



## PERFORMANCE THROUGH EFFICIENCY IN THE PUBLIC HEALTHCARE SYSTEM - A DEA APPROACH IN AN EMERGENT COUNTRY

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**Abstract.** Aiming to analyze the efficiency of the public sector, this paper enriches the literature by providing insights of the healthcare system for an emergent country – Romania. The empirical findings reached by applying the input orientated-variable return to scale (VRS) model of Data Envelopment Analysis (DEA) and Tobit regression method are determined on two key levels of the study. The Data Envelopment Analysis technique quantifies the efficiency within 20 representative hospitals located in the four administrative macro-regions, highlighting the ways of increasing efficiency, while the Tobit regression identifies the factors that influence the efficiency level. The results of the investigation allow for comparisons with other emerging countries, as efficiency has become an increasingly significant factor for public sector evolution.

**JEL classification:** H41, I18, M40

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## 1. Introduction

Performance management in the public sector is a growing phenomenon worldwide (Goh, 2012) designed to improve public sector accountability (Harrison et al., 2012). It is still facing many problems and challenges in implementing effective measurements, despite multiple frameworks developed over the last decades. Performance measurement is widely seen as the cornerstone of public management reforms (Kong, 2005), being researched in-depth for a long time and comprehensively reviewed (van Helden et al., 2008) for highlighting the relevance of performance measurement and reporting.

Access to performance information enhances users' decision-making and promotes public sector accountability (IPSASB, 2011), which is not simply a one-to-one (principal-agent) relationship (Mulgan, 2000). It usually implies different stakeholders whose economic and political interests overlap (Pilcher et al., 2013).

In this context, performance measurement and reporting are a necessary response to public pressure for accountability. Thus, they encourage public entities to disclose publicly and to be responsible for their actions (OECD, 2004), even if there is still no consensus on the real usefulness of performance information (Rossi and Aversano, 2015). Moreover, evidence reveals substantial differences in the adoption of performance measurement and reporting system worldwide, mainly due to the particularities of the institutional, cultural and historical contexts of each country (Benito et al., 2007).

To address this gap, alongside the academic literature, International Public Sector Accounting Standards Board (IPSASB) ensures a strong incentive for promoting the concept of service performance information within public sector entities. Thus, IPSASB published the Recommended Practice Guideline on Reporting Service Performance Information (RPG 4) aiming to develop a framework dedicated to service performance information of public sector entities, meant to enhance accountability for both services provided and resources consumed. Moreover, an essential part of the Conceptual Framework for General Purpose Financial Reporting (GPFR) includes information on performance measurement, thus focusing on service recipients' and the resource providers' needs for high-quality information, for both accountability and decision-making purposes.

Basing on this approach, the primary objective of this study is to provide evidence of the performance assessment in the public sector, by analyzing the efficiency of rendering services, using mathematical techniques and debating potential factors that might affect the outputs, thus leading to inefficiency. Moreover, considering the continuous medical advances, that not only have increased the demand for quality healthcare services but also triggered the challenge of managing rising costs and maintaining efficient operations, the study focuses on the hospital efficiency, one marked in the last decades by serious inefficiencies (Afonso and Aubyn, 2005; Evans et al., 2001; Spinks and Hollingsworth, 2009). Consequently, this study contributes to the prior literature in this field by estimating the technical efficiencies of the hospitals, evaluating the benchmarks and setting the targets for the inefficient hospitals in an emergent country.

For achieving our goal, first of all, we apply a non-parametric technique based on linear programming for assessing the technical efficiency of hospitals,

namely Data Envelopment Analysis (DEA). Secondly, we resort to the econometric analysis using different statistical tools, like descriptive analysis and regressions to identify those factors with an overwhelming influence on inefficient hospitals.

The sample of our paper consists of 20 public county hospitals in Romania collected from the Centre for Research and Evaluation of Health Services website and the Ministry of Health's website for the year 2014. Considering the variables used in the previous studies and the availability of data, we have taken the number of beds, the number of doctors and the non-salary operating expenditure as input variables, while the total operating revenues, the number of cases and hospitalization days are considered as output variables.

The results of our DEA model reveal that among all public hospitals in our sample, five are inefficient and for each of these hospitals a benchmark is being provided for improving their operations. The results of a Tobit regression indicate that the number of cases has a positive influence on the efficiency level. Also, variables such as the total operating revenues also present a positive impact on the efficiency score, while non-salary operating expenditures and the number of doctors influence the efficiency level in a negative manner.

