et al, 1991, pp. 1-2). Thus, DEA identifies the best performers in the sample and they compose the efficiency frontier and the reference set for the inefficient units.

Inefficiency is measured based on the differences between the inefficient units and the efficient units (the radial distance of the point representing the input/output values of an inefficient DMU, from the reference point on the frontier). The linear program of the DEA is run for each observed unit. Considering a production process with a single input X, the DEA formulation aims to find, for each DMU_0, a set of weights w^0 and an efficiency score θ_0, to maximize the output y_{r0} (Smith & Street, 2005, p. 407):

$$\theta_0 = \Sigma_{r=1}^{s} y_{r0} w_r^0 \ / \ X_0, \qquad \text{unde} \ \ \Sigma_{r=1}^{s} y_{rj} w_r^0 \ / \ X_j \leq 1 \qquad\qquad j = 1,......., n.$$

The set of weights w^0 maximizes the performance of DMU_0,, subject to the condition that by using this set, no DMU exceeds the upper bound of 1 for the efficiency score.

The DEA method is data-oriented and allows the estimation of the technical efficiency of the decision making units from the output perspective or from the input perspective. Technical efficiency (ET) indicates either (a) the degree to which a unit produces the maximum output from a given set of inputs, (b) whether the unit uses a minimum amount of inputs to produce the prescribed level of outputs. These two definitions of technical efficiency describe the output-oriented efficiency measure and the input-oriented efficiency measure, respectively. Thus, in DEA analyses, the researcher can emphasize increasing the quantity of outputs or reducing the inputs used in the production process.

The initial DEA-CCR model compares the evaluated decision making units under the restrictive condition of constant returns to scale (CRS) and ignores scale variations in generating efficiency scores. The later DEA-BCC model, developed by Banker, Charnes and Cooper (1984) adjusts the information obtained with the DEA-CCR model, acting under the principle of variable returns to scale (VRS); thus, in generating the efficiency scores, the model considers the size of the unit, respectively the level of operations of each DMU. The analysis focuses on production inefficiencies at a given level of operations for each DMU (Banker et al., 1984, p. 1084). Using the results generated by both models, the scale efficiency of each DMU can be computed.

If inefficiency is present, the surplus of inputs or the deficits of outputs are known in the literature as *slacks* (Ozcan, 2008, p. 29). Slacks analysis will indicate the proportion of reductions (for input) or increases (for output) that can be practiced on each input / output by each inefficient unit, in order to reach the efficiency frontier.

The DEA-CCR and DEA-BCC models represent the basic DEA models, using radial or equiproportional measures. These models aim to optimize all inputs or all outputs of a DMU in the same proportion. However, the radial measures of efficiency do not take slacks into account, when estimating the technical efficiency. As consequence, in the DEA operational framework, non-radial measures (the additive model and the fluctuation-based model) have also been developed, which no longer consider radial changes in inputs or outputs, but focus on the presence of input-slacks and output-slacks and on their impact on the efficiency scores. In an input-oriented production scenario, non-radial models ignore the proportional contraction of inputs and aim to obtain the maximum rate of their reduction, also allowing non-proportional reductions (Avkiran et al., 2008; Zhu, 2014, p. 121).

In the current research, the basic DEA models were used, and also the Slack-Based DEA model, developed by Tone (2001). Figure 4.1 shows the classification of basic DEA models according to input or output orientation, as well as the specification regarding the returns to scale.

