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EFFICIENCY AND PRODUCTIVITY EVALUATION OF HEALTHCARE SYSTEMS OF NORTHERN EUROPE AND THE BALTIC REGION

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Abstract. The study estimates the efficiency of healthcare systems of Northern Europe and the Baltic region countries. The analytical tools of a two-stage Data Envelopment Analysis and Malmquist DEA are applied to assess the efficiency and changes in health systems' productivity for the studied countries. The study data is extracted from the World Development Indicators from 2000 to 2020. Evidence reveals that only nine countries have an efficient healthcare system, and the healthcare systems of Germany and Lithuania were found to be inefficient. A reference between the inefficient and the efficient countries further demonstrates that the inefficient countries outperformed the reference group. Moreover, the estimates obtained by applying the Tobit regression model show that only the Gini coefficient significantly affects the inefficiency of the healthcare systems of the studied countries. Furthermore, it is found that the total factor productivity declined by 0,1% over the period of one decade, and the decay in healthcare systems' productivity is driven purely by technical change not by technological change. Therefore, the policy implication of the findings suggests that pursuing sound economic policies that ensure fair income distribution in the studied countries has the potential to overcome the existing level of inefficiency in the healthcare systems and subsequently lead to improvement in health outcomes.

Keywords: Two-stage DEA, Malmquist DEA, healthcare systems efficiency, Baltic region

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Introduction

For countries, achieving sustainable development requires maintaining functional health systems. As a result, estimating the health systems' performance is integral to strengthening their efficiency. Therefore, having a functional and efficient health system counts greatly as far as improving health outcomes is concerned. The central objective of estimating the healthcare system's efficiency is to understand how resources budgeted for healthcare are utilized for improving health outcomes for the overall population. One of the World Health Organization's (WHO) publications [Tandon et al., 2000] believes that improving the population's health, meeting the population's expectations, and ensuring that the financial burden of accessing healthcare is distributed fairly are the fundamentals for monitoring health systems' performance.

Numerous studies have assessed the performance of healthcare systems worldwide. For instance, Anderson and Hussey [Anderson, Hussey 2001] estimated the performance of health systems across the world through various studies. The health systems of OECD countries are compared with the US health system, and evidence reveals that the efficiency of the latter has declined relatively over four decades [Asandului, Roman, Fatulescu, 2014]. The efficiency of the health systems of European countries is evaluated, and the findings highlight that while a substantial number of countries are not efficient, a large number of countries are positioned well on the efficiency frontier. Similarly, Top, Konca, and Sapaz [Top, Konca, Sapaz, 2020] have evaluated the technical efficiency of African nations' health systems and found that 58,3% of the countries of Africa had efficient healthcare systems [Singh et al., 2021]. The health systems in Southeast Asian countries has been studied, and the authors concluded that total factor productivity declined during the period studied [Mohamadi et al., 2020]. Iran's health system's efficiency is compared with that of the upper middle-income countries, and the findings show that while health system in 15 countries had improved, efficiency declined in 20 countries [Ibrahim, 2023]. The efficiency and productivity of the health systems of African nations are evaluated, and the findings reveal that African countries are not efficient in providing maternal and infant care [El Husseiny, 2023]. The efficiency of the healthcare systems of Arab nations is assessed, and evidence shows that only six countries are efficient, assuming that both returns to scale orientations are examined. A recent study by Konca and Top [Konca, Top, 2023] evaluated the efficiency of the health systems of the OECD countries, and the authors concluded that per capita GDP, unemployment rate, and university graduates negatively affected the efficiency score. Health systems' efficiency estimation within and across serves as a crucial way to understand if the health systems are performing to the expected level, or are underperforming, and a comparative study on the efficiency level of health systems becomes easier than ever with the availability of data. Tigga and Mishra [Tigga, Mishra, 2015] and Naylor, Iron, and Handa [Naylor, Iron, Handa, 2002] have assessed the performance of the health systems of countries with common socioeconomic characteristics. It serves as the usual approach researchers employ to estimate the levels of efficiency among countries. Even though the healthcare systems differ due to their historical and socioeconomic circumstances, they are expected to provide affordable healthcare services to the population they are established to serve.