The study addresses a broad range of users: theoreticians interested in analyzing emerging countries, as parts of the European Union, and practitioners who manage to find justifications and solutions to similar issues faced in their national systems. Moreover, as the first study that investigates the effectiveness of the health system in this manner, focusing on the main causes of inefficiency in Romania, we appreciate it as a valuable reference base for international literature in the field, too.

The limitations of the study are generated by the sample's dimension and by the period considered for analysis. Thus, the study estimates the efficiencies for half of the county public hospitals in Romania and one calendar year only, which can be extended for time series analysis. Anyway, we appreciate all these as challenges that give us outlooks for future research.

The paper unfolds as follows: at first, the topic of performance and efficiency in the public sector is theoretically approached by analyzing the related literature, from general to specific on public health system (literature review). The next section (methodology framework) develops the concept of efficiency by empirically approaching it from a dual perspective. The efficiency measurement using the multi-criteria non-parametric analysis model known as Data Envelopment Analysis (DEA) is followed by an econometric analysis using various statistical tools to identify those factors with an overwhelming influence on inefficient hospitals. Our analysis ultimately leads to validation or invalidation of research hypotheses (result section), thus reaching conclusions and expressing opinions that respond to papers' primary goal and its objectives (conclusions section).

## **2. Literature review and hypothesis development**

According to prior research, there are significant differences in the efficiency of delivering public services across countries, public organizations either being incredibly wasteful and ineffective in performing even core activities or achieving their objectives systematically and comprehensively (Afonso et al., 2005). These differences

are due to various factors such as fiscal decentralization (Adam et al., 2014), political determinants (Adam et al., 2011), the quality of governance (Hwang and Akdede, 2011), education (Afonso and Fernandes, 2008; Bose et al., 2007), investment and the openness of the economy (Angelopoulos et al., 2008).

Therefore, in the latest decades, the cross-country research studies conducted reveal serious inefficiencies in managing public expenditures (Afonso and Aubyn, 2005; Evans et al., 2001; Spinks and Hollingsworth, 2009), especially in the health sector. In this field, it is expected that public spending on health and social care to increase faster than the economic growth over the next 50 years, in line with recent trends across the OECD (Rumbold et al., 2015). Thus, healthcare systems must find ways of delivering health services at acceptable levels of quality, even with budgets that are growing more slowly than in the past decades. They also have to improve the quality of budgeting and financial management, the key determinants of an effective public spending (Fonchamnyo and Sama, 2015).

Also, the rising healthcare expenditure and large public budgets have recently led decision-makers to search for ways to increase the performance of healthcare organizations. Hospitals, in particular, are increasingly held accountable for their efficiency and financial performance (Tiemann and Schreyögg, 2012), thus supporting the motivation of our study.

This situation manifests itself mainly because healthcare is the part of the public sector where various stakeholders might have different needs and performance embraces a diversity of facets (Harrison et al., 2012). Thus, policy makers have a fiduciary duty to make sure that healthcare expenditure is on a sustainable path. Hospital managers are interested either in improving the quality of the output while using the same amount of resources or in reducing the operation expenses without sacrificing the quality of care provided by the hospital. Instead, doctors and nurses have the responsibility to preserve the safety of their patients and the quality of their work, while patients, as customers of the hospitals, need to be provided with the greatest quality of care (Du et al., 2014).

According to prior research, maximizing efficiency has become an increasingly significant factor for hospital executives, as the possibility for cost savings is better if healthcare institutions are managed appropriately (Harrison et al., 2004; Rodriguez-Alvarez et al., 2004). Therefore, this study has been taken up to identify the factors that cause inefficiency in the case of the Romanian healthcare sector and to find suitable ways to improve their efficiency.

In this context, the first hypothesis intends to validate the academic literature, which supports the need to maximize the efficiency of using public funds by increasing the quality of services provided (e.g. Harrison et al., 2004; Harrison et al., 2012; Rodriguez-Alvarez et al., 2004):

*H1. The Romanian healthcare system is efficient.*

Recently, rising of expenditure on health system reflects only partially the changes in health services demands. These are sometimes represented by new technological innovations in diagnosis and treatment, and therefore in high-quality services, but such progress also comes at a cost. Unfortunately, the evidence reveals that although the technical efficiency has benefited from the embodiment of the new medical technology, the scale efficiency remains unaffected (Tsekourasa et al., 2010).