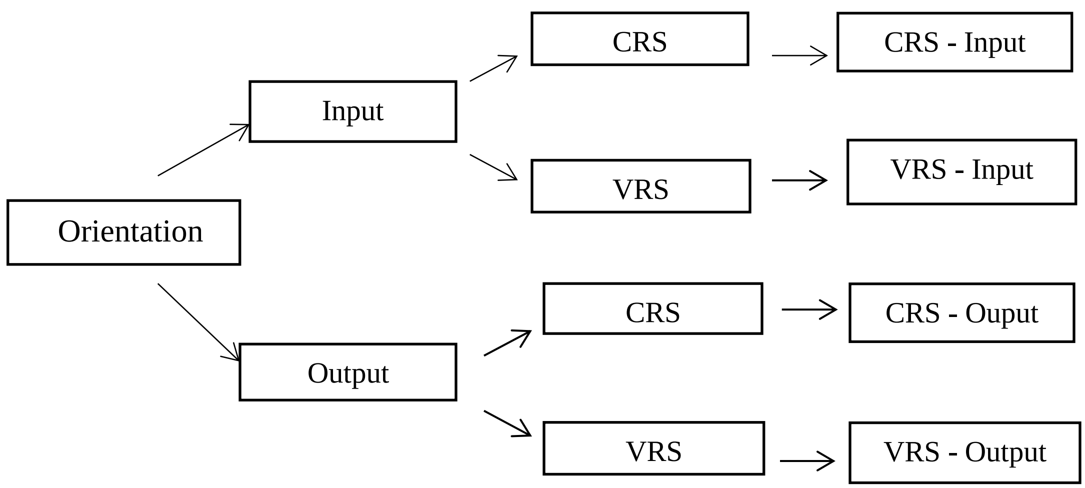


Fig. 4.1 Basic DEA models classification

Sursa: Ozcan, 2008, p. 24

Given that DEA is a non-parametric method, it is sensitive to outliers. Also, DEA computes relative efficiency scores, obtained by reffering the inefficient units, to the efficiency standard of the units that compose the frontier. Thus, in the literature, techniques have been developed to analyze the sensitivity of DEA scores to outliers or „statistical noise”, allowing the evaluation of the frontier stability and also the outliers detection. In the DEA analyses, extreme values obtain scores equal to 1 and influence the construction of the frontier and also the efficiency of the other units. Some studies have focused on the sensitivity of the DEA results to the selection of variables and of the model (Ahn & Seiford, 1993; Ozcan, 1993), but most have focused on maintaining frontier stability after introducing perturbations in all observed units, taking the form of simulation studies, following the example of Banker, Charnes, and Cooper (1994).

Another direction of DEA sensitivity analysis is represented by the idea of super-efficiency, introduced by Andersen and Petersen (1993), with the aim of offering the possibility of ranking efficient units. In the basic models, the efficiency of an observation is evaluated by comparing it with the reference set, which may also include the analyzed unit, and the best performance of a DMU in the sample is indicated by an efficiency score equal to 1. The super-efficiency model excludes the analyzed observation from its reference set, creating the possibility to get efficiency scores > 1. Banker and Chang (2006) and Banker et al. (2017) argue and support the use of the super-efficiency model rather to identify outliers and to have a higher accuracy of efficiency estimates.

Using the idea of the super-efficiency model, Hibiki and Sueyoshi (1999) proposed a DEA cross-sensitivity analysis technique, which examines the robustness of the estimated scores by omitting efficient DMUs one by one from the analysis, thus changing the reference set for the inefficient DMUs. Agarwal et al. (2014) apply the technique of changing the reference set along with the super-efficiency model, to test the robustness of the efficiency scores and also to identify outliers and to perform a ranking of the efficient units. Since these two techniques complet one another, highlighting the robustness of the results, the extreme units and their influence on the efficiency frontier, they were applied in the current study, also.

The statistical properties of DEA estimates can be obtained using the bootstrap method, proposed by Simar and Wilson (1998). This method synthesizes older concepts of resampling and suggests a new framework for simulation techniques, applied to obtain the properties of a sample of observed data, randomly drawn from a population with unknown probability distribution *f*. By repeatedly drawing several random samples (bootstrap samples) from the original sample of the observed data, the distribution of the original sample under investigation can be approximated using Monte Carlo simulations, since the bootstrap samples can be considered as if they were drawn from the base population itself.

CHAPTER V. STATISTICAL EVALUATION OF THE EFFICIENCY OF PUBLIC HOSPITALS IN ROMANIA - EMPIRICAL STUDY

From the hospitals' perspective (as a production unit), efficiency implies producing services of the highest possible value (quality), given the limited resources and the technology available. This process requires the achievement of both allocative (cost) and technical (production) efficiency, the latter being analyzed in the current study.

This study also aims to highlight the impact of the size of hospitals on their technical efficiency and the influence exerted by a series of contextual factors, beyond the hospitals' control, on their efficiency. Thus, the research provides empirical evidence, which can be used as objective support by the decision-makers from the medical field and by hospital managers, for making changes at the structure level and in resource allocation, in order to make more efficient the public hospitals network in Romania.

Study sample and the variables included in the DEA models

The study sample included 258 hospitals with surgical activity in 2019. An output-oriented DEA model was applied, including 3 essential inputs for hospital activity and 2 main outputs. The inputs included in the model were: (1) the number of beds, (2) the number of doctors and (3) the number of nurses.

These 3 indicators approximate the status of a hospital, from the perspective of the structure and essential resources engaged in providing hospital services.

As output variables, were included representative results for the hospitals that provide medical and also surgical services:

(1) the number of discharged patients, which was adjusted with the case-mix index (ICM) of each hospital, in 2019;

(2) the number of surgical procedures (operations), also adjusted with the ICM of each hospital, in 2019.

The sample was divided into 4 relatively homogeneous groups, based on the quantile of the *Beds* variable, in order to have balanced sub-samples in number of observations, also fulfilling the DEA application condition in this regard. We obtained 4 homogeneous groups of hospitals, as follows:

• *Group 1*, consisting of *64 small hospitals*, with a number of beds between 52 and 144;

• *Group 2*, consisting of *66 small to medium hospitals*, with a number of beds in the range of 145-251;

• *Group 3*, consisting of *64 medium to large hospitals*, with a number of beds between 258 and 525;

• *Group 4*, consisting of *64 large hospitals*, with a number of beds between 530 and 1556.

