DEA MODEL FOR ASSESSING EFFICIENCY IN PROVIDING HEALTH CARE AND MANAGEMENT DECISIONS

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Abstract
The present paper analyzes the overall efficiency at the regional level in health care system in the EU states members which joined after 2004 in a time period between 2003 and 2005. Data Envelopment Analysis (DEA), which is a method proven to be useful in a diverse variety of applications in managing, examining and improving efficiency. The DEA technique is used to measure health care efficiencies of transition economies and to discuss potential policy implications of the findings. Data for this study are collected from official sources and covers 14 units, the new states members of the EU (joined the EU after 2004) and two composite group of units (the entire EU region and the group of the 12 new members). The research question concerns the efficiency rates in which different countries use their resources to achieve their health outcomes and the policy implications for pointing out the future attention towards input versus outputs.
In this study, the inputs are the number of physicians, hospital beds and measles immunization and per capita health expenditure. The traditional outputs for the general health status in a country's population are: life expectancy at birth and infant mortality rate. Application of data envelopment analysis (DEA) reveals that some countries achieve relative efficiency advantages, including those with good health outcomes (Cyprus, Hungary, Poland) and those with modest health outcomes (Czech Republic, Latvia, Romania, Slovakia, Slovenia).

Keywords*:* efficiency estimation, health care system, decision making, DEA

1. INTRODUCTION

The DEA method was originally developed to measure the performance of various non-profit organizations, such as educational and medical institutions, which were highly resistant to traditional performance measurement techniques due to the complex and often unknown relations of multiple inputs and outputs and non-comparable factors that had to be taken into account.

The DEA method allows the estimation of such efficiency being inspired from the works of Farrell (1957) who attempted to measure the efficiency of a unit of production in the single input-single output case. Farrell proposed an intuitively appealing definition of relative technical efficiency: the organisation with the highest output given its input (cost) is the most efficient (Vitikainen, 2004). Building on his ideas, in their work "Measuring the efficiency of decision making units", Charnes, Cooper and Rhodes (1978) applies linear programming to estimate an empirical production technology frontier for the first time. Later, Charnes, Cooper

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and Rhodes extended Farrell's idea and proposed a model that generalizes the single-input, single-output ratio measure of efficiency of a single Decision-Making Unit (DMU) in multiple-inputs, multiple outputs setting.

DEA is a multi-factor productivity analysis model for measuring the relative efficiencies of a homogenous set of decision making units (DMUs). The efficiency score in the presence of multiple input and output factors is defined as: Efficiency = weighted sum of outputs / weighted sum of inputs. Generally, the efficiency is determined as the ratio of outputs in relation to inputs of a given entity that is examined, which is referred to as Decision Making Unit (DMU). A DMU is an entity that produces outputs by consuming different quantities and sets of inputs. The technical efficiency of a DMU is computed using the engineering-like efficiency measure of efficiency as ratio of virtual output produced to virtual input consumed:

$$TE = \frac{\sum weighted\ \ outputs}{\sum weighted\ \ inputs} \qquad (1)$$

The DEA model allows each DMU to choose the set of multipliers (weights) vo and uo that permits it to appear in the best light. The efficiency score obtained is relative to a sample of DMUs under analysis since the set of weights has to be feasible for other units and none of these units should have an efficiency score greater than one.

2. THE TOPIC RELEVANCE IN THE SCIENTIFIC LITERATURE IN THE FIELD OF HEALTH CARE

Various state members face the critical issue of determining whether the desirable outcomes from increased medical spending, driven primarily by the global demand for such service, advanced technology, don results in expected and adequate returns. Different authors state that despite dramatic increases in levels of health care expenditures in industrialized countries, insufficient research has been directed to the issues of technical efficiency in resource use and of measuring relative efficiency among countries (Retzlaff-Roberts, 2003). In the paper of Retzlaff-Roberts, Chang and Rubin, the technical efficiency in health care is examined, more explicitly, the resource consumption as compared to the health outputs achieved, given the level of healthcare resources consumed and the health challenges of each country. Technical efficiency is obtained when output is maximized for a given level of inputs, or alternately, when input is minimized for a given amount of output.