Moreover, few innovations in technologies had a substantial impact on reducing costs and improving efficiency (Blank and Van Hulst, 2009).

In this context, there was significant interest in conducting studies in the area of health economics to propose solutions to curb the rapid increase in healthcare spending and to improve the efficiency of the healthcare system. Thus, an insight of the relationship between technology and cost provided relevant results that could influence the long-term cost growth by controlling the availability and diffusion of new technologies (Blank and Van Hulst, 2009). Moreover, most studies analyzing the hospital efficiency focus on technical efficiency (the maximum output given, the input or the minimum input usage given the output), the scale efficiency (the maximum “average product”—i.e., no increasing or decreasing returns), and/or cost efficiency (the minimum cost given, the input prices and the output quantities) and their determinants (Ferrier, et al., 2013).

In this context, our study aims to measure the technical efficiency of public sector hospitals in Romania, to identify the inefficient hospitals and the input reduction required to make them efficient. Consequently, the second hypothesis seeks to validate the positive association between the input and output variables and the efficiency level of the hospitals included in our sample:

*H2. There is a positive association between the input and output variables and the efficiency level*

In the next sections we develop the hypothesis in order to fulfill the objectives of the study.

### **3. Methodology framework**

#### **3.1 Method**

The performance of the healthcare system is an important issue and has been analyzed in many studies from the efficiency perspective by using a non-parametric analysis model known as Data Envelopment Analysis (DEA). DEA is a non-parametric frontier technique used to search for optimal combinations of outputs and inputs based on the real performance of comparable units (Ozcan, 2008) or decision-making units (DMUs). This approach measures the efficiency by determining the capability of accommodating multiple inputs to produce multiple outputs and also establishes an efficient frontier (a graphics segment generated by the efficient units) as a benchmark for underlying the efficient hospitals and the inefficient ones. Moreover, this method highlights the means of increasing efficiency by indicating what inputs must be reduced or what outputs must be increased so that a hospital reaches the efficiency frontier. In DEA, the maximum output that an enterprise can produce from a set of inputs is estimated from the best performers tracing out the border. This efficiency border can be viewed as a benchmark for assessing the efficiency of an organization (Bryce et al., 2005).

Some studies (Burgess and Wilson, 1996) apply DEA to U.S. hospitals to determine whether the ownership structures – not-for-profit (NFP), for-profit (FP), federal, state, and local government hospitals – influence their technical ability to convert inputs into outputs. Their investigation reveals that FP hospitals are more efficient

than NFP hospitals and that NFP hospitals are more interested in providing high-quality services rather than obtaining profit. There are authors (Ersoy et al., 1997) who used the constant return to scale model (CRS) to 573 Turkish general hospitals, highlighting that inefficient hospitals use a large number of specialists and primary care physicians, with over two times the number of beds than the efficient ones. However, even with their excess inputs, inefficient hospitals produce fewer outputs than their counterparts. In Germany, public hospitals are more efficient than private ones because they use fewer resources (Helmig and Lapsley, 2001), compared with the significant investments in improving the quality of medical services in private hospitals.

Following prior studies (Bates et al., 2006; Lee et al., 2008; Wang et al., 2010), this research applies the input orientated model to assess the efficiency of using public resources in case of the Romanian county hospitals. Based on available data this study provides evidence on the technical efficiency of 20 public county hospitals in Romania for the year 2014. Given the size, diversity, and complexity of the healthcare services provided by these hospitals, they are among the largest consumers of financial resources in the Romanian Healthcare System.

The last part of our empirical studies uses the Tobit analysis, which is suitable for continuous data that are censored or bounded at a limiting value (Osgood, et al., 2002) and allows for the estimation of the impact of independent variables on the uncensored variables (Wang, et al., 2010).

Tobit regression represents an alternative to the OLS regression and is regularly used in modeling DEA scores (Hoff, 2007). A large number of studies use the Tobit regression procedure in the second stage of the DEA analysis (McDonald, 2009; Simar & Wilson, 2011). Given that the efficiency scores determined in the first stage of DEA model are between 0 and 1, the use of techniques such as Tobit regression or an exponential function model is preferable, because they are easy to interpret and can accommodate both categorical and continuous variables without changing the number of efficient DMUs (Yang & Pollitt, 2009).