The results of the analyses conducted in the first analytical stage

For each of the 4 groups, the scores of overall technical efficiency, pure technical efficiency, also known as managerial efficiency and the scale efficiency were calculated, based on the basic DEA models, under the constant and variable returns to scale (DEA-CCR and DEA-BCC).

The results showed that, overall, public hospitals in the country are technically inefficient, with each analyzed group having a low number of performers. Only 6% of small hospitals show overall technical efficiency (group 1) and at the opposite pole, only 12.4% of large hospitals (group 4) obtained unity scores for overall technical efficiency. In group 2, of medium-sized hospitals, 13.64% have ET and in group 3, of medium to large hospitals, the percentage of performers is 18%. Although the average level of managerial efficiency (pure technical efficiency) is greater than 0.70 in all 4 groups of hospitals, still a relatively small number of units have managerial efficiency, with the size of the scale as the cause of inefficiency. Thus, only ~8% of small hospitals, inefficient under the CRS condition, present ETP and the same situation is found in the group of large hospitals. Only 6% have managerial efficiency and owe their inefficiency to the technological scale at which they operate. For both, small and large hospitals, returns to scale point to the opportunity to increase the level of inputs to reach the optimal scale of production.

In groups 2 and 3 of hospitals, 11% and 17% of inefficient units, respectively, have pure technical efficiency. It is noted that, in group 2, of medium hospitals, the performers of the group are, in particular, units with cardiovascular specialization or subordinated to other ministries (such as Internal Affairs - M.A.I. or Transport). Also, in group 3, managerial efficiency can be noted in hospitals from other ministries. All these hospitals, with managerial efficiency but with overall technical inefficiency, operate at increasing returns to scale, indicating the opportunity to supplement their resources.

In terms of optimal scale of production, the closest to this are large hospitals, with an average level of 96% scale efficiency. The largest scale inadvertence occurs in group 3, where the average level of scale efficiency is 85%. Although the group of the small hospitals has a slightly higher average scale efficiency than group 3 (88%), half of the units included in this group have a scale efficiency below their group average. Figures 5.1 – 5.8 provide a graphical representation of the hospitals that form the efficiency frontier in each group, under the constant returns to scale condition (DEA-CCR) and under the variable returns to scale condition (DEA-BCC). Hospitals forming the efficiency frontier also are included in the reference set of similar inefficient hospitals from the membership group.