This paper aims to estimate the efficiency and productivity of health systems for the countries of Northern Europe and the Baltic (CUB) region. The subsequent section presents the methods followed in the study, the empirical results and culcusions.

Methods

This study evaluates the performance of the health systems of the CUB countries using two-stage DEA and Malmquist DEA from 2010 to 2020. The study countries have been selected based on the apparent reality that they have the highest burden of NCDs and infant mortality compared to the entire countries of the Euro Area and the OECD countries. Similarly, the study countries have the lowest life expectancy at birth measured in years relative to their counterparts using data reported by World Development Indicators. The study countries have the lowest levels of the indicators considered as health outcomes in this study. Thus, this paper considers assessing the efficiency of the health system of these countries to offer important policy suggestions on the best way to improve health outcomes. In the two-stage DEA method, the input and output variables are collected for 2016, considering that all the countries have reported data in that particular year. Moreover, the data is collected from 2010 to 2020 in the analysis of the Malmquist DEA. The performance of the national health system of countries of CUB is evaluated at a particular period using two-stage DEA and over one decade using Malmquist DEA.

The DEA Method

The DEA method is the most often used approach in assessing health systems' performance in the contemporary literature. This is a nonparametric technique that shows an efficient boundary where only the best-performing countries are positioned after solving the linear programming problem. The common challenge practitioners encounter in evaluating health systems' efficiency is the difficulty in defining the indicators to be used as inputs and outputs. Therefore, to overcome this challenge, this paper followed the existing literature and applied the DEA method, often employed for evaluating health systems' efficiency where defining inputs and outputs seem difficult initially. The DEA method assigns a unit score to the country that performs efficiently and below a unit score to a less well-performing country, which is termed inefficient. Fundamentally, Farrell [Farrell,1957] developed and introduced the DEA methods to the literature. The DEA method can either be input or output-oriented. The output-oriented DEA aims to maximize output subject to the inputs available. However, the input-oriented DEA targets to minimize the available inputs subject to the output. Therefore, this paper applied DEA with input orientation to estimate the performance of the CUB's health systems.

Moreover, Charnes, Cooper, and Rhodes [Charnes, Cooper, Rhodes, 1978] introduced a constant return to scale (CRS) perspective to DEA analysis. Subsequently, Banker Charnes and Cooper [Banker, Charnes, Cooper, 1984] developed the variable return to scale (VRT) approach to the DEA method. The CRT approach argues that inputs and outputs should be increased proportionately. However, the VRT model assumed that an increase in outputs may differ significantly from an increase in inputs. Thus, choosing between CRS or VRT alters the outcome of the efficiency analysis specific to each country.

Moreover, the other factor altering the efficiency analysis results is deciding the specific orientation of the DEA method. Therefore, this paper assesses the efficiency of the CUB countries' health systems under pure technical efficiency change, and thus, the VRT-input-oriented DEA method is applied. This method is applied following the extant literature [Chern, Wan, 2000; Ozcan, 2008]. The VRT input-oriented approach to DEA can be written as:

$$Max \frac{\sum_{r=1}^{s} u_{rk} y_{rk} + \mu_0}{\sum_{i=1}^{m} v_{ik} x_{ik}} \tag{1}$$

$$Constriants; \frac{\sum_{r=1}^{s} u_{rk} \, y_{rk} + \mu_0}{\sum_{i=1}^{m} v_{ik} x_{ij}} \leq 1 \ \ (j = 1,2,3 \ldots \ldots . n)$$

$$v_{ik}, v_{rk} \geq \varepsilon > 0, \text{(r = 1, 2,……s), (i=1,2……,m)}, \mu_0 \in R$$

Furthermore, after obtaining the DEA results, the Tobit regression is applied in the second phase of the investigation. Thus, the general expression for estimating Tobit regression can be written as:

$$. y_i^* = x_i^{\prime} \beta + \mu_i \qquad (i = 1, \ldots \ldots n)$$

$$y_i = \begin{cases} y_i^*, if y_i^* > 0 \\ 0, if y_i^* \leq 0 \end{cases}$$

$$\mu_i \sim IIN(0, \delta^{-2})$$

Where y_i^* is a latent variable taken as "y" if it appears positive and zero otherwise. The error term μ_i is assumed to be normally distributed with zero means and $\delta^2 > 0$. Since the Tobit regression used the DEA results as the dependent variables, the analysis requires that the estimated DEA scores be censored from the left at zero. Therefore, the same censoring process is applied to the Tobit regression model used in this study.

