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EFFICIENCY OF THE HEALTHCARE SECTOR IN THE EU-28 AT THE REGIONAL LEVEL

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Abstract:
The main purpose of the article is to estimate the regional performance of healthcare systems within the EU at the NUTS 2 level. Using multiple regional inputs and outputs to characterize healthcare provision, non-parametric methodology is applied to evaluate the relative efficiency of 151 regions in old EU member states (EU-15) and 54 regions in new EU member states (EU-13) in the period 2007–2012. The empirical results show that efficiency differs significantly across the selected regions. In general, less developed regions show a relatively high level of efficiency whereas capital regions seem to be the least efficient regions since they mainly serve as national medical centers employing a disproportionally large amount of health resources. The empirical study also finds evidence of the potential to improve health outcomes by ensuring a sufficient level of healthcare resources in those regions lagging behind significantly.

Keywords: healthcare systems, performance, efficiency, DEA, NUTS 2 regions, EU-28

1. INTRODUCTION

Healthcare is one of the most important services provided by national, regional and local governments in almost every country. Healthcare systems in the European Union (EU) form an important component of the wider apparatus of social security (Rogelj and Brezovar, 2013; Čok et al. 2013). By preventing and treating ill health and covering its associated – and often catastrophic – costs, they mitigate both health risks and financial risks and make a major contribution to social and economic welfare (Thompson et al., 2009; Hoffman, 2013). Indeed, billions of euros are spent each year at all levels of government on the provision of health services (Finžgar and Oplotnik, 2013). Therefore, effective allocation of these limited funds can save huge sums of money or, conversely, improve services given the existing budget.

While several efforts have attempted to evaluate and rank national healthcare systems, there is a huge lack of empirical literature on regional rankings. Measuring the efficiency of healthcare systems at the national as well as the regional level remains a complex endeavour due to the multiple desirable and undesirable system characteristics, available resources, and socioeconomic differences. A health system that is not efficient means that either the results (or 'outputs') could be increased without spending more, or that expenses could actually be reduced without affecting the outputs, provided that greater efficiency is assured. The research results presented in our study indicate that there are regions where considerable improvements can be made in this respect.

A relatively large amount of literature discusses health system efficiency. Previous research on the comparative performance of the public sector in general and of health outcomes in particular, including Afonso et al. (2005) and Obadić and Aristovnik (2011) for public expenditure in the OECD, and Gupta and Verhoeven (2001) for education and health in Africa, has already suggested that important inefficiencies are at work. These studies use free disposable hull analysis (FDH) with inputs measured in monetary terms. Spinks and Hollingsworth (2005) assess the health efficiency of OECD countries using data envelopment analysis (DEA) based Malmquist indexes. Employing both FDH and DEA analysis, Afonso and St. Aubyn (2005) studied efficiency in providing health and education in OECD countries. Similarly, applying DEA, Cheng and Zervopoulos (2014), Retzlaff-Roberts et al. (2004), Aristovnik (2012), Aletras et al. (2007), Kotodimopoulos et al. (2006) and Linna et al. (2006) used DEA analysis to investigate the efficiencies of the health systems of world countries, the OECD, the EU, Greece, Finland and Norway, respectively. However, a limited number of papers used non-parametric techniques to measure health efficiency at regional levels, for instance in Greece (Halkos and Tzeremes (2011)), Italy (De Nicola et al. (2011)) and China (Hu et al. (2012)).

In this article, we attempt to fill the abovementioned gap by examining the relative efficiency of health systems across the EU's NUTS 2, and to identify combinations of achievable targets that would cause poorly performing regions to become efficient. For this purpose, we use the outputs/outcomes from the healthcare system of a set of EU regions from old and new EU member states with resources employed (i.e. medical doctors). Using DEA, we derive a theoretical production frontier for a healthcare system. In the most favourable case, a region is operating on the frontier (with DEA scores equals to 100.00), and is considered as efficient. However, most regions can be found to perform below the frontier and an estimate of the distance each region is from that borderline is provided – the so-called efficiency score. Moreover, we will also include some variables (e.g. GDP per capita) that are at least in the short to medium run beyond the control of governments.

The rest of the article is organized as follows. Section 2 briefly discusses the role of traditional DEA and presents the model(s) and data for our regional studies. Section 3 shows application of the model and the empirical results. Finally, Section 4 concludes with a summary of the main findings and the conclusion.