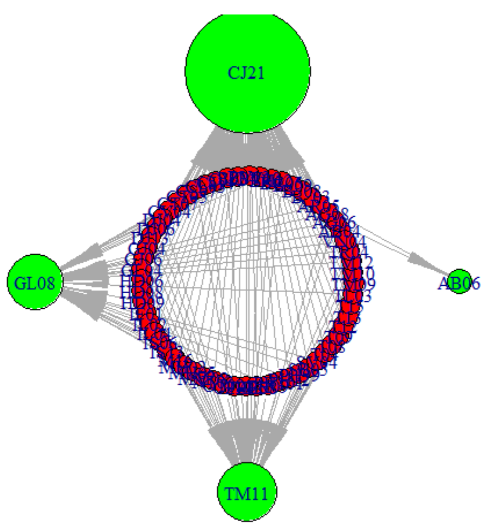


Figure 5.1 The refference set for the group1 of hospitals in DEA-CCR model

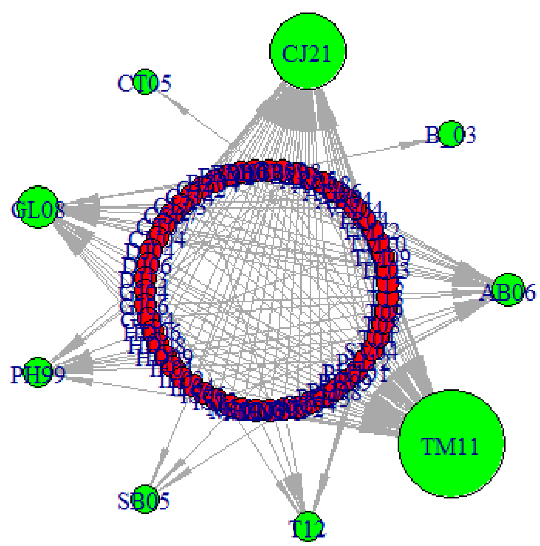


Figure 5.2 The refference set for the group 1 of hospitals in DEA-BCC model

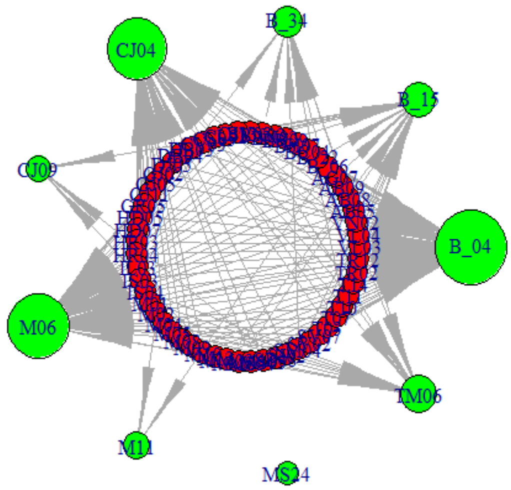


Figure 5.3 The refference set for group 2 of hospitals in DEA-CCR model

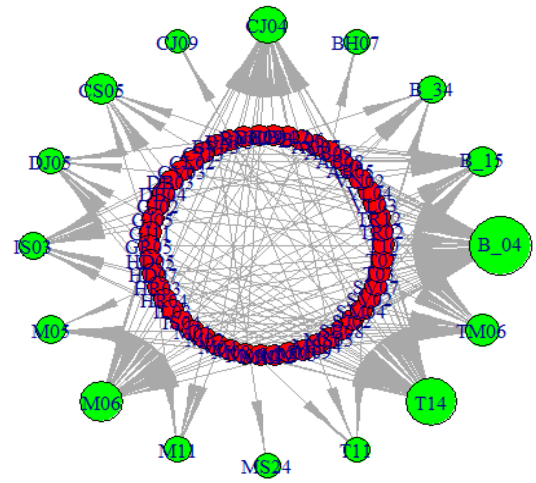


Figure 5.4 The refference set for group 2 of hospitals in DEA-BCC model

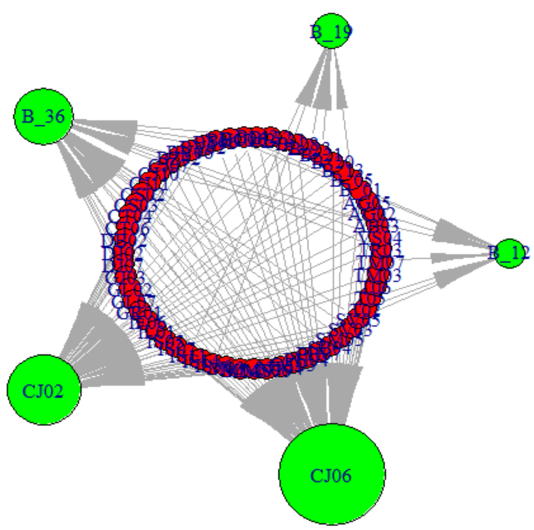


Figure 5.5 The refference set for group 3 of hospitals in DEA-CCR model

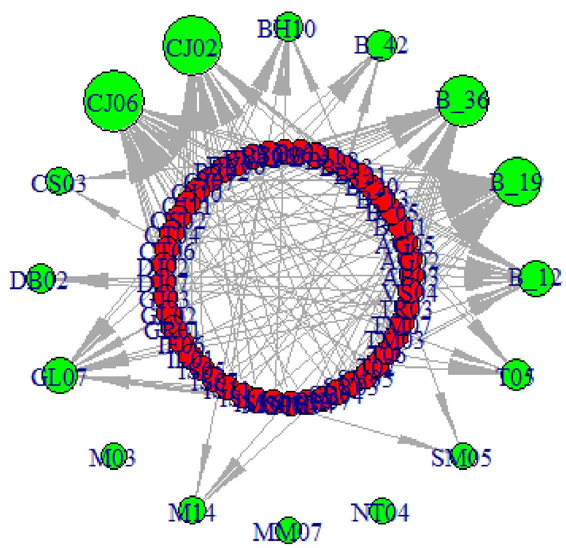
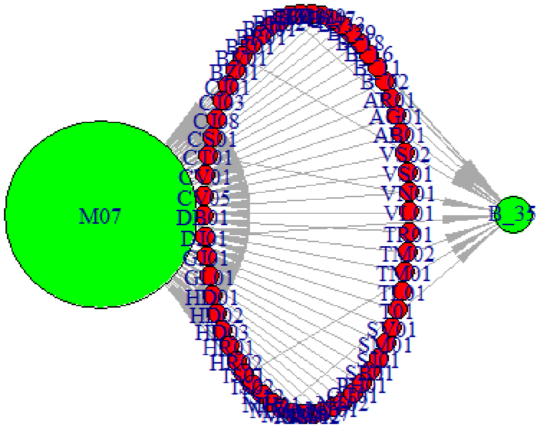