The Malmquist Productivity Index (MPI)

Efficiency entails maximizing output from a set input or achieving a desired output using minimal inputs, under the assumption that efficient firms are operating at the peak of their production capabilities. Technological advancements and reducing wastage of inputs can enhance efficiency gradually. Hence, assessing efficiency fluctuations across different units over time is a sensible approach for management and control purposes.

The MPI is applied to estimate productivity dynamics in the health systems of CUB countries from 2010 to 2020. The DEA method applied in the successive analysis assesses the health systems' efficiency for 2016 alone, considering that all the indicators employed in the model have no missing data in the reference year. The MPI measures efficiency by analyzing changes in performance at different periods and for different countries. The MPI measures changes in total factor productivity in two periods by estimating the ratio of the distance of each period considering the existing technology. Thus, following the efficiency and productivity analysis [Coelli, Prasada Rao, O'Donnell, Battese, 2005], if the level of technology is denoted as the output-oriented MPI between the two periods can be written as:

$$m_o^t\,(q_s, x_s, q_t, x_t) = \frac{d_0^t\,(q_t, x_t)}{d_0^t\,(q_s, x_s)}. \tag{2}$$

In the same way, if s is used as the reference period for the level of technology, equation (2) can be written as:

$$m_o^s\,(q_s, x_s, q_t, x_t) = \frac{d_0^s\,(q_t, x_t)}{d_0^s\,(q_s, x_s)}. \tag{3}$$

If the firm is technically efficient in the two periods, $d_0^s(q_s, x_s) = 1,$ thus

$$m_o^s\,(q_s, x_s, q_t, x_t) = d_0^s(q_t, s_t) \tag{4}$$

Equation (4) shows that the notations $d_0^s\,(q_t, x_t)$ show the expected distance from period t observation to the period s technology, $m_o^s\,(q_s, x_s, q_t, x_t)$ is the lowest output-deflation factor, given that the vector for the deflated-output for the firm in period t, ${}^{q_t}/_{[\,m_0^s(.)]}$, and the input vector, x_t, are on the production frontier of the technology in period s. However, if the firm's level of productivity is higher than the period 's', technology implies, then $m_o^s\,(.) > 1$.

As argued by Farrell [Farrell, 1957], the two periods $(s\ and\ t\,)$ are similar if the level of technology is Hicks and neutral to the output level. This implies that if the output distance functions can be represented as $d_0^s(q_t, s_t) = A(t)d_0(q_t, s_t)$, for all t. Therefore, to do away with the problem of imposing any restriction or choosing one of the technologies arbitrarily, following Caves, Christensen and Diewert [Caves, Christensen, Diewert, 1982], the MPI is commonly given as the geometric mean of the two periods and can be written as:

$$m_0\,(q_s, x_s, q_t, x_t) = \left[\frac{d_0^s(q_t, x_t)}{d_0^s(q_s, x_s)} \times \frac{d_0^t(q_t, x_t)}{d_0^t(q_s, x_s)}\right]^{1/2} \quad , \tag{5}$$

The productivity's index distance functions can be disentangled into the technical efficiency change and technical change written as:

$$m_0\,(q_s, x_s, q_t, x_t) = \frac{d_0^t(q_t, x_t)}{d_0^s(q_s, x_s)}\left[\frac{d_0^s(q_t, x_t)}{d_0^t(q_t, x_t)} \times \frac{d_0^s(q_s, x_s)}{d_0^t(q_s, x_s)}\right]^{1/2} \quad , \tag{6}$$