### 3.2 Variables and data

First of all, aiming to perform a cost-oriented analysis the Romanian public hospitals, we consider the most popular variables for applying DEA in the healthcare system (ÓNeill et al., 2008), thus using similar inputs and outputs for our model (see Table 1).

**Table 1. Variables considered for DEA analysis**

Variables	Literature references
<i>Inputs:</i>	
(a) number of beds	Tiemann and Schreyögg (2009); Kirigia, et al. (2008); Staat (2006); Hu and Huang (2004); Puig-Junoy (2000); Ersoy, et al. (1993); Valdmanis (1992)
(b) number of doctors	Ng (2011); Kirigia et al. (2008); Puig-Junoy (2000); Ersoy et al. (1993); Valdmanis (1992)
(c) non-salary operating expenditure	newly introduced by our study

Variables	Literature references
<i>Outputs:</i>	
(d) total operating revenues	Lobo, et al. (2014); Du, et al. (2014); Kirigia, et al. (2008)
(e) the number of cases	Du et al. (2014); Staat (2006); Thanassoulis (1993); Valdmanis (1992)
(f) hospitalization days	Lobo et al. (2014)

Source: authors' projection

Following the selection, we provide arguments to support the choice of each variable considered for our model:

(a) *Number of beds* – is used as a proxy for the hospital size, aiming to determine if managers are using hospital facilities in an efficient and effective way. Prior evidence suggests a positive association between the number of beds and efficiency (Hu and Huang, 2004; Tiemann and Schreyögg, 2009), thus revealing that an increased number of beds improves hospital efficiency.

(b) *Number of doctors* – is used as a substitute for the labor force. Capital and labor are both imperial in delivering healthcare services in hospitals (Ng, 2011). Some studies measured the labor through other related variables, such as the number of physicians, including residents (Puig-Junoy, 2000) or by considering only the inhabitants (Valdmanis, 1992), as well as the number of doctors plus nurses (Kirigia et al., 2008).

(c) *Non-Salary operating expenditure (NSOE)* – is a new variable introduced in our DEA model as a consequence of prior literature limitations (Kirigia et al., 2008), which did not consider the administrative costs as inputs. We appreciate that physicians are responsible for significant amounts of resource consumption in hospitals and, consequently, they should be accountable for the financial implications of their decisions and actions.

Consequently, regarding the input variable of our study, we use the number of beds and the hospital's expenditure as two separate variables. From the entire hospital's expenditures, we have excluded payroll expenses to avoid the double counting problem (the doctors' incomes), considering that we have already selected the number of doctors as inputs.

(d) *Total operating revenues* – is used as a financial proxy, measured in other studies by patient admissions (Kirigia et al., 2008) or high complexity procedures (Lobo et al., 2014).

(e) *The number of cases*. This variable was often used in prior analyses being encountered in various forms, such as the number of patients by age - adult, pediatric, or elderly (Valdmanis (1992), normal/severe patients (Thanassoulis, 1993), including their survival rate (Du, et al., 2014).

(f) *Hospitalization days*, proven to be positively associated with the number of beds (Lobo et al., 2014).

For the second part of our empirical analysis aimed to identify those factors influencing the efficiency in Romanian public hospitals by using the regression analysis, we consider the efficiency score generated by DEA as the dependent variable and the above-described inputs and outputs as the independent variables.

Among the results revealed by the prior evidence, we glean that there are significant differences between the efficient and inefficient hospitals regarding the number of beds (Lobo et al., 2014). Moreover, the size of the hospital and the average length of stay have a positive impact, while the ratio of doctors and nurses per patient has an adverse impact (Karagiannis, 2013; Chu and Chiang, 2013).

The sample of our study consists of a reduced sample (20 hospitals) because the minimum number of DMUs that can be used in a DEA model is the number of inputs multiplied by the number of outputs (Boussofiene et al., 1991; Ozcan and McCue, 1996). Also, prior researchers recommend that the number of DMUs should be at least twice (Golany and Roll, 1989) or three times the number of inputs and outputs selected (Bowlin, 1998). In addition to that, Dyson et al. (2001) propose that the total number of units must be two times the product of the number of inputs and outputs.

The selection of hospitals in this study is based on administrative and development considerations. One of the main characteristics of healthcare policy in the public systems is the frequency with which restructurings take place, redefining institutional roles, centralizing or decentralizing, splitting or consolidating different delivery organizations. These reorganizations have a significant impact on the careers of healthcare workers and the quality of the care experienced by the patients (Datta et al., 2013).