Figure 5.6 The refference set for group 3 of hospitals in DEA-BCC model



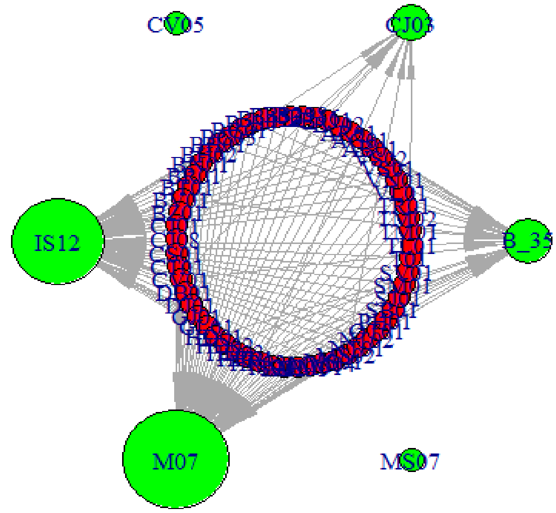


Figure 5.7 The refference set for group 4 of hospitals in DEA-CCR model

Figure 5.8 The refference set for group 4 of hospitals in DEA-BCC model

Using the optimal screen level of 1.2, highlighted in the results obtained by Banker and Chang (2006), after the application of the super-efficiency model, the following outliers were highlighted:

- for group 1, the „Clinical Institute of Urology and Renal Transplant” from Cluj stands out with a super-efficiency score equal to 1.86, followed by the „Sânnicolau Mare City Hospital” from Timiș county, with a super-efficiency of 123% . These 2 units stand out by producing an amount of output approximately 2 times higher than the average values of their group, but using an amount of resources close to its average values;

- for group 2, „Clinical Hospital for Orthopedics-Traumatology and TBC Osteoarticular-Foișor” from Bucharest and „Clinical Emergency Hospital - Avram Iancu” from Oradea (subordinated to M.A.I.) obtained super-efficiency scores > 1.20. „Spitalul Foișor” stand out by a large number of discharged patients in 2019, 2.5 times higher than the average of the group and 2 times more surgical interventions than the average of the group. For the production of these outputs, the resources involved were numerically close to the average of the group. Only in the case of nurses, „Foișor Hospital” had in 2019, a number of nurses 1.5 times higher than the average of the group;

- for group 3, the „Regional Institute of Gastroenterology and Hepatology” from Cluj-Napoca, with an efficiency of 125%, is detached. This medical unit discharged, in 2019, 3 times more patients than the average value of the group and performed approximately 2 times more surgical procedures, but had a number of nurses 1.5 times higher than the average of its group;

- for group 4, the outliers that stood out was the „Central Military Emergency University Hospital” in Bucharest, subordinated to the M.A.I., with an efficiency of 147%. In 2019, this medical unit produced approximately 4 times more results (discharges and operations) than the other hospitals in the group but using resources numerically close to the group average. Regarding the number of doctors, „Central Military Hospital" had a number 1.7 times higher than the average of the group.

It was found that DEA is sensitive to outliers, which influence the stability of the frontier in the case of groups 1 and 4, but without having a major impact on the inefficiency scores of the other DMUs. The outliers are hospitals that, in the super-efficiency model, score higher than 1.20 and influence the stability of the frontier, especially under variable returns to scale, highlighting managerial differences.

It is noted that, although by eliminating the outliers from the group of small hospitals and from the group of large hospitals favors the performance of other units, which end up occupying a position on the frontier, overall, the robustness of the efficiency scores is high. The correlations between the distribution of initial scores and the distributions of re-estimated scores after applying Jackknife technique are positive and very strong (correlation coefficients > 0.80 and > 0.90). Also, bootstrap based bias correction highlights the existence of larger variations between the initial scores and the corrected ones, only in the case of performers, where the corrected scores are 0.11 up to 0.22 lower than the initial ones, but not in the case of inefficient units in group, where the correction is only of 0.01 up to 0.05. A greater stability is found both in the group and in the composition of the frontier in the case of small to medium hospitals and in the case of medium to large hospitals, where the presence of possibly extreme values does not influence the construction of the frontier. The robustness of the scores estimated with the basic DEA models is confirmed by the high correlation coefficients between the scores computed in the presence of possible outliers and the same scores computed in the absence of outliers.