2. METHODOLOGY AND DATA DESCRIPTION

For the empirical research we adopted the mathematical development of Data Envelopment Analysis (DEA) by Charnes et al. (1978). DEA is a non-parametric programming technique that develops an efficient frontier based on observed indicators from all DMUs (we refer to producers as decision-making units (DMUs) (Aristovnik, 2014). The efficiency frontier is developed by optimizing the weighted output/input ratio of each provider, subject to the condition that this ratio can equal, but never exceed, unity for any other provider in the data set (Charnes et al., 1978). Let us assume that there

are *k* inputs and *l* outputs for *n* DMUs. Moreover, we can define *X* as an (*k*n)* input matrix and *Y* as an (*l*n)* output matrix. For the i-th DMU, y_i is the column vector of the outputs and x_i is the column vector of the inputs. The formulation of the DEA model (VRS – variable returns to scale) for a given i-th DMU (in our case NUTS 2 regions) is as below:

$$
\begin{aligned}
&Max_{\lambda,\delta_i}\ \delta_i \\
&\text{s.to}\quad \delta_i y_i \le Y\lambda \\
&\qquad x_i \ge X\lambda \\
&\qquad n1'\lambda = 1 \\
&\qquad \lambda \ge 0
\end{aligned}
$$

In our DEA model, δ_i is a scalar satisfying $\delta_i > 1$, and measures the technical efficiency of the i-th DMU as the distance to the efficiency frontier. With $\delta_i < 1$, the DMU is inside the efficiency frontier and is inefficient, while $\delta_i = 1$ implies that the DMU is on the frontier and is efficient. The vector λ is a (*n×1*) vector of constants that estimates the weights used to calculate the location of inefficient decision units if it were to become efficient.

In our case, the data set for all tests in the study includes average (available) data for the 2007 (or 2008) – 2011 (or 2012) period in order to evaluate the relative efficiency of the healthcare systems of EU member states at the regional level. All of the results in the empirical part of the paper will be related to DEA with an output orientation, allowing for constant (CRS) and variable returns to scale (VRS) in order to gain better insights into regional healthcare efficiency. The output orientation focuses on the amount by which output quantities can be proportionally increased without changing the input quantities used. The output-oriented model was preferable because in the EU regions, as well as at the national level, the policy focus on reducing the public deficit has compelled health organizations to keep the amount of resources consumed constant, even while increasing the extent of health services provided (de Nicola et al., 2011). Moreover, VRS is assumed to be the relevant model for analysis since the study includes regions of varying sizes.

Further, one of the key requirements in DEA is the homogeneity of decision-making units (DMUs) (Tiemann and Schreyögg, 2012). In our case, to avoid problems with outliers and to provide a homogeneous group, two subgroups of regions, a group of old EU member state regions and a group of new EU member states, have been established. In this way, the homogeneity of the sample was increased significantly. Another important prerequisite for applying DEA is that inputs are positively correlated with the output set. In our selection of outputs, both death rate values had to be inverted because both inputs are negatively linked to these two outputs and, for this reason, the data were transformed.

The regional inputs utilized in our article are the number of medical doctors (per 100,000 inhabitants) and gross domestic product (GDP) per inhabitant (at current market prices in EUR), both for NUTS 2 regions. The regional outputs comprise the life expectancy at birth (in years), the standardized death rate (per 100,000 inhabitants) and the infant mortality rate (per 1,000 live births) at the regional level. The data for the empirical analysis come from the Eurostat databases and cover the 2007–2012 period (for Summary statistics, see Table 1). The program used for calculating the DEA scores is the Frontier Analyst 4.0 software.

Table 1: Summary statistics (NUTS 2 level)

	Average	St. Dev.	Min.	Max.
Input				
Medical doctors (per 100,000 inhabitants) (2009–2011)	342.02	111.80	130.22 (Flevoland– NL)	835.96 (Attiki– GR)
Input (non-discretionary)				
GDP per capita (at current market prices in EUR) (2007–2011)	23,573.02	10,744.36	3,000.00 (Severozapaden – BG)	84,225.00 (Inner London– UK)
Outputs				
Life expectancy (at birth in years) (2008–2012)	79.94	2.49	72.82 (Severozapaden – BG)	83.70 (Comunidad de Madrid - ES)
Death rate (standardized, per 100,000 inhabitants) (2008–2010)	1,101.81	15.45	799.10 (Bassin Parisien – FR)	1,812.80 (Severozapaden – BG)
Infant mortality rate (per 1,000 live births) (2008–2012)	4.02	1.80	1.38 (Åland – FI)	12.14 (Yugoiztochen – BG)