The country taken into account for our study is divided into regions, on three levels: NUTS-I, NUTS-II, and NUTS-III. The level NUTS-I consists of four macro-regions, the NUTS-II level is composed of eight regions, and the NUTS-III level consists of 41 counties plus the capital of the country (Boldea et al., 2013). The selection of the hospitals is made so that every macro-region is fairly represented in the study. Thus, the sample includes five hospitals from the macro-region 1, six hospitals from the macro-region 2, four hospitals from macro-region 3 and five hospitals from macro-region 4. It is important to mention that each one of the macro-regions consists of a different number of counties.

Following literature recommendation and considering the inputs and outputs variable selected for our study, the minimum number of DMUs should be 9 or 18, so this constraint has been satisfied by our analysis.

The hospitals and variables included in our study are described in Appendix 1.

### 3.3 Results and discussions

In this study, we apply an input-oriented variable returns to scale (VRS) model to measure county hospitals technical efficiency. Our choice of model is based on the assumption that public hospitals have more control over their inputs than over the outputs. According to this model, the inputs are minimalized, and the outputs are kept at their current level (Banker et al., 1984):

$$\theta^* = \min \theta$$

subject to:

$$\sum_{j=1}^n \lambda_j x_{ij} \leq \theta x_{i0} \quad , (i=1,2,\dots,m)$$

$$\begin{aligned} \sum_{j=1}^n \lambda_j y_{rj} &\geq y_{r0} && , (r=1,2,\dots,s) \\ \sum_{j=1}^n \lambda_j &= 1 && , \\ \lambda_j &\geq 0 && , j=1,2,\dots,n \end{aligned}$$

Let  $y_{rj}$  be a vector of outputs ( $r=1,\dots, s$ ) and  $x_{ij}$  a vector of inputs ( $i=1,\dots, m$ ) for each hospital  $j$  ( $j=1,\dots, n$ ). Since  $\theta = 1$  is a feasible solution to the optimal value,  $\theta^* \leq 1$ . If  $\theta^* = 1$ , then the current input levels cannot be reduced (proportionally), indicating that  $DMU_0$  is on the frontier. Otherwise, if  $\theta^* < 1$ , then  $DMU_0$  is dominated by the frontier.  $\theta^*$  represents the (input-oriented) efficiency score of  $DMU_0$ .

For a given level of outputs  $y_r$  and a given level of inputs  $x_i$  for hospital 0, we will determine the input and output slack values by solving the following model (Charnes, et al., 1982):

$$\max \sum_{i=1}^m s_i^- + \sum_{r=1}^s s_r^+$$

subject to:

$$\begin{aligned} \sum_{j=1}^n \lambda_j x_{ij} + s_i^- &= \theta^* x_{i0} && , (i=1,2,\dots,m) \\ \sum_{j=1}^n \lambda_j y_{rj} - s_r^+ &= y_{r0} && , (r=1,2,\dots,s) \\ \sum_{j=1}^n \lambda_j &= 1 && , \\ \lambda_j &\geq 0 && , (j=1,\dots,n) \end{aligned}$$

Where  $s_i^-$  and  $s_r^+$  represent input and output slacks for  $DMU_0$  under evaluation and  $\lambda_j$  is the weight for hospital  $j$ . This model enables us to analyze inefficiency in each input and each output to have a view on which variable(s) makes a specific DMU be inefficient compared to others. For the current application, we use the VRS (variable returns to scale) DEA model, rather than the CRS (constant returns to scale) one. As a justification for our choice of the model we exemplify the set of slacks we obtained for  $DMU_9$  by using the CRS version of DEA:

$$\begin{aligned} s_{19}^- &= 0; & s_{29}^- &= 22.55; & s_{39}^- &= 0.45; \\ s_{19}^+ &= 0 & s_{29}^+ &= 0 & s_{39}^+ &= 9233.84 \end{aligned}$$

These results indicate that for  $DMU_9$  to reach 100% efficiency compared with all the other DMUs in the observation set, its hospitalization days should increase with 9233.84 days/ year. In general, a high number of hospitalization days per patient

is not desirable for a hospital. The purpose of implementing the reimbursement system according to DRGs (diagnosis-related groups) is to reduce the average length of staying, which in the end conducts to an efficient use of a hospital's resources. The DRG scheme classifies patients into a restricted number of medically justified groups, with a statistically stable distribution of resource consumption in each cluster (Thompson et al., 1979).