The DEA-SBM model computes significantly lower efficiency scores than the basic DEA models. The differences between the scores obtained with the two types of models are larger in the case of constant returns to scale and vary between 7% and 18%. The biggest difference is in the group of small hospitals, where the average of the overall technical efficiency scores obtained with the DEA-CCR model is 18% higher than the average of the overall technical efficiency scores obtained with the SBM model. Hospitals from group 2 (small to medium) show the smallest difference between the scores obtained with the basic models and those calculated based on slacks, of 7% (ET) and 5% (ETP), respectively. The SBM model suggests an increase in the average level of outputs for the inefficient hospitals with 48% of discharges and 89% of surgical procedures compared to the average achieved in 2019. Group 3, of medium to large hospitals, requires the highest increases in the level of achieved outputs of inefficient hospitals: they would have to discharge, on average, 67% more patients and double the number of surgical procedures performed annually, to become technically efficient. In group 4 of hospitals, in the absence of the extreme unit M07-Spitalul Militar Central in Bucharest, which is a super-efficient unit and establishes the performance standard for the whole group, the need for an average increase in the number of discharges is of 35% compared to the achieved average and of 52% in the number of surgical procedures.

The results of the analyzes carried out in the II analytical stage

In order to identify the variables that significantly influence the technical inefficiency of hospitals, we used the Tobit regression model, because the efficiency variable is a censored variable, which requires the application of an appropriate regression model. Following the recommendations in the literature, we considered the censoring point of the variable to the left, at zero value. Previously, we transformed the efficiency scores into inefficiency scores, using the formula: *inefficiency score = (1/DEA efficiency score) – 1* (Zere Asbu, 2000; Kirigia and Zere Asbu, 2013; Mujasi et al., 2016). Thus, efficient hospitals had the inefficiency score equal to zero, and the inefficient hospitals got an inefficiency score > 0. By applying this tranformation, the DEA efficiency scores are normalized, allowing to interpret the model coefficients in the same way to linear regression.

The hypothesis of the Tobit regression model was that the technical inefficiency of hospitals is influenced by 7 contextual variables: (1) *population density* from the geographical area where the hospital is localized, (2) *GDP / capita in each county*, in the previous year, (3) *percentage of elderly population* in the total population of the county served by the hospital, (4) *percentage of active population*, contributing to the National Social Health Insurance Fund and to the financing of the healthcare system, (5) *mortality rate of active population* as an expression of the health status of the population from each county (6) *the socialy assisted population (7) the annual percentage of graduates of any form or level of education* in total population of the county, in the previous year.

For overall technical inefficiency, after running several models, with different combinations of the explanatory variables, the best estimated model was as follows:

$$\textit{Overall technical inefficiency} = \alpha + \beta_1 \text{ pop\_density} + \beta_2\text{GDP\_per\_capita\_2018} + \beta_3 \text{ percentage\_pop\_socially\_assisted} + \beta_4\text{percentage\_pop\_elderly} + \varepsilon_i$$

where

Inefficiency = partially continuous dependent variable, censored to the left, obtained by transforming the overall technical efficiency score according to the formula inefficiency score = (1/DEA efficiency score) – 1

Population density, GDP/capita in 2018, percentage of socially assisted population, percentage of the elderly population = continuous independent variables;

β_1, β_2, β_3, β_4 are the estimated coefficients of Tobit regression; they indicate the change produced in the latent variable $y_i$by a unit change in each of the independent variables. Studies using Tobit regression to model DEA efficiency scores are limited only to the interpretation of the sign of the regression coefficients, since the dependent variable is a censored one. But the normalization of the variable through the transformation of the efficiency scores into inefficiency scores, offers the possibility to interpret the values of the Tobit regression coefficients as well;

ε_i = the error component, which requires a normal distribution $(0, \sigma^2)$, to ensure consistency of estimators. The Tobit regression model is based on satisfying the assumptions of normality and homoscedasticity of errors, and due to the censoring of a number of observations, the distribution of residuals tends to be skewed to the right.

For pure technical (managerial) inefficiency, the best estimated empirical model is the following:

$$\textit{Managerial inefficiency (pure technical inefficiency)} = \alpha + \beta_1 \text{pop\_density} + \beta_2 \text{GDP\_per\_capita} + \varepsilon_i.$$

For scale inefficiency, the Tobit regression analysis demonstrated that none of the contextual variables used in modelling the inefficiency scores has a significant influence on the dependent variable.

The analyzes showed that the best empirical model, which also respects the assumptions of normality and homoscedasticity of the errors, is the explanatory model for the overall technical inefficiency, The dependent variable left censored, has a percentage of 8% censored observations. For managerial inefficiency, the dependent variable has a percentage of 22% censored observations, and the empirical model includes only 2 explanatory variables and no longer respects the assumption of homoscedasticity of errors. Scale inefficiency could not be modeled, given its dependence on internal factors, related to the hospital, and not on external factors. Although the size of the hospitals may be conditioned by their location and by the size of the population served (Zere Asbu et al., 2020), the scale efficiency shows the degree of adequacy between the hospital's level of operations and its size and our conclusion is that the scale efficiency is influenced, first of all, by the factors related to the hospital. Moreover, no significant relations were identified between scale inefficiency and the contextual variables considered in our research, suggesting the existence of a causal relationship between them.