Sources: Eurostat, 2014; own calculations

3. EMPIRICAL RESULTS

In the first stage of the empirical research, a healthcare efficiency measurement at the national level was performed. For this analysis, one discretionary input (medical doctors), one non-discretionary input (GDP per capita) and two outputs (life expectancy and infant mortality) were selected. The empirical results show that among old EU member (EU-15) states four or eight out of the fifteen countries analysed with the CRS or VRS DEA models for healthcare efficiency were estimated as efficient. Luxemburg, Spain, Sweden and Italy are among the best performers. Considering the dominating countries, one can distinguish different background reasons for being efficient. For instance, Luxembourg has few resources allocated to health (in terms of medical doctors) with above-average health outcomes. On the other hand, Italy and Sweden are the countries where people, on average, expect to live longer (81.95) and the infant death rate is the lowest (2.44), respectively, by using above-average health inputs. Interestingly, the performance and efficiency of the healthcare system is not determined by the level of its centralization or funding as one can find efficient healthcare systems in Spain, Italy and Sweden (with highly decentralized and mixed – private and public – service provision) as well as in Luxembourg (with centralized and mainly public service provision) (Committee of the Regions, 2012).

In addition, we observe a high degree of efficiency for new EU member states as even nine out of thirteen countries seem to be efficient according to estimations of the (VRS) DEA model. The first group attains the best outcomes with below-average medical doctors (Slovenia and Cyprus). Indeed, Cyprus and Slovenia attain the longest expectancy to live (81.08) and the lowest infant death rate (2.36), respectively. Similarly, Czech R. shows above-average health outcomes by employing significantly high health resources. Finally, Croatia attains average health outcomes with a below-average number of medical doctors (276.2). Similarly to the EU-15, even within the EU-13 we cannot

find an efficient healthcare system management model because efficiency could be found in countries with relatively centralized systems (Cyprus, Slovenia and Croatia) on one hand, and Czech R. with a decentralized system on the other hand. Nevertheless, in all of the efficient countries mixed service provision could be noticed. The efficiency scores for both subgroups are reported in Table 2.

Table 2: Relative performance of the health systems in the EU-28 (two subgroups at the national level)

Old EU member states (EU-15)			New EU member states (EU-13)		
	CRS	VRS		CRS	VRS
Finland (FI)	100.0	100.0	Bulgaria (BG)	100.0	100.0
Luxembourg (LU)	*100.0*	*100.0*	*Czech R. (CZ)*	*100.0*	*100.0*
Portugal (PT)	100.0	100.0	Poland (PL)	100.0	100.0
United Kingdom (UK)	100.0	100.0	Romania (RO)	100.0	100.0
Belgium (BE)	98.2	99.4	*Slovenia (SI)*	*100.0*	*100.0*
Spain (ES)	*97.7*	*100.0*	Estonia (EE)	99.9	100.0
Netherlands (NL)	94.1	99.7	*Croatia (HR)*	*94.7*	*100.0*
Ireland (IE)	92.6	99.2	Hungary (HU)	88.2	97.2
France (FR)	92.5	100.0	Lithuania (LT)	87.8	96.1
Sweden (SE)	*91.9*	*100.0*	*Cyprus (CY)*	*81.8*	*100.0*
Italy (IT)	*90.1*	*100.0*	Latvia (LV)	78.8	95.6
Germany (DE)	85.1	98.1	Malta (MT)	74.7	100.0
Denmark (DK)	82.5	97.3	Slovak R. (SK)	69.9	96.6
Greece (GR)	82.0	99.5			
Austria (AT)	66.2	97.8			

Note: Model – inputs (medical doctors, GDP per capita); outputs (life expectancy, infant mortality rate); the countries in italics achieve above-average life expectancy and a below-average death (or infant mortality) rate; CRS-Constant Return to Scale/VRS-Variable Return to Scale.
Sources: Eurostat, 2014; calculations by the author

The main focus of the empirical part is concentrated on the regional level which is divided into two subgroups, old EU member states (EU-15) and new EU member states (EU-13). The empirical results based on an output-oriented (CRS and VRS) formulation of the DEA analysis suggest that the most efficient regions in the EU-15 (old EU member states) are in Greece (Sterea Ellada and Thessalia), Spain (Extremadura), Sweden (Aland), Portugal (Norte) and the Netherlands (Zeeland) (see Table 3). Interestingly, many of these regions are often characterized as being less developed and rural areas with relatively low levels of population density. Nevertheless, these regions, in particular Aland and Zeeland, could serve as a good benchmark for the other regions as they featured among the highest in health outcomes. Some other Greek regions also seem to be efficient (for instance, Iepiros and Kriti), yet they show the relatively high employment of health resources compared to the other regions. On the other hand, Flevoland, Guyane, Alentejo attain efficient scores due to the low number of medical doctors. Ultimately, more than 11% of the observed regions (out of 151) are efficient and could be a good example for less efficient regions. The least efficient regions in this group are mainly from Austria, Germany, the Netherlands and Belgium. In particular, Wien (Austria), Bremen and Saarland (Germany), and Groningen (Netherlands) are extremely inefficient as they use above-average health inputs for below-average health outcomes. These regions should significantly increase life expectancy and/or decrease the death rate and/or the infant death rate in order to become efficient. Nevertheless, many inefficient regions are capital regions (e.g. Wien, Stockholm, Lazio) or regions with large cities (e.g. Hamburg, Bremen), which is in line with expectations as these regions are health (tertiary) centres for neighbouring regions or even the country as whole.