Among the various methods of efficiency assessment, Data Envelopment Analysis (DEA) has gained the attention of many researchers, along with other techniques. Although there are published system-wide comparisons of health care efficiency, the literature still lacks research papers which apply the DEA method in assessing macro-level efficiencies.

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DEA approach involves the application of the linear programming technique to put into evidence the efficiency frontier (an envelopment surface) on a certain economic process that supposes the transformation of set of inputs into various outputs.

The fundamental difference between traditional statistical approaches and DEA is that while the former reflects the average behavior of the observations, DEA deals with best performance, evaluating all performances from the efficiency frontier formed by the most efficient DMUs.

Since early DEA models, there have been a large number of books and journal articles written on DEA or applying DEA on various sets of problems. Other than comparing efficiency across DMUs within an organization, DEA has also been used to compare efficiency across firms. There are several types of DEA with the most basic being CCR model based on Charnes, Cooper and Rhoades (model1), however there are also DEA which address varying returns to scale, either CRS (constant returns to scale) or VRS (variable returns to scale). Charnes, Cooper and Rhodes (1981) and, then, Charnes et al (1994) defined efficiency by reference to the orientation chosen:

- In an output oriented model, a DMU is not efficient if it is possible to augment any output without increasing any input or decreasing any other output. DMUs are supposed to produce with given amounts of inputs the highest possible of outputs;
- In an input oriented model (meaning that inputs are controllable), a DMU is not efficient if it possible to decrease any input without augmenting any other input and without decreasing any output.
- Base-oriented model, where DMUs are to deemed to produce the optimal mix of inputs and outputs (both inputs and outputs are controllable).

Assuming that there are n DMUs, each with m inputs and s outputs, the first standard DEA model as proposed by Charnes, Cooper, and Rhodes (1978), in ratio form is expressed as follows:

$$\max \frac{\sum_{k=1}^{s} v_k \cdot y_{kp}}{\sum_{j=1}^{m} u_j \cdot x_{jp}}$$

subject to:

$$\frac{\sum_{k=1}^{s} v_k \cdot y_{kp}}{\sum_{j=1}^{m} u_j \cdot x_{jp}} \leq 1 \; for \; \forall \, i \;, \qquad v_k, u_j \geq 0, \quad \forall k, \forall j \qquad \text{(model1)}$$

where:

k = 1 to s, j = 1 to m, i = 1 to n, yki = amount of output k produced by DMU i, xji = amount of input j utilized by DMU i, vk = weight given to output k, uj = weight given to input j.

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Given a set of J Decision Making Units (in our case, the countries), the model determines for each DMU0 the optimal set of input weights $\{v_{i0}\}, \forall i$ and output weights $\{\mu_{r0}\}, \forall r$ that maximizes its efficiency score eo. Mathematically, a DMU is termed efficient if its efficiency rating θ_0 obtained from the DEA model is equal to one. Otherwise, the DMU is considered inefficient.

The fractional program shown as model1 can be converted to a linear program as shown in model2, proposed by Charnes et al. (1978); using the linear transformation to eliminate the fractional computations, a new model can be sketched as follows:

$$\max \sum_{k=1}^{s} v_k \cdot y_{kp}$$

subject to: (model2)

$$\sum_{j=1}^{m} u_j \cdot x_{jp} = 1$$

$$\sum_{k=1}^{s} v_k \cdot y_{kp} - \sum_{j=1}^{m} u_j \cdot x_{jp} \leq 0$$

$$v_k, u_j \geq 0, \quad \forall k, \forall j$$

The above problem (model2) is run n times in identifying the relative efficiency scores of all the particular DMUs, designated by p. Each DMU selects input and output weights that maximize its efficiency score. In general, a DMU is considered to be efficient if it obtains a score of 1 and a score of less than 1 implies that it is inefficient.