The contextual variables, with relevance in explaining the overall technical inefficiency, are the *population density* and the *percentage of the elderly population* (≥ 65 years) in the total population, the *percentage of the socially assisted population* and the *GDP per capita* in each county. The impact of these variables on the (in)efficiency of hospitals is justified by the fact that a larger population served puts more pressure on the hospitals operating in each geographical area. Also, a higher percentage of the elderly population, which is more dependent on hospital care than the younger population, leads to a greater demand for hospital services and a greater consumption of resources for the hospitals serving geographical areas with higher percentages of elderly population.

The managerial inefficiency of hospitals is significantly influenced by the GDP/capita in each county and the density of the population in each county, the results being justified by the dependence of hospital resources on local budgets, most of the health units being subordinated to local authorities. Also, the density of population conditions the demand for hospital services, exerting greater pressure on hospitals, in case of high density of population of the served areas.

CONCLUSIONS

The purpose of the present research was to evaluate the efficiency of public hospitals in Romania, using the results of medical activity from 2019, the last year with no epidemiological and normative changes. The subject was chosen because hospital services are the pillar of the healthcare system in Romania, which has one of the lowest performances in the European Union, despite reform policies for compliance with European Community standards. The chronic underfunding of the health system has generated many difficulties and the poor management of the existing resources has led to the neglection of prevention and primary care sectors and to the provision of medical care mainly through hospital services, which are much more expensive. The evaluation of the national network of public hospitals thus becomes a necessity, all the more since such efforts have only been carried out on a small scale, on a limited number of health units.

It was found that overall, Romanian public hospitals are technically inefficient, with each analyzed group having a low number of hospitals with 100% efficiency. Thus, the first question of the research was answered, which questions whether public hospitals in Romania are inefficient. Large hospitals are characterized by high scale efficiency, suggesting that their inefficiency is primarily caused by poor management. In contrast, small hospitals show a relatively high average level of scale efficiency, but operate below this average level in a majority proportion, suggesting hospital size as the major cause of inefficiency. Among medium-sized hospitals and medium-to-large hospitals, the managerial efficiency of units with a cardiovascular profile and units subordinated to other ministries (M.A.I. and the Ministry of Transports) stands out. The inefficiency of medium and medium-to-large hospitals can be attributed more to poor management than to the size of the health facilities included in these two groups. Thus, the second question of the research was also answered, regarding the size of hospitals as the main cause of inefficiency, a question justified by the fact that the network of public hospitals in Romania is composed in a significant proportion of small and medium hospitals, with a reduced level of competence.

The disadvantage of the applied non-parametric method concerns the accuracy of the efficiency scores obtained based on it, so that the bootstrap technique was used for bias correction. Statistically significant differences were obtained between the initially estimated scores and the bootstrap scores, for an assumed risk of 5%. The DEA method tends to overestimate the efficiency of the performing units in the analyzed hospital groups, especially the managerial one (VRS condition), but detects inefficiency with a precision of 0.01 to 0.05 difference between the initial scores and the corrected scores.

The ouliers were kept in the analysis, for 2 reasons: by omitting them, important information for the purpose of the research could have been lost and other health facilities would have been highlighted as outliers, which would have ultimately led to a substantial reduction of the study sample. The results obtained indicated that the presence/absence of extreme values/outliers in each analyzed group significantly influences the performance of other units in the group and the stability of the efficiency frontier only for the case of small and large hospitals: the exclusion of outliers from these groups gets other health units, initially inefficient, on the efficiency frontier. The sensitivity analyzes showed, however, that the robustness of the computed efficiency scores is not in doubt, overall, they have a high stability. The influence of outliers became more apparent in the slack-based model, which was applied to detect the annual increases in results required for inefficient hospitals to reach the efficiency standards of their efficient peers. The largest increases should be operated by medium-to-large hospitals, for which the recommendation is to double the number of discharges and the number of surgeries annually performed, and the smallest recommended increases were formulated for the group of large hospitals. Thus, it was considered to obtain the answer for the 3rd question of the research regarding the production level changes that the inefficient hospitals have to make.

The second stage of the research consisted in a Tobit regression analysis, which answered the question related to the influence of contextual factors on the (in)efficiency of hospitals. It was found that the population density of the county where hospital is located, the percentage of elderly people, the percentage of socially assisted people and the GDP per capita in each county significantly influence the overall technical inefficiency of hospitals. Managerial inefficiency is significantly influenced only by the density of the population and GDP per capita. In contrast, scale inefficiency could not be modeled, no valid Tobit regression model was identified, also no statistically significant relations were identified between scale inefficiency and contextual variables. These results suggest the hypothesis that scale inefficiency could be influenced, first of all, by internal factors related to the hospital, given that it expresses the degree of adequacy between the level of operations of the hospital and its size.