The descriptive statistics for the study variables is illustrated in Table 2. Note that the variations in most input and output variables are significant. For instance, in the case of bed size, the minimum is 350 beds while the maximum is 1560 beds, with a standard deviation of 360.91.

**Table 2. Descriptive statistics of the inputs and outputs used in the analysis**

Variables	Inputs			Outputs		
	Beds	Doctors	NSOE <sup>1</sup> (millions)	TOR <sup>2</sup> (millions)	Cases	HD <sup>3</sup>
Mean	961.45	160.52	11.57	25.04	34603.65	226671.50
Maximum	1560.00	345.00	29.09	53.33	60392.00	386226.00
Minimum	350.00	60.00	4.00	10.51	14644.00	81931.00
Std. Dev.	360.91	80.78	7.99	14.18	13966.77	93597.84

1 EUR=4.41 RON (Romanian currency)

Where <sup>1</sup> – Non-salary operating expenditures

<sup>2</sup> – Total operating revenues

<sup>3</sup> – Hospital days

Regarding the inefficient hospitals, their technical efficiency scores are presented in the second column of Table 3, along with their corresponding slack values.

The non-zero slack values represent resource excesses or wastes regarding inputs and insufficiencies or shortfalls in term outputs. Thus, for increasing the performance, hospitals such as DMU5 and DMU7 should decrease the number of beds, while DMU6, DMU7, and DMU14 should have fewer doctors.

On the other hand, the results show that all five inefficient hospitals have too few cases.

**Table 3. Results for DEA model-inefficient DMUs**

Hospital	Technical efficiency	Slacks					
		Beds	Doctors	NSOE	TOR	Cases	HD
DMU3	0.85	0.00	0.00	0.41	0.55	4625.83	0.00
DMU5	0.90	6.06	0.00	0.00	1.16	2326.75	0.00
DMU6	0.9	0.00	17.64	0.00	0.00	110.58	0.00
DMU7	0.97	3.85	25.32	0.00	0.00	1036.27	0.00
DMU14	0.84	0.00	4.33	0.00	0.00	4236.15	0.00

The lowest technical efficiency score was registered by DMU14 (0.84). In this context, Table 4 presents a comparative analysis between DMU 14 and DMU 1, which is considered the benchmark for DMU 14.

**Table 4. DMU1 vs. DMU14**

Hospital	Inputs				Outputs	
	Beds	Doctors	NSOE	TOR	Cases	HD
DMU1	758	116	8.58	20.76	33619	205111
DMU14	818	141	8.89	18.82	23357	168845
DMU1-DMU14	-60	-25	-0.31	1.94	10262	36266

Analyzing the table above, we can draw some preliminary conclusions, regarding the discrepancies between DMU1 and DMU14, latter being the most inefficient hospital within our sample.

It can be noticed that, with almost the same budget and less personnel, DMU1 can treat more cases than DMU14 and to support more hospitalization days/year with a lower number of beds. Also, in the case of DMU1, the number of cases/doctor is higher, as average turnover/doctor, the latter being significantly higher. Also, the cost per case and the cost of hospitalization day/case are lower in the case of DMU1, given that the average length of stay is lower for DMU1.

However, taking into consideration that the cases had been validated and the costs for treating these patients had been reimbursed by The National Health Insurance House, as reflected in the total operating revenues (TOR), and also by the average revenue per case, it is plausible to assume that DMU14 is treating more complicated cases than DMU1. Nonetheless, the non-zero slack value for the number of cases provided by the DEA analysis in the case of DMU14 might be explained by the investments performed by this hospital in 2014. Public hospitals receive financial resources that can be used for the specific purpose of purchasing medical equipment, investments, modernization and extension of existing buildings or repairs. These amounts are comprised in the total non-salary operating expenditure, but cannot be used for treating patients. The budget reveals that in 2014, DMU14 invested 8.3 times more in renovations and medical equipment than DMU1. The same link was found in the case of the other three hospitals determined as inefficient by the DEA model (DMU3, DMU5, and DMU6). All these three hospitals invested more in their infrastructure and equipment for improving the quality of medical services.