The problem under the model2 description allows the determination of relative efficiency: for a set of unrestricted factor weights (vk and uj), the targeted DMU can achieve a high relative efficiency score (Dyson and Thannassoulis, 1988).

For every inefficient DMU, DEA identifies a set of corresponding efficient units that can be utilized as benchmarks for improvement. The benchmarks can be obtained from the dual problem shown as:

$$\min \theta$$

subject to:

$$\sum_{i=1}^{n} \lambda_i \cdot x_{ji} - \theta \cdot x_{jp} \leq 0$$ (model3)

$$\sum_{i=1}^{n} \lambda_i \cdot y_{ki} - y_{kp} \geq 0$$

$$\lambda_i \geq 0 \quad \forall i$$

where:

θ= efficiency score, and λ_i = dual variables.

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Based on above problem (model3), a test DMU is inefficient if a composite DMU (linear combination of units in the set) can be identified which utilizes less input than the test DMU while maintaining at least the same output levels. The units involved in the construction of the composite DMU can be utilized as benchmarks for improving the inefficient test DMU. DEA also allows for computing the necessary improvements required in the inefficient unit's inputs and outputs to make it efficient. It should be noted that DEA is primarily a diagnostic tool and does not prescribe any reengineering strategies to make inefficient units efficient. Such improvement strategies must be studied and implemented by managers by understanding the operations of the efficient units.

In interpreting its solution, any particular DMU0 has the latitude to choose the set of weights that maximize its efficiency relative to other DMUs of the sample provided that no other DMU or convex combination of DMU could achieve the same output vector with a smaller input vector (Tutorial, 2000).

DEA can be viewed as a projection mechanism of a multi-input, multi-output entity onto an envelopment surface (Tutorial, 2000). DEA is especially valuable where the relative importance of the various inputs employed and outputs produced by a DMU cannot be defined, owing to the absence of market prices. The method reveals additional advantages, such as the possibility to estimate efficiency of DMUs with multiple inputs and output production technology that allows avoiding calculating a single measure of input or output; the possibility to determine the amount of input to be used or the size of output to be achieved for each organization to become fully efficient (Roman, 2010).

In contrast to regression analysis, which gives us an average profile of DMUs under analysis, DEA yields a piecewise empirical external production surface that, in economic terms represents the revealed best practice production envelope curve. By projecting each unit onto the frontier, it is possible to determine the level of inefficiency by comparison to a single reference unit or a convex combination of other reference units. The projection refers to a virtual DMU which is a convex combination of one or more efficient DMUs (Tutorial, 2000).

However, the complete flexibility of DEA may induce undesirable consequences, since any particular DMU can appear efficient in ways that are difficult to justify. The DEA model gives often excessively high or low values to multipliers in an attempt to drive the efficiency score as high as possible. Charnes et al (1994) cite three situations where additional control on multipliers is needed:

- The analysis ignores additional information that can not be directly incorporated into the model or that contradicts expert opinions
- Management has strong preferences about the relative importance of different factors

- When the number of factors is relatively large compared with the number of DMUs under analysis, the model fails to discriminate and most DMUs appear efficient.

Charnes et al (1994) give a complementary list of other advantages of DEA:

- the possibility of handling multiple inputs and outputs stated in different measurement units;
- the focus on a best-practice frontier, instead of on population central-tendencies. Every unit is compared to an efficient unit or a combination of efficient units. The comparison, therefore, leads to sources of inefficiency of units that do not belong to the frontier;
- no restrictions are imposed on the functional form relating inputs to outputs.

Traditional DEA analysis displays certain limitations:

- in aggregating different aspects of efficiency, especially in the case where DMUs perform multiple activities.
- insensitivity to intangible and categorical components (for instance, the service quality in a bank branch setting).
- Since DEA is an extreme point technique, noise (even symmetrical noise with zero mean) such as measurement error can cause significant problems.
- Since DEA is a non-parametric technique, statistical hypothesis tests are difficult and are the focus of ongoing research.
- Since a standard formulation of DEA creates a separate linear program for each DMU, large problems can be computationally intensive.