Table 3: Relative performance of the healthcare system in the old EU member states (EU-15) at the regional (NUTS 2) level

151 regions					
The most efficient regions (15)			The least efficient regions (15)		
	CRS	VRS		CRS	VRS
Sterea Ellada (GR)	*100.0*	*100.0*	Wien (AT)	32.9	95.4
Aland (SE)	*100.0*	*100.0*	*Hamburg (DE)*	*34.7*	*96.6*
Flevoland (NL)	100.0	100.0	Hovedstaden (DK)	*39.1*	*94.6*
Guyane (FR)	100.0	100.0	Bremen (DE)	39.2	95.4
Norte (PT)	*100.0*	*100.0*	Groningen (NL)	39.4	95.7
Thessalia (GR)	*100.0*	*100.0*	*Utrecht (NL)*	*42.2*	*97.4*
Zeeland (NL)	*100.0*	*100.0*	*Région de Bruxelles-Capitale (BE)*	*42.4*	*96.0*
Alentejo (PT)	100.0	100.0	*Salzburg (AT)*	43.2	*97.7*
Centro (PT)	99.2	99.9	*Prov. Brabant Wallon (BE)*	*44.7*	*96.6*
Ipeiros (GR)	94.5	100.0	*Noord-Holland (NL)*	*46.2*	*98.6*
Regiao Autónoma dos Açores (PT)	93.2	95.7	*Attiki (GR)*	*48.8*	*96.4*
Extremadura (ES)	*93.0*	*100.0*	*Lazio (IT)*	*49.2*	*97.6*
Regiao Autónoma da Madeira (PT)	91.4	95.1	*Oberösterreich (AT)*	*49.7*	*97.1*
Notio Aigaio (GR)	*89.6*	*99.3*	*Stockholm (SE)*	*50.1*	*98.3*
Kriti (GR)	*88.3*	100.0	Saarland (DE)	50.3	95.2

	CRS	VRS
Average Efficiency Score	67.3	97.9
Standard Deviation	15.0	1.5
No. (%) of Efficient Regions	8 (5.3%)	17 (11.3%)

Note: Model – inputs (medical doctors, GDP per capita); outputs (life expectancy, infant mortality rate); the countries in italics achieve above-average life expectancy and a below-average death (or infant mortality) rate; CRS-Constant Return to Scale/VRS-Variable Return to Scale.
Sources: Eurostat, 2014; calculations by the author

The empirical results for the new EU member states (EU-13) suggest that 16 regions or almost 30% of all regions (a total of 54) included in the analysis have been efficient. Similarly to the EU-15 regions' analysis, the efficient regions and good benchmarks are, in general, the least developed regions in Czech R. and Slovenia (see Table 4). Regions like Střední Cechy (CZ) and Vzhodna Slovenija (SI) attain relatively good health outcomes with low health resources. As both regions border the capital regions (Praha and Zahodna Slovenija, respectively), we can realistically assume that patient mobility and positive 'spillover' effects (e.g. interregional labour migrations) could be among the reasons for the attained health outcomes. Some poor regions in Romania (e.g. Nord-Est, Sud-Muntenia), Bulgaria (e.g. Severen tsentralen, Severozapaden) and Poland (e.g. Warminsko-Mazurskie, Wielkopolskie) are also efficient due to their extremely low numbers of medical doctors per 100,000 inhabitants and low GDP per capita. By contrast, the most inefficient regions are predominantly capital regions, particularly in Bulgaria (Yugozapaden), Romania (Bucuresti – Ilfov), Slovak R. (Bratislavský kraj), Hungary (Közép-Magyarország) and Poland (Mazowieckie). Since capital regions mainly serve as national medical centres with developed tertiary healthcare employing a disproportionally large amount of health resources this could be one of the main reasons for their inefficiency.