It is observed that the output-oriented component of efficiency between the two periods ($s\ and\ t$) is given as the ratio of the expression written outside the brackets of equation (6). This implies that the efficiency change ratio in period t to the efficiency change in the s period is analogous to the change in the efficiency index. The rate of technical change between the two periods is measured by the other component given in equation (6). Thus, the geometric mean of the entire frontier shift in the level of technology between two periods given as x_t and x_s shows the geometric mean part of the index. Therefore, the two terms in equation (6) can be separately written as:

$$\text{Efficiency change} = \frac{d_0^t(q_t, x_t)}{d_0^s(q_s, x_s)} \tag{7}$$

and

$$\text{Technical change} = \left[\frac{d_0^s(q_t, x_t)}{d_0^t(q_t, x_t)} \times \frac{d_0^s(q_s, x_s)}{d_0^t(q_s, x_s)}\right]^{1/2} . \tag{8}$$

Moreover, some authors have offered other plausible divisions in the efficiency change and technical change component of the MPI index. Farell [1957] suggested that efficiency change could be divided into scale efficiency and pure efficiency change. This division has been widely used in the literature and heavily criticized on the other hand. This division involves taking the efficiency change components in equation (7) and disentangling them into a pure efficiency change component written as:

$$\text{Pure efficiency change} = \frac{d_{0v}^t(q_t, x_t)}{d_{0v}^s(q_s, x_s)} \quad , \tag{9}$$

The scale efficiency change component and

$$\text{Scale efficiency change} = \left[\frac{d_{ov}^t(q_t, x_t)/d_{oc}^t(q_t x_t),}{d_{ov}^t(q_s, x_s)/d_{oc}^t(q_s, x_s)} \times \frac{d_{ov}^s(q_t, x_t)/d_{oc}^s(q_t, x_t)}{d_{ov}^s(q_s, x_s)/d_{oc}^s(q_s, x_s)}\right]^{1/2} \tag{10}$$

The component scale efficiency change is given as the geometric mean of the estimates of two scale efficiency changes. The first portion is relative to the technology period designated as t, and the second is related to the technology period taken as s. Accordingly, it is important to understand that the extra subscripts, v and c are related to the VRT and CRS technologies.

Table 1 shows the variables defining the model of this study. In the two-stage DEA method, this paper collects data for 2016, considering that data for all the variables is reported in that particular year. For the Malmquist DEA method, the data is collected from 2010 to 2020 for all the variables. The interpolation method is applied where missing values are reported in the data. The variables used as inputs in this model consisted of current health expenditure, physician density, nurse density, hospital beds, Gini-coefficient, and unemployment rate. Life expectancy at birth (total), infant mortality rate (total), and mortality rate from chronic diseases are employed as the output variables.

Table 1

Study variables and definitions

Variables	Description
Physician per 1000 population	This gives the number of qualified medical professionals who supply care to the population
Nurses and midwives per 1000 people	Indicates the number of nurses and midwives that are helping the physicians in providing care to the population
Hospital beds per 1000 population	Indicates the available hospital beds that are currently supplied to the health facilities per 1,000 population
Current health expenditure	Refers to public and private health expenditure that is being used to finance the health system
Gini Coefficient	It measures the level of inequality in the country using a scale of zero to one
Unemployment rate	Shows the proportion of the workforce who are currently not employed
Life expectancy at birth (total)	Is the estimated number of years an individual is ought to live in a given country, all else is assumed away
Infant mortality rate (total)	It measures the number of infant deaths per 1,000 live births
NCDs mortality rate	It shows the estimated number of adults who died from diabetes, cancer, cardiovascular, or respiratory diseases between the exact ages of 30 to 70 years.

Source: *Prepared by the authors*

Table 2 reports the descriptive statistics of the variables employed in the model. Among the input variables, Gini-coefficient has the highest mean value of 30,73, followed by nurses and midwives with 10,66. However, among the health systems output variables, life expectancy at birth (total) has the largest mean value of 77,75 years, followed by 15,08 for the mortality rate from chronic diseases.