An analyst should keep this list of advantages and limitations in mind when choosing whether or not to use DEA.

3. METHODOLOGY AND INTERPRETATIONS ON RESULTS

The number of inputs and outputs selected was established according to the necessity of maximizing the discrimination existing in the technical efficiency of the observed units. The authors were followed the recommendations on choosing the appropriate number of DMUs, inputs and outputs. As it can be referred from the field’s literature, Dyson at al (1991) recommend that the number of units should be at least twice the number of input and output considered (Roman, 2010). Charnes and Cooper (1991) have suggested, as a rule of thumb, that there should be three times as many DMUs as the number of inputs plus outputs. Therefore, we estimate that the minimum number of DMUs required is achieved by applying the rule of thumb: $n \geq \max\{m*s, 3(m+s)\}$, where n is number of DMUs, m is number of inputs and s is number of outputs.

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DEA was launched by Charnes et al. (1978) under the assumption that production exhibited constant returns to scale (an increase in the amount of inputs consumed would lead to a proportional increase the amount of outputs produced). The purpose of an output-oriented approach is to study by how much output quantities can be proportionally augmented without changing the input quantities produced. The analytical format of the linear programming problem, in the constant returns to scale hypothesis, is given for an output-oriented specification.

TABLE 1 - THE THEORETICAL DESCRIPTION

Indicator	Short characterization
Physicians per 100000 population	A physician is a person who has completed studies in medicine at the university level. To be legally licensed for the independent practice of medicine (comprising prevention, diagnosis, treatment and rehabilitation), (s)he must in most cases undergo additional postgraduate training in a hospital (from 6 months to 1 year or more). To establish his or her own practice, a physician must fulfill additional conditions. The number of physicians at the end of the year includes all active physicians working in health services (public or private), including health services under other ministries than the Ministry of Health. Interns and residents, i.e. physicians in postgraduate training, are also included. The number of physicians excludes: physicians working outside the country; physicians on the retired list and not practicing or unemployed; physicians working outside health services, e.g. employed in industry, research institutes etc.; dentists who should be defined as a separate group. Joint definition used by WHO, OECD and EUROSTAT.
Hospital beds per 100000 population	A hospital bed is a regularly maintained and staffed bed for the accommodation and full-time care of a succession of inpatients and is situated in wards or areas of the hospital where continuous medical care for inpatients is provided. It is a measure of hospital capacity. Beds in all hospitals should be included. The number of hospital beds should be measured, whenever possible, in available bed-years during the calendar year or, if this is not possible, in available beds at mid-year (preferably) or end-year count can be used depending on the current national practice. Hospital beds excludes: cots for neonates; day beds; provisional and temporary beds, beds in storerooms; beds for special purposes or belonging to special health devices, e.g. dialysis, delivery (but not post-delivery beds in maternity hospitals), etc. Joint definition used by WHO, OECD and EUROSTAT.
Measles incidence per 100000 population (%)	Data are available from the CD Unit at WHO/EURO.
Total health expenditure, PPP$ per capita, WHO estimates	Sum of General Government and of Private Expenditure on Health. Estimates for this indicator were produced by WHO. The estimates are, to the greatest extent possible, based on the National Health Accounts classification. The sources include both nationally reported data and estimates from international organizations like IMF, WB, UN and OECD.
Life expectancy at birth, in years	Calculated by WHO/EURO for all countries which report detailed mortality data to WHO, using Wiesler's method. Age disaggregation of mortality data: 0, 1-4, 5-9,10-14, etc, 80-84, 85+.
Infant deaths per 1000 live births	A measure of the yearly rate of deaths in children less than one year old. The denominator is the number of live births in the same year. *Infant mortality rate = [(Number of deaths in a year of children less than 1 year of age) / (Number of live births in the same year)] *1000 (**ICD**-10).*

The model is applied using official data compiled for the observed states. In this exercise, a DMU is defined as a country in the following geographical coverage: Bulgaria (BG), Cyprus (CY), Czech Republic (CZ), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Malta (MT) Poland (PT), Romania (RO), Slovak Republic (SK), Slovenia (SI), adding two virtual units - the European Union (as whole, in average) and the EU New member state (acceded after 2007, in average); the data is released by the international organization World Health Organization (WHO) for Europe (http://data.euro.who.int/hfadb/).