Prior work also supports these results. In this context, Gok and Sezen (2011) state that one crucial way to increase the efficiency of the Turkish hospitals is by decreasing investments in the health field and/or increasing the production factors, such as the existing beds or physicians (Rezapoor et al., 2011). Moreover, Araújo and his colleagues (2014) argue that high investments in equipment and resources required to treat the patients can generate hospitals' inefficiency. Also, significant investments have the goal to improve the quality and the position of the hospitals against the health insurance companies regarding the budget negotiations (Agai, 2015;

Helmig and Lapsley, 2001; Hsu, 2010). However, hypothesis H1 can be confirmed, given that 75% of hospitals included in the sample are efficient, according to the DEA analysis.

The second part of our investigation focuses on determining the factors that might influence the efficiency level. We use the Tobit regression because our dependent variable does not present a continuous structure, mainly taken the values of 0 or 1. The econometric model must take into consideration the possibility that the dependent variable could be censored/truncated in the extremes of 0 and 1 and the Tobit regression is a classical model that addresses this possibility.

**Table 5. The results of Tobit regression**

Variables	Coefficient		Std. Error	
LOG (BEGS)	-0.194	0.223	S.D. dependent var	0.048
LOG (CASES)	0.618***	0.171	Akaike info criterion	-0.069
LOG (DOCTORS)	-0.369***	0.127	Schwarz criterion	0.328
LOG (HOSP_DAYS)	-0.369	0.263	Left censored obs	0
NSOE	-0.044***	0.014	Uncensored obs	5
TOR	0.037***	0.011	Right censored obs	15
			Total obs	20

\* p-value is <10%, \*\* p-value is <5%, \*\*\* p-value is <1%

The results provided by the Tobit regression reveal that the number of cases has a positive influence on the efficiency level. In Romania, according to the Health Reform Law no. 95/2006, public hospitals are being funded according to the number of cases validated by the Health Insurance House. In this context, the number of patients positively influences the revenue, while the latter influences the efficiency.

The inadequate infrastructure and outdated medical equipment could raise difficulties in establishing a precise diagnosis, generating waste of resources and leading to inefficiency. This argument is also supported by the results provided by the Tobit regression in the case of NSOE.

As we can notice from the Table 5, the non-salary operating expenditures influence the efficiency level, but the sign reveals a negative correlation, meaning that the lower the level of the expenditures the higher the efficiency score. This result is supported by the insights provided by the DEA model, which highlights that all inefficient hospitals in our sample performed substantial investments in 2014, compared to their benchmarks. Investments in technology, renovations or modernizations are necessary and, even if they could lead to inefficiency, they only have an intermediate effect on the efficiency and do not influence efficiency in the same year (Frohlof, 2007).

Regarding the number of doctors, it appears that this factor influences the efficiency level but in a negative manner. This result is supported by the non-zero slack values provided by DEA for the number of doctors. As we already pointed, a high

number of doctors within the hospital involves a decrease of the average turnover/doctor and the average number of cases/doctors, and an increase of the salary expenditures, leading to inefficiency. This result is consistent with other prior studies arguing that the ratio of doctors and nurses per patient has an adverse impact (Karagiannis, 2013).

Concerning to the last two factors, prior studies have found a positive association between both the number of beds (Karagiannis, 2013; Lobo et al., 2014) and the hospitalization days (Karagiannis, 2013) and the efficiency score but in our case, no such connection was found. Therefore, hypothesis H2 can be only partially confirmed.

#### **4. Conclusions**

The new trends in public sector organizations have recently changed the approach of resources allocation and use, the importance of the public services quality being to the detriment of their quantity. This issue undoubtedly involves assessing the efficiency and performance of the public services. Moreover, public entities gradually became accountable for the services provided and for the resources employed in their activity as a consequence of the worldwide adoption of performance measurement and reporting systems. In this context, a broad range of stakeholders might benefit from this reporting, while allowing all users to assess the entity's service efficiency and effectiveness.

Assessing the performance of the health care system has increasingly become one of the most intensely explored areas of research at international level, due to the severe inefficiencies that marked this sector in the last decades. In this context, our study has an absolute novelty degree for Romania and enriches the literature specific to emergent countries by analyzing the efficiency of public health system, using a sample of 20 selected hospitals from the four Romanian macro-regions.