Table 4: Relative performance of the healthcare system in the new EU member states (EU-13) at the regional (NUTS 2) level

54 regions					
The most efficient regions (15)			The least efficient regions (15)		
	CRS	VRS		CRS	VRS
Severen tsentralen (BG)	100.0	100.0	*Bratislavský kraj (SK)*	*35.7*	95.5
Nord-Est (RO)	100.0	100.0	Bucuresti – Ilfov (RO)	38.0	94.0
Střední Cechy (CZ)	*100.0*	*100.0*	*Malta (MT)*	*49.8*	*100.0*
Sud – Muntenia (RO)	100.0	100.0	*Közép-Magyarország (HU)*	*50.0*	94.7
Vzhodna Slovenija (SI)	*100.0*	*100.0*	Praha (CZ)	50.3	100.0
Warminsko-Mazurskie (PL)	100.0	100.0	Východné Slovensko (SK)	53.1	96.0
Wielkopolskie (PL)	100.0	100.0	Vest (RO)	57.0	94.2
Severozapaden (BG)	100.0	100.0	Mazowieckie (PL)	63.7	96.2
Lubelskie (PL)	99.2	100.0	Kontinentalna Hrvatska (HR)	66.0	96.3
Podlaskie (PL)	98.6	100.0	Yugozapaden (BG)	66.5	95.5
Podkarpackie (PL)	98.5	100.0	Severozápad (BG)	66.6	96.1
Severovýchod (CZ)	*96.4*	*100.0*	Slaskie (PL)	68.6	96.0
Yuzhen tsentralen (BG)	96.3	100.0	Stredné Slovensko (SK)	69.4	95.6
Jihozápad (CZ)	*96.3*	*99.9*	Dolnoslaskie (PL)	71.5	96.7
Jihovýchod (CZ)	*93.9*	*100.0*	Nord-Vest (RO)	71.8	95.7

	CRS	VRS
Average Efficiency Score	80.8	97.7
Standard Deviation	16.8	2.0
No. (%) of Efficient Regions	8 (14.8%)	16 (29.6%)

Note: Model – inputs (medical doctors, GDP per capita); outputs (life expectancy, infant mortality rate); the countries in italics achieve above-average life expectancy and a below-average death (or infant mortality) rate; CRS-Constant Return to Scale/VRS-Variable Return to Scale.
Sources: Eurostat, 2014; calculations by the author

4. CONCLUSIONS

Large amounts of resources have been devoted to healthcare in many countries and regions in the EU. Indeed, expenditure on healthcare has been growing in both absolute and relative terms ever since governments took on the responsibility for the universal provision of healthcare. Moreover, it is expected to continue growing over the decades to come in the context of ageing populations and growing public expectations regarding the accessibility and quality of care. As a public good provided, at least in basic terms, free of charge to the whole population, healthcare is a major and constantly growing component of public finances with a growing risk of undermining its long-term sustainability. Therefore, evaluating the efficiency of healthcare at all levels is crucial for designing policies to improve resource allocation.

The paper joins the efforts of other scholars in investigating healthcare efficiency by applying a non-parametric methodology at the regional level. In this respect, the Data Envelopment Analysis (DEA) technique was applied to a wide range of EU-28 (NUTS 2) regions to evaluate technical efficiency within the healthcare sector. The empirical results show that efficiency differs significantly across the selected regions. The research findings of our DEA model(s) suggest that, among old EU member states, in particular Sterea, Ellada, and Thessalia (Greece), Extremadura (Spain), Aland (Sweden), Norte (Portugal) and Zeeland (Netherlands) belong to the best performing NUTS 2 regions located on the regional efficiency frontier. These EU regions could also serve as peers to improve the efficiency of the less efficient ones. On the other hand, in the new member states, efficient benchmarks represent, in particular, regions from Czech R. (Střední Cechy) and Slovenia (Vzhodna Slovenija). Interestingly, both regions benefit from bordering the capital regions and their health infrastructure. The empirical analysis also finds evidence of potential to improve health outcomes in the vast majority of EU regions by ensuring a sufficient level of healthcare spending (in terms of the number of medical doctors) in those regions that are lagging behind (particularly in Poland, Romania and Hungary).

However, the empirical study presented here has also some limitations. First, the application of the presented techniques is hampered by a lack of suitable data, in particular outputs. Quality data are called for because the techniques available to measure efficiency are sensitive to outliers and may be influenced by exogenous factors. Second, the precise definition of inputs, outputs and outcomes may significantly influence the results. Next, it seems important to bear in mind that when using a non-parametric approach, and in spite of DEA being an established and valid methodology, differences across regions are not statistically assessed and this may be considered a limitation of the methodology. Finally, further research is clearly needed to eliminate the above deficiencies, in particular to test the influence of different external factors (e.g. patient mobility) on healthcare efficiency.

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