The choice of inputs and outputs in health efficiency are similar to the works done by Mirmirani (2008).

In this study, we specify two outputs: y1 and y2; and four inputs: x1, x2, x3 and x4. The input components would include:

x1: Physicians density (per 10 000 population),

x2: Hospital beds (per 10 000 population);

x3: Measles (MCV) immunization coverage among 1-year-olds (%)

x4: Per capita total expenditure on health (PPP int. $).

Because direct measurement of change in health status is impractical, intermediate outputs of health services are generally used in most studies as proxy to outputs. The output variables would include:

y1: Life expectancy at birth (years) or newly proposed: Healthy life expectancy (HALE) at birth (years)

y2: Infant mortality rate (probability of dying between birth and age 1 per 1000 live births).

TABLE 2 - INPUT DATA FOR BULGARIA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	72.77	73.07	73.41	73.77
Infant deaths per 1000 live births	9.73	9.16	8.6	9
Measles incidence per 100000	0.01	0.01	0.01	29.65
Hospital beds per 100000	619.81	636.43	649.41	659.72
Physicians per 100000	365.12	364.38	360.47	368.99
Total health expenditure, PPP$ per capita, WHO estimates	765.62	813.32	974.1	985.52

TABLE 3 - INPUT DATA FOR CYPRUS

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	80.59	80.44	81	81.37
Infant deaths per 1000 live births	3.09	3.15	3.48	3.33
Measles incidence per 100000	0	0	0.13	0
Hospital beds per 100000	371.5	346.58	375.41	...
Physicians per 100000	252.94	254.71	287.01	...
Total health expenditure, PPP$ per capita, WHO estimates	1639.04	1720.12	1837.54	1825.04

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TABLE 4 - INPUT DATA FOR CZECH REPUBLIC

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	76.82	77.1	77.42	77.5
Infant deaths per 1000 live births	3.33	3.14	2.83	2.88
Measles incidence per 100000	0.07	0.02	0.02	0.05
Hospital beds per 100000	742.65	731.42	718.37	711.12
Physicians per 100000	356.45	356.64	354	356.01
Total health expenditure, PPP$ per capita, WHO estimates	1553.82	1650.28	1829.7	1924.44

TABLE 5 - INPUT DATA FOR ESTONIA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	73.14	73.21	74.34	75.31
Infant deaths per 1000 live births	4.44	5.01	4.99	3.55
Measles incidence per 100000	2.01	0.07	0	0
Hospital beds per 100000	564.77	556.99	571.35	543.85
Physicians per 100000	319.01	325.71	333.34	326.65
Total health expenditure, PPP$ per capita, WHO estimates	961.82	1122.54	1324.56	1372.58

TABLE 6 - INPUT DATA FOR HUNGARY

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	73.57	73.66	74.23	74.45
Infant deaths per 1000 live births	5.72	5.91	5.58	5.13
Measles incidence per 100000	0.01	0	0	0.01
Hospital beds per 100000	791.68	718.59	710.51	714.38
Physicians per 100000	303.58	280.33	309.06	302.08
Total health expenditure, PPP$ per capita, WHO estimates	1486.38	1429.06	1506.38	1440.7

TABLE 7 - INPUT DATA FOR LATVIA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	70.96	71.2	72.53	73.28
Infant deaths per 1000 live births	7.62	8.76	6.72	7.75
Measles incidence per 100000	0.31	0	0.13	0
Hospital beds per 100000	760.81	757.13	746.09	640.14
Physicians per 100000	293.67	303.85	310.67	299.49
Total health expenditure, PPP$ per capita, WHO estimates	927.94	1060.36	1206.36	995.56