Moreover, we added value to this paper by the methodology employed that successfully combines two research methods. Thus, firstly, we used data envelopment analysis (DEA), by applying the input orientated variable returns to scale (VRS) model, which determines the minimal use of inputs while keeping the outputs constant, based on the assumption that public hospitals have more control over their inputs than over the outputs. Moreover, this model enabled us to analyze inefficiency in each input and each output to have a view on which variable(s) makes a particular decision-making unit (DMU) to be inefficient compared to others. Afterward, a regression analysis was performed, offering a relevant image on how the considered variables influence the efficiency scores within the hospitals included in the sample.

For testing our first hypothesis (H1) we use the number of beds (size), the number of doctors, and non-salary operating expenditure as the input variables and total operating revenues, the number of cases and hospitalization days as output variables. The attained results allow us to conclude that 15 of the considered hospitals are efficient while 5 of them are inefficient. Although the official statistics indicate a lower degree of efficiency in the Romanian health system, our results show that 75% of the sampled hospitals are efficient. In this case, the first hypothesis (H1) is validated by the findings based on DEA.

Identifying the factors that generate inefficiency demonstrates that efficiency requires not only reducing the allocated resources, but also increasing of the generated results, and consequently it should be a top priority for hospitals operating with limited resources.

Regarding the second hypothesis (H2), the results provided by the Tobit regression indicate that the number of hospital cases and the total operating revenues have a positive influence on the efficiency score. On the other hand, the non-salary operating expenditures influence the efficiency level, but the sign reveals a negative correlation. In other words, it means that the lower the level of expenses the higher the efficiency scores. Regarding the number of doctors, this variable influences the efficiency level, but in a negative way. Thus, a large number of doctors in a hospital determine a decrease of the average turnover/doctor and the average number of cases/doctors and, on the other hand, an increase of the salary expenditures leading to inefficiency. Consequently, the second hypothesis (H2) is partially confirmed.

In conclusion, the results of the study reveal that the efficiency of the public sector does mean not only the ability to reduce the operating costs but also the capacity to ensure a rational use of resources to obtain the necessary results. The most significant limitations of the study concern the small size of the sample and the fact that the research regards only one country. Also, the aim of the further research is to investigate the efficiency for a greater number of hospitals from a series of countries, using more input and output variables for the DEA approach.

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## Appendix 1. Database used in methodological framework

DMU No.	Macro-region	DMU Name	Efficient Input Target			Efficient Output Target		
			BEDS	DOCTORS	NSOE	TOR	CASES	HD
1	2	Vrancea	758,00000	116,00000	8,58495	20,7558233619,00000	205111,00000	
2	4	Valcea	1353,00000	188,00000	9,50317	24,1546550336,00000	348936,00000	
3	4	Caras Severin	716,31682	103,80160	7,60433	18,5212530929,83489188047,00000		
4	4	Gorj	1009,00000	164,50000	4,79383	16,3668234996,00000	216608,00000	
5	1	Bistrita	884,46650	114,04461	7,70951	18,7403133234,75458222298,00000		
6	1	Satu Mare	1041,08228	146,73290	9,47163	24,1376437612,58666262496,00000		
7	1	Sf. Gheorghe	577,39858	61,61965	4,10940	10,7909321649,27969128554,00000		
8	2	Constanta	1560,00000	261,50000	25,96371	47,9444255704,00000	345380,00000	
9	3	Ifov	350,00000	85,00000	5,37311	10,5178314644,00000	81931,00000	
10	3	Slobozia	510,00000	69,00000	4,00944	11,3453818848,00000	101119,00000	
11	3	Giurgiu	514,00000	71,00000	4,67945	10,9613516714,00000	121708,00000	
12	3	Calarasi	571,00000	60,00000	4,09705	10,5723421611,00000	127762,00000	
13	3	Alexandria	725,00000	99,00000	4,39478	15,8600922501,00000	146723,00000	
14	4	Hunedoara	693,53751	115,21423	7,53949	18,8197427593,15740168845,00000		
15	1	Baia Mare	920,00000	205,00000	14,96380	32,3648037305,00000	220297,00000	
16	4	Timisoara	1174,00000	318,00000	29,09891	53,3350644759,00000	304770,00000	
17	2	Braila	1215,00000	172,00000	17,55910	38,0777543539,00000	311973,00000	
18	1	Cluj	1542,00000	345,00000	26,18240	53,0284860392,00000	386226,00000	
19	2	Bacau	1444,00000	235,00000	18,63741	36,6387853414,00000	321631,00000	
20	3	Prahova	1199,00000	171,00000	12,77506	29,6509045007,00000	323015,00000	