Table 2

Summary Statistics

Variables	Description	Observation	Mean	Std. Dev.	Minimum	Maximum
Physician per 1000 population	Input	121	3.59	1.01	2.20	9.10
Nurses and midwives per 1000 people	Input	121	10.66	4.15	4.10	20.40
Hospital beds per 1000 population	Input	121	5.69	3.76	2.10	39.70
Current health expenditure	Input	121	8.16	2.72	4.90	29.10
Gini Coefficient	Input	121	30.73	4.63	4.80	40.90
Unemployment rate	Input	121	7.57	3.22	2.70	19.50
Life expectancy at birth (total)	Output	121	77.75	7.30	7.80	83.40
Infant mortality rate (total)	Output	121	4.01	6.20	1.60	69.70
NCDs mortality rate	Output	121	15.08	6.73	2.10	30.90

Source: *Prepared by the authors using Stata Software*
https://databank.worldbank.org/source/world-development-indicators

Note: Physicians, nurses, and hospital beds are measured per 1,000 population. Current health expenditure is measured as a percentage of GDP budgeted every year. The Gini coefficient is taken as estimates computed by the World Bank, and the unemployment rate is measured as a total percentage of the labor force national estimate. While life expectancy at birth is measured in years, infant mortality is measured per 1,000 live births, and NCDs mortality is measured as a percentage of mortality rate from diabetes, cancer, cardiovascular diseases, and respiratory diseases between the exact ages of 30 to 70.

Table 3 presents the list of countries of the CUB and the data for the variables used in the Two-stage DEA collected for 2016. The data shows physician density is higher in Lithuania and Sweden, and Norway and Finland have the highest nurse scores. Similarly, while

Germany has the highest score for hospital beds and current health expenditure, Lithuania reports the highest score for the Gini coefficient. The highest data for unemployment is reported in Latvia, and Iceland has the largest score for life expectancy at birth. The mortality rate from chronic diseases and infant mortality is highest in Russia compared to all the CUB countries.

Table 3

Countries of the study and the variables

Countries	Physicians per 1000 population	Nurses and Midwives per 1000 population	Hospital beds per 1000 population	Current Health Expenditure % GDP	Gini coefficient	Unemployment rate	Life expectancy at birth (total)	Infant Mortality (total)	NCDs Mortality (total)
Denmark	4.0	10.3	2.6	10.1	28.2	6.0	80.9	3.5	11.9
Estonia	3.5	6.4	2.1	6.6	31.2	6.8	77.6	2.1	17.2
Finland	3.8	14.7	3.97	9.4	27.1	8.8	81.4	1.8	10.4
Germany	4.2	13.2	8.06	11.3	31.9	4.1	80.9	3.3	12.4
Iceland	3.9	15.2	3.1	8.2	27.2	2.9	82.2	1.7	8.8
Latvia	3.2	4.8	5.7	6.2	34.3	9.6	74.6	3.9	22
Lithuania	4.3	7.9	6.7	6.6	38.4	9.1	74.6	3.9	21.4
Norway	2.7	17.9	3.7	10.6	28.5	4.7	82.4	2.1	2.7
Poland	2.4	5.8	6.6	6.5	31.2	6.2	77.9	4.0	18.6
Russia	4.0	8.5	8.2	5.3	36.8	5.6	71.7	6.5	27.0
Sweden	4.3	11.7	2.3	10.8	29.6	7.4	82.3	2.3	9.1

* The year of data reported in Table 1 is 2016 because all the variables have reported data in 2016.
Source: *Prepared by the authors. URL: https://databank.worldbank.org/source/world-development-indicators*
Note: Physicians, nurses, and hospital beds are measured per 1,000 population. Current health expenditure is measured as a percentage of GDP budgeted every year. The Gini coefficient is taken as estimates computed by the World Bank, and the unemployment rate is measured as a total percentage of the labor force national estimate. While life expectancy at birth is measured in years, infant mortality is measured per 1,000 live births, and NCDs mortality is measured as a percentage of mortality rate from diabetes, cancer, cardiovascular diseases, and respiratory diseases between the exact ages of 30 to 70.