TABLE 8 - INPUT DATA FOR LITHUANIA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	71.16	71	72.05	73.23
Infant deaths per 1000 live births	6.81	5.87	4.91	4.93
Measles incidence per 100000	0.03	0	0.03	0
Hospital beds per 100000	688.82	688.26	683.66	680.32
Physicians per 100000	365.25	371.81	369.64	365.06
Total health expenditure, PPP$ per capita, WHO estimates	1002.4	1134.4	1317.64	1096.56

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TABLE 9 - INPUT DATA FOR MALTA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	79.59	80.05	79.86	80.46
Infant deaths per 1000 live births	3.61	6.43	8.1	5.3
Measles incidence per 100000	0.25	0.49	0.24	0.24
Hospital beds per 100000	754.82	780.26	734.22	481.41
Physicians per 100000	...	...	...	303.63
Total health expenditure, PPP$ per capita, WHO estimates	4334.4	4119.76	4196.68	4264.32

TABLE 10 - INPUT DATA FOR POLAND

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	75.38	75.45	75.73	75.91
Infant deaths per 1000 live births	5.98	5.99	5.64	5.57
Measles incidence per 100000	0.31	0.1	...	0.3
Hospital beds per 100000	647.35	642.45	662.13	665.25
Physicians per 100000	217.97	219.12	216.17	217.05
Total health expenditure, PPP$ per capita, WHO estimates	934.72	1073.68	1270.56	1358.6

TABLE 11 - INPUT DATA FOR ROMANIA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	72.69	73.27	73.47	73.61
Infant deaths per 1000 live births	13.91	11.99	10.97	10.12
Measles incidence per 100000	14.81	1.64	0.06	0.04
Hospital beds per 100000	674.23	654.15	657.2	662.33
Physicians per 100000	215.6	212.22	221.43	225.82
Total health expenditure, PPP$ per capita, WHO estimates	568.42	669.88	839.68	773.02

TABLE 12 - INPUT DATA FOR SLOVAKIA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	74.54	74.66	75.05	75.42
Infant deaths per 1000 live births	6.59	6.14	5.86	5.65
Measles incidence per 100000	0	0	0	0
Hospital beds per 100000	671.19	675.26	655.67	650.53
Physicians per 100000	...	300.14	...	...
Total health expenditure, PPP$ per capita, WHO estimates	1349.58	1605.28	1848.56	1897.74

TABLE 13 - INPUT DATA FOR SLOVENIA

Indicators	2006	2007	2008	2009
Life expectancy at birth, in years	78.35	78.53	79.29	79.46
Infant deaths per 1000 live births	3.38	2.78	2.62	2.4
Measles incidence per 100000	0	0	0	0
Hospital beds per 100000	476.32	466.18	470.04	459.72
Physicians per 100000	236	238.39	238.01	240.66
Total health expenditure, PPP$ per capita, WHO estimates	2091.76	2125.94	2419.9	2475.92

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The analysis starts with calculating the efficiency measures for each unit using the linear programming problem, based on empirical data (Tables 2-13). There is a great variability in our sample on the referred indicators. Descriptive statistics of the raw data are displayed in Table 14.

TABLE 14 - DESCRIPTIVE STATISTICS OF DEA MODEL INPUTS AND OUTPUTS FOR INPUT AND OUTPUT VALUES IN 2009

	X1	X2	X3	X4	Y1	Y2
Mean	299,57	611,2779	2,389286	1708,044	76,08929	5,662857
Standard Deviation	48,53783	103,7386	7,87099	884,6102	2,666506	2,284986
Sample Variance	2355,921	10761,7	61,95248	782535,1	7,110253	5,22116
Kurtosis	-0,71486	0,593943	13,77869	5,070049	-0,25899	-0,38863
Skewness	-0,27357	-1,28496	3,701992	1,98851	0,912707	0,457409
Minimum	217,05	375,41	0	773,02	73,23	2,4
Maximum	368,99	714,38	29,65	4264,32	81,37	10,12