PERSONAL CONTRIBUTIONS

The contribution brought by this thesis is addressed to health management and the public health sector, by approaching this subject, for the first time, in the Romanian scientific literature, with an advanced statistical method and on a large number of public hospitals. The value of the first 4 chapters consists in:

A. the holistic presentation of the efficiency concept, applied in the medical sector, in chapter 1, connected with the concepts of quality and performance of medical services;

B. a detailed description of the state of the Romanian health system, in chapter 2, connecting the reports and analyses carried out on different dates, by international agencies, such as the World Bank, OECD, the European Health Consumer Index, completed by personal analyses, performed on the latest statistical data from Eurostat;

C. the contribution of chapter 3 consists in presenting the indicators and methods used in international studies for evaluations of hospitals efficiency, in the larger context of their performance and in close relation with the quality of medical care;

D. contribution of chapter 4 consists in the synthetic presentation of the methods for efficiency estimation: the non-parametric Data Envelopment Analysis method and complementary techniques. The contribution of this chapter is also given by the review of the international papers and of the Romanian scientific papers, which used DEA to assess the efficiency of the hospitals.

E. the value of the empirical study, described in chapter 5, consists in the way in which the data was managed: the grouping of the hospitals in 4 homogeneous sub-samples, balanced in number, respecting the statistical criteria for applying the method; adjusting the output variables with the case-mix index, to take into account the pathology treated by each healthcare unit; keeping the outliers in the analysis, to highlight their impact on efficiency scores through the super-efficiency model and through sensitivity analyses. The results obtained with the basic DEA models were completed with the results provided by the DEA-SBM model, based on the output-slacks and the input-slacks, providing clear recommendations for inefficient hospitals, regarding the increase of the annual results of their medical activity. Also, chapter 5 includes a qualitative analysis of scientific papers on the topic of hospital efficiency in Romania, published after the year of implementation of the evaluation system for the hospital management and the implementation of the DRG system for hospitals financing.

The Tobit regression, applied in the second stage of the research to identify the determining factors of the (in)efficiency of hospitals, highlighted, as a new element for the inefficiency of hospitals in Romania, the significant influence of the variable *percentage of the socially assisted population*, along with other demographic and economic variables, also applied in international studies.

RESEARCH LIMITS AND FUTURE RESEARCH DIRECTIONS

The limitations of the research concern aspects related to research design. A first observation could be made on the way that hospitals were grouped. The results obtained showed that there are specialized hospitals with low admission capacity, but with high quantitative results, compared to the achievements of hospitals of the same size. These stood out as extreme values/outliers from the point of view of the results obtained, although the level of resources correctly placed them in the membership group. Also, specialized hospitals, which provide medical services for certain conditions, were considered as reference units for general hospitals, generating large differences in the output level. Since the study aimed a global assessment, and such units/situations were highlighted in a small number, for the current research it is justified to divide the sample according to the number of beds. For future research directions, however, we recommend an analysis of hospitals taking into account, first of all, their profile / specialization.

A second limitation of the research is the option to evaluate only one dimension of hospital efficiency, namely the technical dimension, without addressing allocative efficiency by including financial variables. However, the goal of global evaluation of the efficiency of the national network of public hospitals justifies this option and the limitation to a 3 x 2 model, which reflects the use of the main resources in the healthcare sector. The model proposed in this paper is a primary model, able to highlight the efficiency of public hospitals with surgical activity, especially since the output variables were adjusted with the case-mix of the hospitals. In future studies, financial variables and other staff categories could be taken into account, to develop more models. Undesirable outputs, such as hospital in-hospital mortality, can also be taken into account, thus including the quality dimension in the analyses.

The results of this research could be used as references in further reforms in the national health system. Although public hospitals in Romania are among the facilities that spend the most on inpatients in the EU, mortality from treatable causes is the highest. Although the cardiovascular profile hospitals stood out with managerial efficiency, they do not possess overall technical efficiency because they do not operate at the optimal technological scale. Small hospitals are also operating below optimal levels and require an infusion of resources to increase their efficiency. Considering the fact that 90% of public hospitals in Romania are located in the urban environment, and the health network consists mainly of small and medium-sized hospitals, with limited competences, they could be merged to increase the level of results, but also to reduce expenses and distribute them on a larger base.

The National Health Strategy for the period 2022-2030 admits the concentration of medical services on the hospital sector and the need to reform/restructure the hospital network, but also the need to develop the pre- and post-hospital services (for medical rehabilitation). The health strategy for the upcoming years aims to increase the capacity of response the health sector to sanitary crises such as the COVID-19 pandemic, to invest in hospital infrastructure and to restructure the number of beds for acute patients and their territorial distribution, considering the prevailing morbidity in the population and the need for medical services (SNS 2022-2030, 2022, pp. 31-32). The present research provides results that support these new health goals for 2022-2030.

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