Results

Table 4 reports the DEA results with a CRT orientation obtained by solving the linear programming problem of this study. Table 4 reports both the best-performing and the less-performing countries, along with the best-performing countries as a reference to the less-performing countries. Evidently, among the 11 countries of the CUB region, nine countries (81,8%) had healthcare systems that were considered efficient. It is found that the difference in the DEA scores between the efficient and inefficient countries of the CUB lies between 0,1 – 0,6. Thus, this implies that the countries being studied had a significant difference in variables employed as healthcare outputs. It might be the case that the efficient countries utilized fewer healthcare resources (inputs) to generate improved health outcomes relative to the inefficient ones.

Similarly, Denmark, Estonia, Finland, Iceland, Latvia, Norway, Poland, Russia, and Sweden are found to be efficient or the best-performing countries. However, Germany and Lithuania are classified as countries that are inefficient in turning healthcare inputs into improved health outcomes. A comparison has been made between efficient and inefficient countries to understand the relative efficiency or inefficiency dynamics among these countries. Though Germany and Lithuania are classified as inefficient, comparing Germany with Iceland, Poland, and Russia shows that Germany outperformed these countries using healthcare inputs and outputs. Similarly, a reference of Lithuania with Estonia, Latvia, and Russia shows the same results. Therefore, comparing the inefficient countries with the efficient countries shows that the inefficient countries outperformed the reference countries in processing healthcare inputs into outputs.

Table 4

VRS-INPUT Oriented DEA Efficiency Results

Countries	Rank	Theta	Reference (Lambda)										
			Denmark	Estonia	Finland	Germany	Iceland	Latvia	Lithuania	Norway	Poland	Russia	Sweden
Denmark	1	1	1	-	-	-	-	-	-	-	-	-	-
Estonia	1	1	-	1	-	-	-	0	-	-	-	0	-
Finland	1	1	1	-	1	-	0	-	-	-	-	-	-
Germany	10	0.996	-	1	-	1	0.679	-	-	-	0.049	0.299	-
Iceland	1	1	-	0	1	-	1	-	-	-	-	-	-
Latvia	1	1	-	-	-	1	-	1	-	-	-	-	-
Lithuania	11	0.916	-	0.492	-	-	1	0.142	1	-	-	0.361	-
Norway	1	1	0	-	-	-	0	-	-	1	0	-	-
Poland	1	1	-	-	-	-	-	-	-		1	0	-
Russia	1	1	-	-	-	-		-	-		-	1	-
Sweden	1	1	0	-	-	-	-	-	-		-	-	1

CNT means constant return to scale, DEA means Data Envelopment Analysis
Source: *Prepared by the authors using Windeap Software*

Table 5 reports the Tobit regression results, forming the second stage of the DEA analysis. The Tobit regression performed is censored from the left at zero, showing the explanatory variables' effects on the estimated efficiency scores. Therefore, the only positive and significant variable is the Gini coefficient, and thus, it has a positive effect on the inefficiency of the health systems of the CUB countries. Though insignificant, the other input variables hurt the health systems' of the health systems of the CUB countries.

Table 5

Estimates of the Tobit regression

Variable	Coefficient	Std. Error	z-statistics	Probability
Current health expenditure	-2.1215	1.4315	1.49	0.137
Physician density	-2.0715	2.8815	-0.72	0.473
Nurses and midwives	-5.4217	5.3216	-0.10	0.919
Hospital beds	-4.59.16	1.8315	-0.25	0.801
Gini coefficient	1.6915	6.8816	2.46	0.014
Unemployment rate	-3.8416	7.6516	-0.50	0.616
Constant	1.2441***	3.0800	15.54	0.001
Error Distribution				
Scale	9.31012	7.3330	1.9930	0.00070
Log-likelihood	288.142			
Chi-squared	9.83			
Number of obs.	9			
Left-censored obs.	9			
Right-censored obs.	0			