TABLE 15 - INPUT DATA FOR DEA MODEL FOR 2009

	x1	x2	x3	x4	y1	y2
BG	368,99	659,72	29,65	985,52	73,77	9,00
CY	287,01	375,41	0,00	1825,04	81,37	3,33
CZ	356,01	711,12	0,05	1924,44	77,50	2,88
EE	326,65	543,85	0,00	1372,58	75,31	3,55
HU	302,08	714,38	0,01	1440,70	74,45	5,13
LV	299,49	640,14	0,00	995,56	73,28	7,75
LT	365,06	680,32	0,00	1096,56	73,23	4,93
MT	303,63	481,41	0,24	4264,32	80,46	5,30
PL	217,05	665,25	0,30	1358,60	75,91	5,57
RO	225,82	662,33	0,04	773,02	73,61	10,12
SK	300,14	650,53	0,00	1897,74	75,42	5,65
SI	240,66	459,72	0,00	2475,92	79,46	2,40
EU27	347,12	648,89	0,86	2178,25	76,23	7,34
EU12	271,56	664,82	2,30	1324,37	75,25	6,33

Finding the DEA is a matter of defining a linear program, or more generally a constrained optimization. We solved the above DEA problem with the Solver facility incorporated in Microsoft Excel. Interpreting the results of the DEA, a numerical coefficient is given to each unit, defining its relative efficiency.

TABLE 16 - THE DEA SOLUTIONS - THE EFFICIENCY SCORES OF THE DMU IN 2006-2009

Value	BG	CY	CZ	EE	HU	LV	LT	MT	PL	RO	SK	SI	EU27	EU12
θ_{2006}	1	1	0,791	0,977	1	1	1	1	1	1	1	1	0,779	0,888
θ_{2007}	1	1	0,797	1	1	1	0,995	1	1	1	1	1	0,753	0,904
θ_{2008}	1	1	0,810	1	1	1	1	1	1	1	1	1	0,801	0,867
θ_{2009}	0,928	1	0,717	1	1	0	1	0	1	0	0	0	0,837	0,873

Efficiency scores for all regions studied relative to a best practice frontier are computed using the output-oriented model, thus countries or regions aim to maximize the volume and quality in terms of resulting health care outputs from their inputs.

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DEA measures the relative efficiency by the observable inputs and outputs of several, different DMUs, assigning them efficiency scores ranging from 0 to 1, the score of 1 given to the most efficient in the group measured (Table 16).

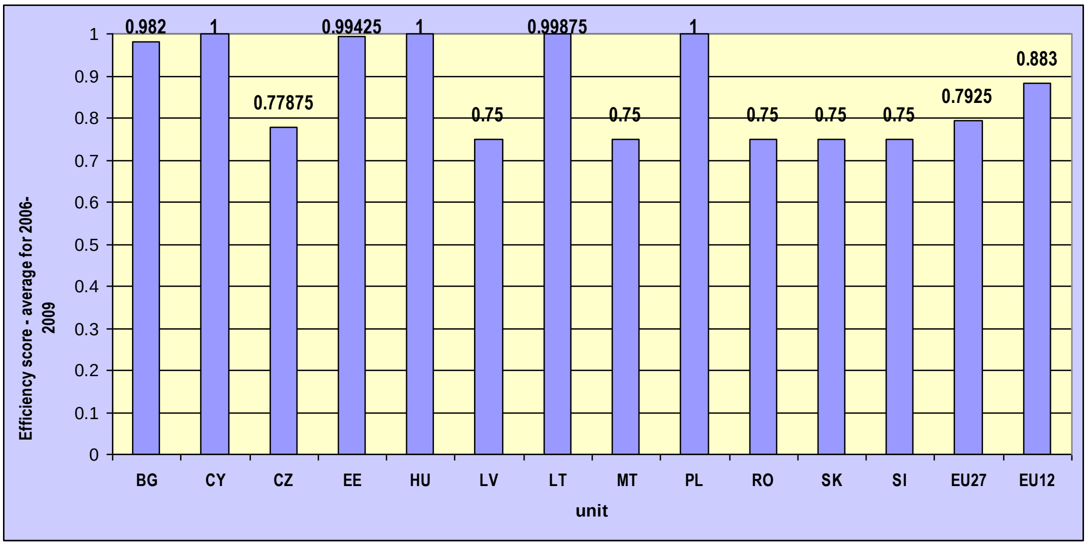

FIGURE 1 - THE AVERAGE EFFICIENCY SCORES FOR THE PERIOD 2006 - 2009

Note that DMUs in the categories of Cyprus, Hungary and Poland are overall efficient and DMUs as Bulgaria, Estonia, Lithuania are average efficient, and Latvia, Malta, Romania, Slovakia and Slovenia are inefficient at least in one year with an efficiency rating of 0 value. In another category, Czech Republic and the region of EU27 and EU 12 are inefficient in all years. The efficient levels of inputs and outputs for those DMUs in the last class can be computed, for example, for the EU12 in 2009 the virtual levels of efficiency are given by:

For inputs:

x1: Physicians density (per 10 000 population)	237.293
x2: Hospital beds (per 10 000 population)	580.930
x3: Measles (MCV) immunization coverage among 1-year-olds (%)	0.083
x4: Per capita total expenditure on health (PPP int. $)	1157.255

For outputs:

y1: Life expectancy at birth (years)	75.250
y2: Infant mortality rate (probability of dying between birth and age 1 per 1000 live births)	7.308

The inefficient DMU is supposed to emulate the benchmark's practices in order to become efficient (Tutorial, 2000).

5. THE DECISION MAKING IN POLICY DESIGN BASED ON DEA SOLUTION. EFFICIENCY CHANGES OVER TIME

It is a performance measurement technique which, can be used for evaluating the relative efficiency of decision-making units (DMU's) in organizations/ institutions/ units to be compared. DEA compares each producer with only the "best" performers.

In the input-orientated models, the DEA method seeks to identify technical inefficiency as a proportional reduction in input usage. It is also possible to measure technical inefficiency as a proportional increase in output production. The output- and input-orientated models estimate exactly the same frontier and, therefore, by definition, identify the same set of efficient DMUs. The choice of orientation has both practical and theoretical implications. In some applications, the choice of the orientation is clear; for example, in industries where the emphasis is on cost-control, the 'natural' choice would be an input-orientation.

In order to capture the variations of efficiency over time, Charnes et al. (1985) proposed a technique called 'window analysis' in DEA. Window analysis assesses the performance of a DMU over time by treating it as a different entity in each time period. This method allows for tracking the performance of a unit or a process. For example, if there are n units with data on their input and output measures in k periods, then a total of nk units need to be assessed simultaneously to capture the efficiency variations over time. In the window analysis, when a new period is introduced into the window, the earliest period is dropped out.

6. CONCLUSIONS

The evaluation of overall performance in providing health care for the 2006 – 2009 period, in the new state members of EU, in terms of technical efficiency (TE) constitutes the main goal of this research.

Data Envelopment Analysis (DEA) has been recognized as a valuable analytical research instrument and a practical decision support tool. DEA has been credited for not requiring a complete specification for the functional form of the production frontier nor the distribution of inefficient deviations from the frontier.

DEA is a popular method in efficiency assessment technique used in this paper to measure health care efficiencies of transition economies especially those joined the European Union after 2004: The aspect of efficiency analysis in health care systems calls the increased attention of the policy makers and of researchers mainly in the nowadays economy prejudiced by the scarcity of public funds allocated to the public services. In is obvious that health care costs have become a financial burden for developing and transition economies which have experienced turbulent dynamics of the public expenditure pressured by higher demands from the population expectations. A faster growing demand on their health care systems correspond to the world's tendency of globalization health care to address the health economics and policy actions while aiming to improve efficiency in delivery public services such as health care.

In assessing the efficiency at domestic level of an entire health care system, through such longitudinal system-wide assessments, countries with higher healthcare efficiency can be identified. Some lessons can be learned from the leaders in efficient spending, and for a specific country under the frontier of efficiency, corrective allocations and management practices can be borrowed from the first category, to be able to provide more adequate health care at lower costs to its citizens.

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