*** denotes 1% level of significance
Source: *Prepared by the authors through Stata Software*

The Malmquist DEA results are reported in Table 6, which shows the dynamics of the healthcare system productivity of the CUB countries. Specific to the Malmquist summary of the country, the average growth in total factor productivity for Denmark and Poland for one decade remains static. Similarly, total factor productivity has increased by 0,1% for Estonia, Iceland, and Sweden. However, it declined by 0,1%, in Finland and Lithuania, 0,2%, in Germany, Latvia, and Norway, and 0,6% in Russia. While the largest decline in the productivity of the health system is evident in Russia, there is a mild productivity gain in Estonia, Iceland, and Sweden. It is important to note that the growth in total factor productivity is brought about by technical change, not by efficiency change in these three countries.

Table 6

Output-oriented Malmquist DEA results

Malmquist Index summary of country means						Malmquist Index summary of annual means					
Countries	**effect**	**techch**	**pech**	**sech**	**tfpch**	**Year**	**effch**	**techch**	**pech**	**sech**	**tfpch**
Denmark	1.00	1.02	1.00	1.00	1.00	1	-	-	-	-	-
Estonia	0.99	1.01	0.99	0.99	1.01	2	1.00	1.67	1.00	1.00	1.17
Finland	0.99	0.99	0.99	0.99	0.99	3	1.00	0.86	1.00	1.00	0.86
Germany	0.99	0.99	1.00	0.99	0.98	4	1.00	0.99	1.00	1.00	0.99
Iceland	1.00	1.01	1.00	1.00	1.01	5	0.99	1.01	0.99	0.99	1.00
Latvia	1.00	0.99	1.00	1.00	0.98	6	0.98	0.98	1.00	0.99	0.97
Lithuania	1.00	0.99	1.00	1.00	0.99	7	1.00	1.00	0.99	1.01	1.00
Norway	1.00	0.98	1.00	1.00	0.98	8	0.99	1.01	1.00	0.99	1.00
Poland	1.00	1.01	1.00	1.00	1.00	9	1.00	1.00	1.00	1.00	1.02
Russia	1.00	0.95	1.00	1.00	0.94	10	1.00	0.98	1.00	1.00	1.01
Sweden	1.00	1.02	1.00	1.00	1.01	11	1.00	0.96	0.99	1.00	0.97
Means	0.99	0.99	1.00	1.00	0.99	Means	0.99	0.99	1.00	1.00	0.99

Effect means efficiency change; tech means technical change; pech means pure scale change; such means scale efficiency change; and teach means total factor productivity change. All Malmquist Index averages are geometric means
Source: *Prepared by the authors through Windeap Software*

Furthermore, in the Malmquist DEA estimates of the annual means, it is found that the total factor productivity had increased greatly by 17% in the two years, and it was driven by technical change only. Similarly, it increased by 0,2% and 0,1% in the years 9 and 10, respectively. While it remained stagnant in the years 5,7, and 8, it declined in the years 2, 3, 6, and 11. Therefore, overall, total factor productivity declined by 0,1% for the period studied, and the overall decline in total factor productivity is attributed to a proportionate decline in efficiency and technical change in the components of the health systems.

Discussion

Strengthening the capacity of the healthcare systems requires efficient allocation of resources to the healthcare systems. Evidence shows that among the 11 countries of CUB, nine countries representing (81,8%) had an efficient healthcare system. Germany and Lithuania are found to have inefficient healthcare systems. A reference analysis between the inefficient and the efficient countries further reveals that the inefficient countries outperformed the referred countries in terms of efficiency. Germany, the economic powerhouse of Europe, is not expected to lie away from the efficiency frontier because it has the resources to establish an efficient healthcare system. This result contrasts with the findings of previous studies [Ahmed et al., 2019], where economically buoyant countries are found to be among the most efficient countries in their studies. However, if different time frames and inputs and output variables are used, the findings will likely differ.

Moreover, the Tobit regression model applied in the second state analysis highlights that only the Gini coefficient has a positive and significant effect on the inefficiency of the health systems of the CUB countries. Though insignificant, the other input variables used in the model have shown negative effects on the health systems' inefficiency of the CUB countries. Furthermore, from 2010 to 2020, the Malmquist DEA method reveals that total factor productivity remains stagnant in Denmark and Poland. While it increased by 0,1% in Estonia, Iceland, and Sweden, it declined by 0,2% in Lithuania and 0,6% in Russia. Total factor productivity declined by 0,1% for the studied countries for one decade. The decline in total factor productivity is largely driven by technical change in the three countries where it occurred. Differences in income per capita, uneven distribution of income, absence of protection schemes, lack of serious political commitment to strengthening healthcare systems, and differences in healthcare systems' goals could lead to variations in the performance of the countries' health systems [Kirigia et al., 2007]. The current findings are consistent with the results of many previous studies. The study that estimated the healthcare system performance of 173 countries for eight years found a considerable variation in the performance of the countries studied [Sun et al., 2017]. The study conducted by Cetin and Bahce [Cetin, Bahce, 2016] evaluated the performance of the health systems of OECD countries and concluded that only 11 out of 26 countries are efficient after eliminating the countries that constituted an outlier in the population. A different study that analyzed health system performance of 191 countries concluded that only five countries provided the most efficient healthcare services [Tandon et al., 2000]. Regarding the statistical significance and theoretical sign of the Gini coefficient in effecting the inefficiency score, the findings of this study aligned with the results of Konca and Top [Konca, Top, 2023] studies for the OECD countries. Therefore, the policy advice of this study suggests the unfair distribution of income largely affects the health systems' efficiency in the CUB countries, and thus, taking the right steps to ensure fair income distribution will result in efficient healthcare systems for the countries studied. Similar to the findings of this paper, are the findings reported in research that measures the health systems' productivity of Southeast Asian countries [Singh et al., 2021].

The limitations of this study could be that even though there are numerous indicators of the healthcare systems, only three variables are employed as healthcare system outputs, with only six variables applied as inputs to the model for the 11 countries of the CUB. Utmost caution should be exercised in interpreting the findings of this research since the performance of the healthcare system of the CUB countries is assessed for one-decade using nonparametric techniques. Moreover, the variables used in this model, such as healthcare system outputs, do not represent the conventional variables used to measure health outcomes in a given health system. For instance, the mortality rate under 5, maternal mortality rate, and crude death rate per 1000 population are important health outcome indicators but are not part of this study. Furthermore, other factors, which include social, nutritional, environmental, housing, educational, and economic, contribute to altering health outcomes in many ways but do not constitute part of this study. Finally, another shortcoming of this paper is that it has not specifically addressed any contemporary policy of the studied countries. However, it only evaluates the performance of the health systems of these countries.

Future studies should incorporate numerous health outcome variables vis-à-vis many health system capacity indicators as healthcare systems inputs and examine the health system performance of the CUB countries. Additionally, it will be important to integrate the social, nutritional, housing, environmental, and educational factors in evaluating the health system performance of the CUB in particular, or massively expand the dataset by integrating other European countries.

Conclusion

This empirical study evaluates the health systems' efficiency for the CUB countries for a single period and one decade using two stages of DEA and the Malmquist DEA approach. Accordingly, the variables used as healthcare inputs are current health expenditure, physician density, nurses and midwives, hospital beds, Gini-coefficient, and unemployment rate. Life expectancy at birth, Infant mortality rate, and mortality rate attributed to chronic diseases are used as healthcare system outputs. Therefore, only nine countries (81,8%) are efficient in producing health, and estimates of the Tobit regression model show that only the Gini coefficient is significantly and positively associated with the inefficiency of the healthcare systems of the CUB countries. Though insignificant, the other input variables negatively affect the inefficiency of the CUB countries' healthcare systems.

Moreover, the Malmquist DEA method highlights that, overall, for the period studied, total factor productivity declined by 0,1%. And the decline in total factor productivity is purely brought about by technical change against efficiency change. Therefore, the overall productivity volume in the national healthcare systems of CUB countries could be enhanced by implementing national policies that could result in a fair income distribution. The mild decrease in health system productivity of the CUB countries could be overcome by pursuing policies geared towards technical progress in the healthcare systems.

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